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A FORMALISM FOR THE SYNTACTIC DESCRIPTION AND RECOGNITION OF TWO DIMENSIONAL PATTERNS

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A FORMALISM FOR THE SYNTACTIC DESCRIPTION AND RECOGNITION OF TWO DIMENSIONAL PATTERNS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

In partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

SARUKKAI R. NARAYANAN

Norman, Oklahoma

1981

A FORMALISM FOR THE SYNTACTIC DESCRIPTION

AND RECOGNITION OF TWO DIMENSIONAL PATTERNS

APPROVED BY

DISSERTATION COMMITTEE

To

Sri Venkateswara

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ABSTRACT

A new formalism is proposed for the syntactic description and recognition of two-dimensional patterns. The recognition problem is treated comprehensively from scanning and primitive identification all the way to recognition of patterns syntactically.

The vehicle of grammars coupled with ideas of static and dynamic chaining of pattern primitives are used for describing arbitrary two-dimensional patterns. Primitives in the grammar are unquantized vector entities. The grammar derives a "pattern form," while parametrization of the pattern form yields specific patterns.

The concept of imaginary parsing is advanced for recognition of partially obscured patterns.

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CHAPTER I

OVERVIEW OF PROBLEM

1.0 Introduction

The past two decades have witnessed a tremendous growth in the body of knowledge in pattern recognition. This growth has been spurred on by the evolution of the computer during the same period. As in other areas of study, the use of computers as a tool has opened up exciting new possibilities for the processing of two-dimensional patterns, which would otherwise be impossible.

Of the three approaches to pattern recognition, the heuristic approach is perhaps the most efficient, but the least amenable to generalization (38). Since the solutions are problem knowledge-based, the solution to one problem is not readily translated to other areas of study. The statistical approach accounts for the major portion of work done to date in pattern recognition. In this approach, recognition classes are first established from known samples. Subsequently, the objective is to identify an unknown sample with one of the classes previously established. The literature is very extensive in this area and one may refer to the bibliography for reference information. The third approach - namely, the syntactic approach, is relatively a recent entry to the field of pattern recognition compared to the other two. In this study, this is the area of prime interest.

The interest in syntactic pattern recognition is a natural outgrowth of the highly successful use of the syntactic technique in processing computer languages. A formidable body of knowledge has developed in the field of formal language theory and one can almost trace its development paralleling that of the computer. The main difficulty in applying the principles of syntactic techniques of language theory to two-dimensional pattern recognition is that, in languages, the only relationship between the primitives is one of concatenation, while in the case of two-dimensional patterns, spatial relationships, size and shades of color play an important role.

Some of the earlier works in syntactic pattern recognition overcame the above difficulty by defining the primitives in such a manner as to reduce a two-dimensional pattern to a one-dimensional string. This approach was successfully demonstrated in the chromosome analysis by Ledley et al. (21). Narasimhan (26,27,28) has used this approach for analysis of Fortran characters and hand-printed English characters. Shaw (40) has formulated the "Picture Description

Language," which is similar in concept and has used this idea for the analysis of Bubble Chamber pictures, description of Alphabetic characters and recognition of line patterns. This approach of reducing a two-dimensional pattern to a one-dimensional string has produced a number of publications in the syntactic analysis of wave forms. Stockman et al. (42), Pavlidis (31), Horowitz (18), Udupa et al (44), have carried out syntactic analysis of wave forms by reducing them to one dimensional string.

Researchers in syntactic pattern recognition have sought to overcome the limitations of representing two-dimensional patterns as one-dimensional strings. This led to the development of formalisms that took into account spatial relationships. The most noteworthy among these are the "Plex Grammar" by Feder (9), "Web Grammar" by Pfaltz and Rosenfeld (35) and "Tree Grammar" by Brainerd (4). In these works, the relationship between the primitives is more involved than mere concatenation. Productions in some of the grammars are depicted pictorially with additional qualifications that specify the constraints that must be adhered to in the rewriting process. Anderson (2) has made use of coordinates in the syntactic recognition of two-dimensional handprinted mathematics. Rosenfeld (39) has extended the concept of string grammars to array grammars in which the syntactic entities are elements in a two-dimensional array.

In reviewing these formalisms, there are several interesting and important questions that seem to remain unanswered. The first and most basic question that comes to one's mind is - "How are the primitives in the various schemes identified?" It appears that syntactic analysis of a pattern can be carried out after the primitives are identified and "handed over" to the various schemes. This is done almost without an exception by the various statistical methods (13).

The second point to be made is that there is no uniformity in the manner in which the primitives are chosen in the various formalisms. This makes it very difficult to use the solution of one problem area in another - at least in part, if not in whole.

Thirdly, almost without an exception, none of these formalisms address the question of partial patterns. It is not clear as to how to cope with situations wherein a pattern desired to be recognized is partially hidden or obscured by others that overlap them.

1.1 Objectives of Study

The formalism developed in this study endeavors to address the important questions raised above. The objectives of this study are fourfold. The first of these is to develop a framework in which provision is made for syntactically identifying the pattern primitives. The second objective is to seek to formulate the pattern primitives in such a manner as to provide a more uniform basis for their definition from one problem area to another. The third objective is to address the issue of how partial patterns may be recognized within this framework. The last, but not the least important of the objectives, is to verify the ideas advanced through computer implementation and draw conclusions as to the validity of this formalism.

1.2 The Two-Dimensional Pattern

If a two-dimensional pattern is placed under a microscope, without a doubt one will observe that the pattern is nothing more than a collection of fine points, each with an associated color of some intensity. In this sense, one might call these fine points the "universal primitives" in terms of which every two-dimensional pattern is composed. However, one might additionally observe that it is not the microscopic points themselves that are perceived by the human eye, but a collection of such points, which, taken together, forms the meaningful pattern. Therefore, for purposes of this study, collection of such points is considered for pattern primitives rather than the microscopic points themselves.

Intuitively speaking, the microscopic points can combine to form one of three entities in any arbitrary two-dimensional pattern. They are - dots, lines and areas. No effort is made in this work to precisely define each of these entities, for the simple reason that what constitutes a dot in one application can turn out to be an area in another! Associated with each of these is a color of a given intensity. The color may be uniform throughout or vary within each of the above three entities. It is the arbitrary combination of these dots, lines and areas that makes an arbitrary two-dimensional pattern. Specific combination of these imparts meaning to the two-dimensional pattern that we are conditioned by experience and learning to recognize. Additionally, it must be noted that in a real two-dimensional pattern, there are situations in which the variation in colors and intensity levels are such that the demarcation between these entities is not clear. This study assumes that a two-dimensional pattern is composed of an arbitrary combination of dots, lines and areas, distinguishable from one another by their associated color functions. The inability to distinguish one entity from another on the basis of color, while a limitation of this formalism, is common to most pattern recognition systems.

The principal dilemma in using linguistic ideas for description of two-dimensional patterns is, that the primitives in languages have only identity and their position within a string of these primitives, while pattern primitives not only have identity, but magnitude as well as direction or spatial position. This factor needs to be remembered in developing a syntactic formalism for patterns if it has to be a viable one. This requirement seems to be naturally met by choosing vectors as the basis for describing two-dimensional patterns. Vectors are entities that may be represented symbolically, which have magnitude as well as associated direction. These symbols may be manipulated using the linguistic approach to define a "pattern form," while the final pattern may be derived by parametrization of the attributes of this pattern form.

1.3 The Two-Dimensional Pattern Representation Space

The system proposed to be used for representing the pattern is the familiar x-y coordinate system. The pattern is assumed to lie entirely within the top right-hand quadrant of this x-y coordinate system. It is bounded on the left by the y-axis; the bottom by the x-axis; to the right and top by the outer periphery of the pattern. The lengths defining the boundary of the pattern space are finite. Within this space, a vector of unit length V_0 is considered to lie along the +x-axis, starting at the origin and moving away from it. Its rotation counter-clockwise is considered positive and clockwise, negative. Its movement away from the origin is considered positive and towards it, negative. This is illustrated in Figure 1.1. From here on, the term "pattern space" refers to the physical pattern representation space.

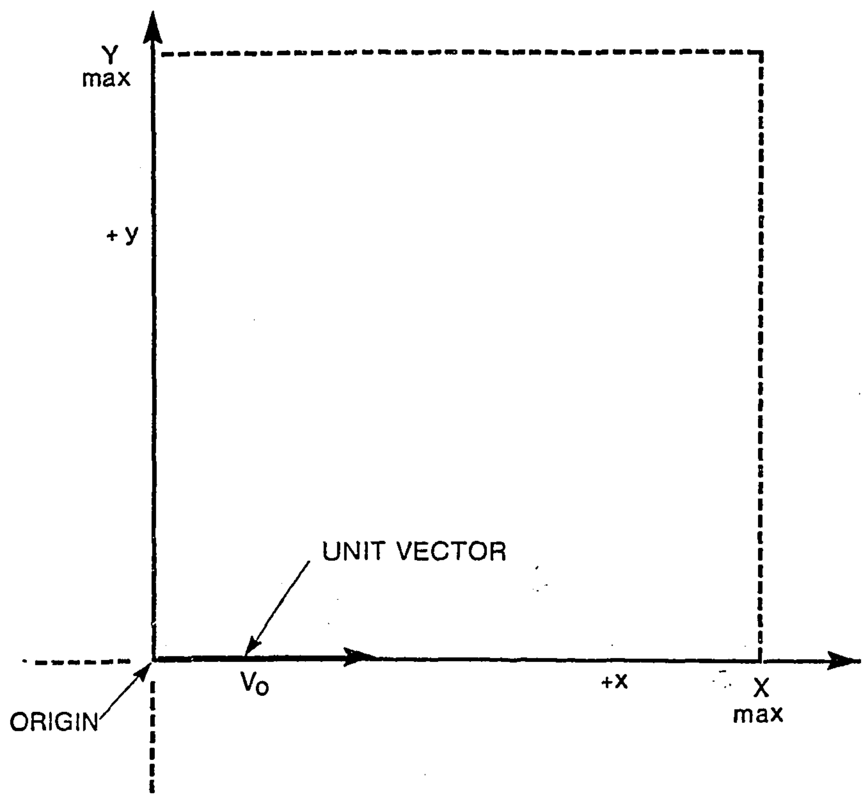

Figure 1.1 The Two-dimensional Pattern Space

CHAPTER II

SYNTACTIC PATTERN DESCRIPTION

2.0 Introduction to Pattern Description

The logical first step in the recognition of two-dimensional patterns is their description. The basic building block in this formalism is the unit vector. By means of operations on the unit vector and the transformation of the resulting vectors thereof, the entities of dots, lines and areas are derived. Within this formalism, the concept of chaining, coupled with the vehicle of grammars, enable the description of arbitrary two-dimensional pattern forms in terms of these three entities. Specific patterns are obtained through parametrization of the pattern forms. These ideas are covered in detail in the following sections of this chapter.

2.1 First Set of Operations on Unit Vector

Two operators on the unit vector are defined.

1. Length modifying operator, denoted by "q."
2. Rotation modifying operator, denoted by "Θ."

By temporarily shifting the origin to a point within the pattern space, any arbitrary vector within this space may be represented by the letter "V" as

$$V = q\Theta\ V_0, \quad 0 \leq q \leq q_{max}$$

$$0 \leq \Theta \leq 2\pi \tag{2.1}$$

The pattern entities of dots, lines and areas are derived from vectors in a unified manner. The first set of operations deal with the derivation of dots from vectors to accomplish the first of these objectives.

If the vector is treated as a non-terminal entity, one of three alternatives is possible.

1. Replace the vector by a point or dot at the arrowhead of the vector.
2. Replace the vector by a point at the starting point of the vector.
3. Replace the vector by a null value.

It is possible to show that the above three entities are obtained through the operator q; but for the present study the above statements suffice. The above operations may be represented symbolically as shown below.

$$(q\ \Theta\ V_0)\ ::=\ \boxed{\cdot} \tag{2.2}$$

$$(q\ \Theta\ V_0)\ ::=\ \boxplus \tag{2.3}$$

$$(q\ \Theta\ V_0)\ ::=\ \Phi \tag{2.4}$$

Since $q \ominus V_0$ represents an arbitrary vector V, the above can simply be written as

$$V ::= \boxed{\cdot}\ ^{*} \tag{2.5}$$

$$V ::= \boxplus\ ^{*} \tag{2.6}$$

$$V ::= \Phi \tag{2.7}$$

2.2 Chaining

The concept of chaining is an important one in this formalism. Chaining allows the derivation of complex patterns from simpler ones.

Two types of chaining are defined.

1. Static chaining
2. Dynamic chaining

In static chaining, the point at which chaining occurs remains fixed, while in dynamic chaining, this shifts to the end point of the newly chained vector. This concept is best illustrated by the graphic example as seen in Figure 2.1.

It should be noted that in static chaining, the order in which the vectors are chosen is not important, while in

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* The symbols chosen reflect the idea of looking at a point when it is located at the tip of the arrow (2.2) and (2.5) or at its tail (2.3) and (2.6).

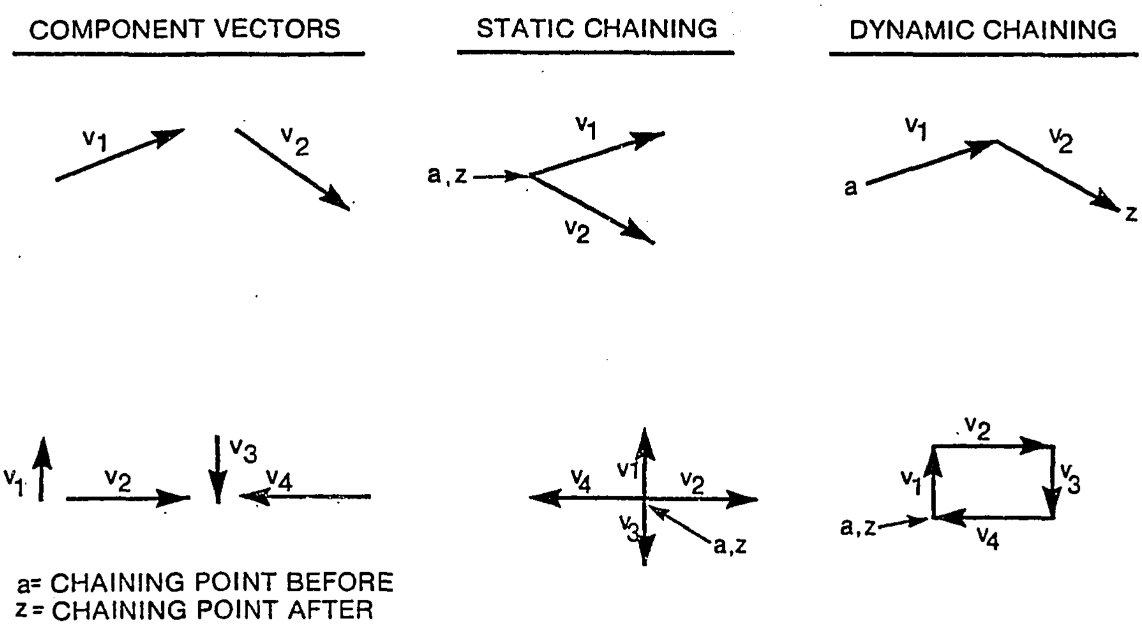


Figure 2.1 Examples of static and dynamic chaining.

dynamic chaining, the order determines the final pattern form derived. Two distinguished symbols are introduced at this time. They are the letters "S" and "D." S stands for a statically chained sub-pattern, while D stands for a dynamically chained sub-pattern. Further, symbols enclosed within parenthesis indicate statically chained pattern elements and square brackets are used to indicate dynamic chaining. Entities within these delimeters are taken in a strictly left-to-right sequence in the chaining process. To keep the number of brackets used to a minimum, the following expressions are equivalent and the simplest expressions are used.

1. $(V(V)) = (V)(V) = (VV)$ static
2. $[V[V]] = [V][V] = [VV]$ dynamic (2.8)

2.3 Dot Grammar

The operations on unit vector described in section 2.1 together with chaining described in section 2.2 enable the description of any arbitrary collection of points or "dots" within the two-dimensional space chosen. This grammar is, therefore, referred to as the "dot grammar."

Dot Grammar

1. $P ::= [QP] \mid (QP) \mid [Q]P \mid (Q)P \mid QP \mid [Q] \mid (Q) \mid Q$
2. $Q ::= S \mid D$
3. $D ::= [V]D \mid [V]$
4. $S ::= (V)S \mid (V)$
5. $V ::= f_1(h)\boxdot \mid f_2(h)\boxplus \mid \Phi$ (2.9)

In the above expressions, $\left.\begin{array}{l} V_{\boxdot} = q\Theta \\ V_{\boxplus} = q\Theta \end{array}\right\} \begin{array}{l} 0 \le q \le q_{max} \\ 0 \le \Theta \le 2\Pi \end{array}$

Discussion

Productions 1 and 2 state that a dot pattern is derived from an arbitrary combination of statically and dynamically chained vectors. Production 3 indicates that a dynamically chained dot pattern is derived from an arbitrary number of vectors dynamically chained together. Please note that the vectors are enclosed in square brackets, implying dynamic chaining. Production 4 is a repeat of production 3, but for statically chained vectors, as indicated by round brackets. Production 5 shows the reduction of a vector to a point at its tip ($\boxdot$) with an associated color function $f_1(h)$ or at its tail ($\boxplus$) with its associated color function $f_2(h)$ or a null value Φ. The above grammar merely derives the form of the dot pattern. Parametrization of this form yields specific patterns.

2.4 Dot Grammar Examples

Example #1

Consider the following derivation of the dot grammar.

$$P \Rightarrow QP \Rightarrow DP \Rightarrow [V_a]P \Rightarrow [\boxdot_a]P \Rightarrow [\boxdot_a]Q$$
$$\Rightarrow [\boxdot_a]S \Rightarrow [\boxdot_a](V_1)S \Rightarrow [\boxdot_a](\boxdot_1)S \Rightarrow$$
$$\Rightarrow [\boxdot_a](\boxdot_1)(V_2)S \Rightarrow\Rightarrow [\boxdot_a](\boxdot_1\boxdot_2 \cdots \boxdot_8) \quad (2.10)$$

Derivation 2.10 represents all dot pattern forms that comprise eight points $(\boxdot_1\boxdot_2 \cdots \boxdot_8)$ about a point $[\boxdot_a]$ which is located away from the origin.

Case #1 Consider the following parametrization of the above derivation. Since V_0 is unit length, it is omitted.

Since $V_i = q_i\Theta_i$, with $q_i = q_{i+1} = d \quad i = 1,3,5,7$

and $\Theta_i = (i-1) \times \Pi/4;\ \Theta_1 = 0 \quad i = 1,2,..8$

and $V_a = q_a\Theta_a$, with $q_a = c$ and $\Theta_a = \Pi/4$ yields the dot pattern shown in Figure 2.2.

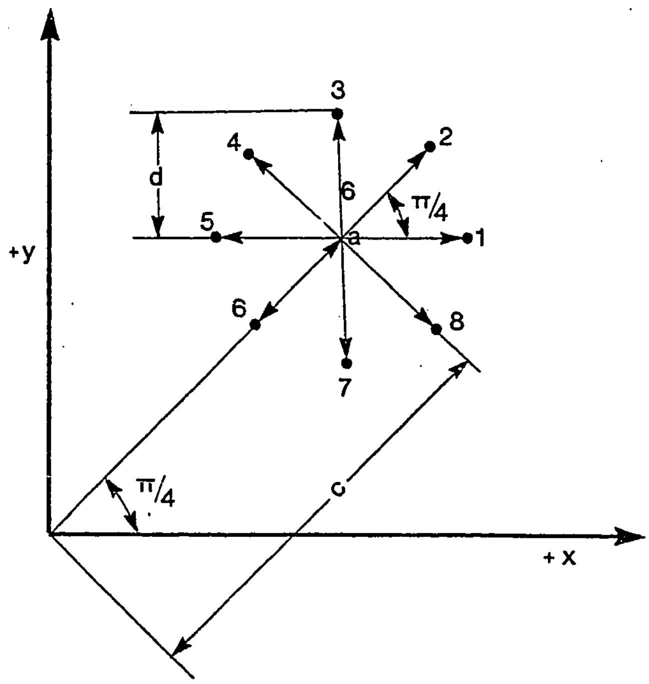


Figure 2.2 Dot pattern example #1, case #1

Case #2 Consider the following parametrization of the same derivation in (2.10).

$$q_i = d - (d/8)i; \qquad q_1 = d$$
$$\Theta_i = (i-1) \times \Pi/4; \qquad \Theta_1 = 0$$

and $q_a = c$ and $\Theta_a = \Pi/4$ yields the dot pattern shown in Figure 2.3.

Example #2

Consider the following derivation of the dot grammar.

$$P \Rightarrow QP \Rightarrow DP \Rightarrow [V_1]\ P \Rightarrow [\boxdot_1]\ QP \Rightarrow [\boxdot_1]\ DP$$
$$\Rightarrow [\boxdot_1]\ [V_2]DP \Rightarrow [\boxdot_1][\boxdot_2]DP \Rightarrow [\boxdot_1][\boxdot_2\ \boxdot_3\ \boxdot_4]P$$

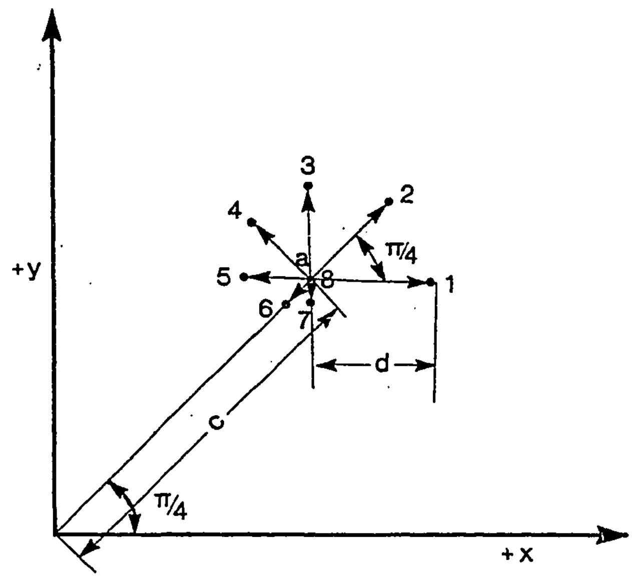


Figure 2.3 Dot pattern example #1, case #2

$$\Rightarrow [\boxdot_1][\boxdot_2\boxdot_3\boxdot_4] \text{ QP}\Rightarrow \Rightarrow [\boxdot_1][\boxdot_2\boxdot_3\boxdot_4][\boxdot_5][\boxdot_6\boxdot_7\boxdot_8] \tag{2.11}$$

The pattern form represented by the above derivation is a set of dynamically chained points, but grouped together as shown for convenience.

<u>Case #1</u> Consider the following parametrization of the derivation in (2.11)

Since $v_i = q_i\, \Theta_i$

a. $q_1 = d_1;\ \Theta_1 = \Pi/6$

b. $q_2 = q_3 = q_4 = q_6 = q_7 = q_8 = d$

$\Theta_2 = \Theta_3 = \Theta_4 = \Theta_6 = \Theta_7 = \Theta_8 = \Pi/4$

c. $q_5 = d_2;\ \theta_5 = 3\pi/4$

This yields two parallel sets of 4 dots each as shown in Figure 2.4.

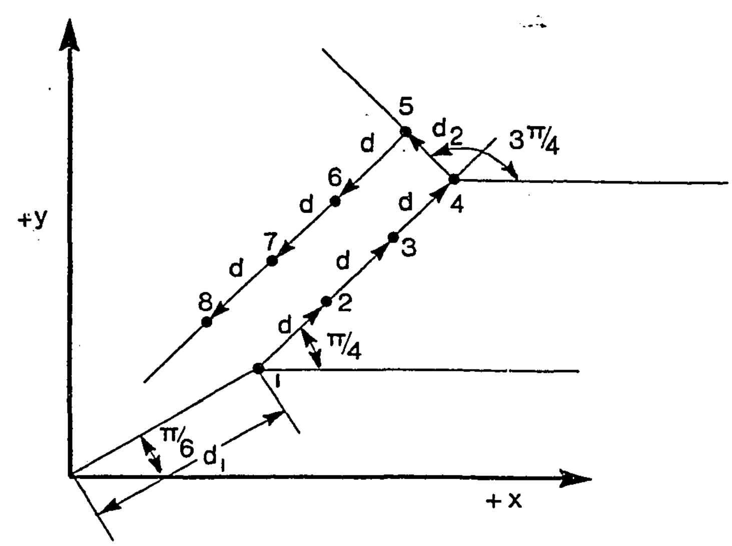


Figure 2.4 Dot pattern example #2, case #1.

Case #2 For the same derivation as in (2.11) consider the following parametrization.

a. $q_1 = d_1$; $\Theta_1 = \Pi/6$

b. $q_2 = q_3 = q_4 = d_2$

$\Theta_2 = \Pi/6$; $\Theta_3 = 5\Pi/6$; $\Theta_4 = 3\Pi/2$

c. $q_5 = d_3$; $\Theta_5 = \Pi/2$

d. $q_6 = q_7 = q_8 = d_4$

$\Theta_6 = \Pi/6$; $\Theta_7 = 5\Pi/6$; $\Theta_8 = 3\Pi/2$

This yields a dot pattern, with the dots located at the corners of two equilateral triangles as shown in Figure 2.5.

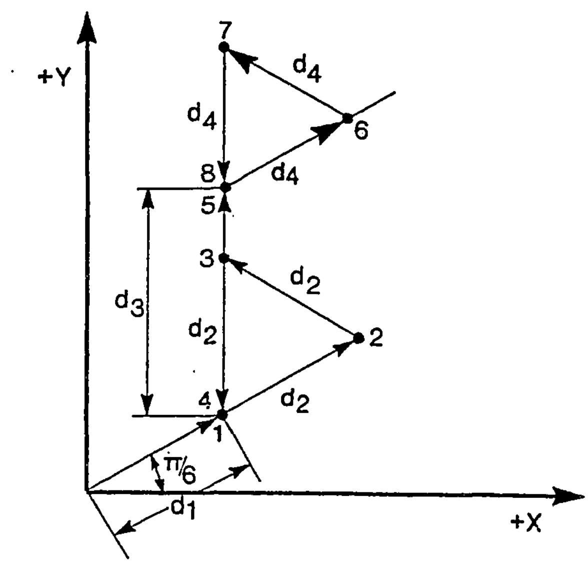


Figure 2.5 Dot pattern example #2, case #2.

2.5 <u>Classification of Line Patterns</u>

A line pattern may be thought of as being made up of "line-components." In this formalism, two types of line-components are defined.

1. Straight lines.

2. Curves.

Even though a straight line is a special case of a curve, it is given special consideration because of the importance it plays in two-dimensional line patterns. Further, straight line patterns may be described in terms of vectors themselves as the primitives.

A straight "line-component" is defined to be that part of a curve wherein the slope remains constant for all points within that line-component.

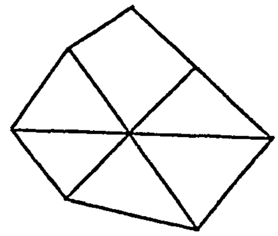
A curve "line-component" is defined to be that part of a curve wherein there is a continuous change of slope along the points that lie on that line-component. Figure 2.6 illustrates some line patterns composed of straight and curve line-components.

2.6 Straight Line Grammar

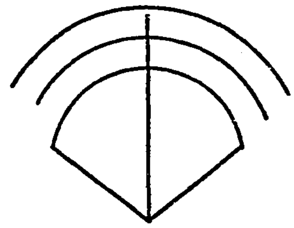
If the dot grammar presented in section 2.3 is stripped of those productions that replace the vectors by dots, then the grammar that results describes all arbitrary straight line pattern forms and is presented below for completeness. Discussion of each production is dispensed with, however.

Straight line grammar

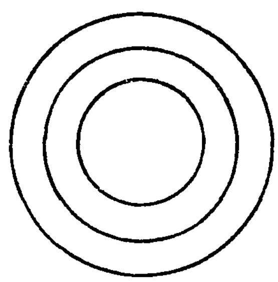
1. $P ::= [QP] \mid (QP) \mid [Q]P \mid (Q)P \mid QP \mid [Q] \mid (Q) \mid Q$
2. $Q ::= S \mid D$
3. $D ::= [V']D \mid [V']$
4. $S ::= (V')S \mid (V')$
5. $V' ::= f(h)\ V \mid \Phi$ (2.12)



STRAIGHT LINE
PATTERN



STRAIGHT LINE
&
CURVE
PATTERN



CURVE
PATTERN

Figure 2.6 Examples of straight line and curve patterns

2.7 Straight Line Grammar Examples

Example #1

Consider the following derivation of the straight line grammar.

$$P \Rightarrow QP \Rightarrow DP \Rightarrow [V_a]\ P \Rightarrow [V_a]\ QP \Rightarrow [V_a]\ SP \Rightarrow \Rightarrow$$

$$\Rightarrow [V_a]\ (V_1V_2V_3)\ P \Rightarrow [V_a]\ (V_1V_2V_3)\ Q \Rightarrow$$

$$\Rightarrow [V_a]\ (V_1V_2V_3)\,D \Rightarrow \Rightarrow [V_a]\,(V_1V_2V_3)\ [V_2'V_3'V_4'V_5'V_6'] \qquad (2.13)$$

The above derivation represents a line pattern form composed of a vector dynamically chained to the origin followed by three statically chained vectors and five dynamically chained vectors.

For one parametrization (not shown), the line pattern obtained may be as shown in Figure 2.7.

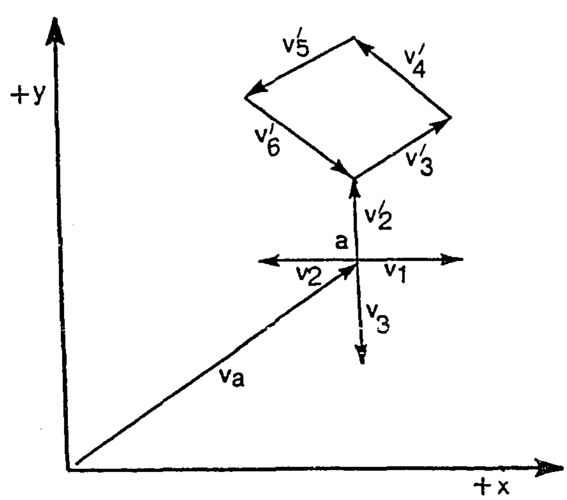


Figure 2.7 Straight line pattern, example #1.

Example #2

This example presents a more interesting line-pattern, which is encountered in several areas of study and application. Consider the following derivation of the straight line grammar.

$$P \Rightarrow Q \Rightarrow D_0 \Rightarrow [V_1]D_1 \Rightarrow [V_1V_2]D_2 \Rightarrow [V_1V_2V_3]D_3 \Rightarrow [V_1V_2V_3V_4] \qquad (2.14)$$

Please Note. Subscripts are associated with the distinguished symbol D to show sub-patterns. Choosing the following parameters we have -

$$q_1 = q_2 = q_3 = q_4 = 1 \text{ (unit length)}$$

and $\Theta_1 = 0$; $\Theta_2 = -\Pi/2$; $\Theta_3 = 0$; $\Theta_4 = +\Pi/2$,

The sub-patterns of the above derivation are as shown in Figure 2.8a.

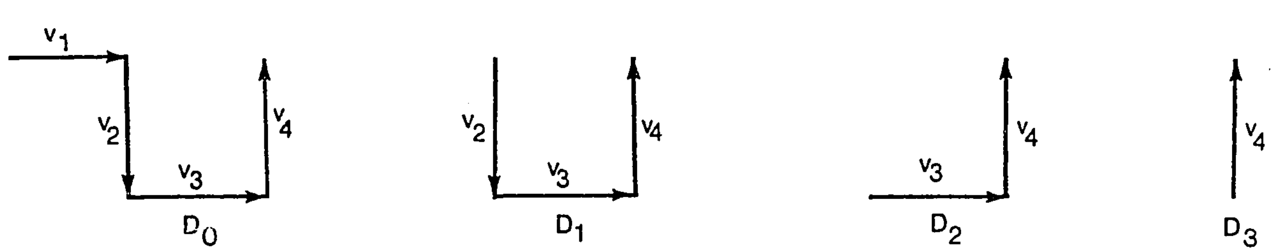


Figure 2.8a

By repeating the above process, square wave patterns of unit length are obtained as shown in Figure 2.8b.

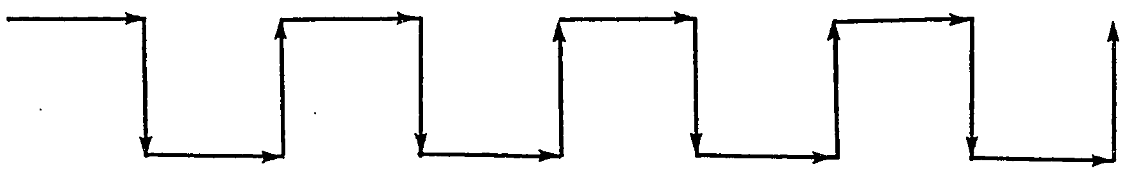


Figure 2.8b

By varying only the value chosen for q_1, the patterns shown in Figure 2.8c are obtained.

In general, the derivation given in this example, with Θ_i, $\Theta_{i+2} = 0$; $\Theta_{i+1} = -\Pi/2$; $\Theta_{i+3} = +\Pi/2$ and the appropriate choice of values for q all arbitrary square wave patterns are defined as shown in Figure 2.8d.

2.8 Second Set Of Operations On Unit Vector

Consider the following derivation of the straight line grammar.

$$P = Q = S = (V_1)S = (V_1V_2)$$

Since $V_i = q_i\Theta_iV_0$, the above derivation may be graphically

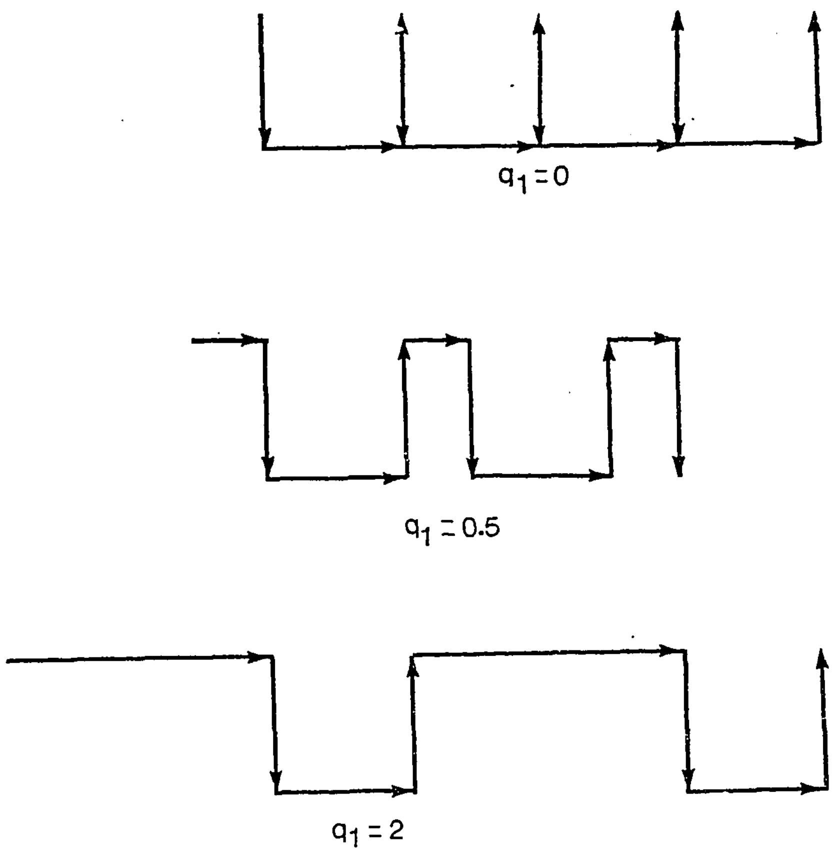


Figure 2.8c

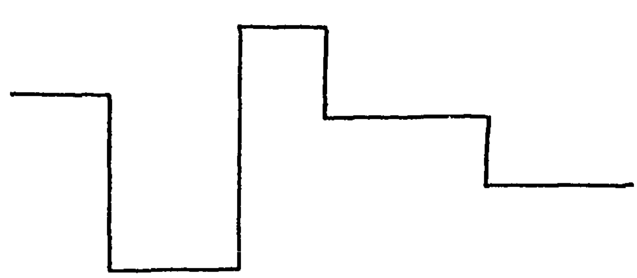


Figure 2.8d

represented as shown in Figure 2.9 with 1 and 2 labelling the end points of the two vectors. For small change in the values of q and Θ between vectors V_1 and V_2, they constitute what might be termed an "incremental vector pair."

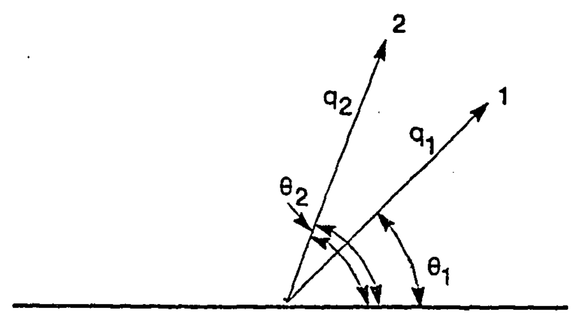


Figure 2.9 Incremental vector pair for curves

The letter "v" is used for incremental vector pairs. In instances where $\Theta_2 = \Theta_1 \pm \delta\Theta_1$ and $q_2 = q_1 \pm \delta q_1$, the two vectors may be replaced by the resultant vector. The above operation on the incremental vector pair is shown symbolically as follows.

$$\{\bar{v}_{(1,2)}\} :: = (v_1 v_2) \tag{2.15}$$

In the above notation, the left part comprises the two vectors v_1 and v_2 and is shown in parentheses implying static chaining. The right part is shown in chain brackets and means that it is a resultant vector. Its subscripts indicate that the resultant vector originates at point 1 and ends at point 2. Further, chaining with the resultant vector, if any, should occur with 2 as the starting point. The general form of the above operation may be symbolically represented as shown below.

$$\{v_{(i,i+2)}\} \; ::= \{v_{(i,i+1)}\} \; (v_{i+2}) \qquad (2.16)$$

The significance of this operation on the vectors must be obvious. It enables the syntactic description of curves in this formalism, as presented in the following section.

2.9 Classification of Curves

A curve may be thought of as being made up of "curve-components." A distinguished symbol, which is the letter "C," is introduced at this time and stands for a curve-component.

A curve-component is defined to be that portion of a curve between two "curve-points." If vectors are drawn from the origin to points on a curve, then for a curve component the following conditions hold.

1. The sign of the x and y component change of incremental vector pairs for all points on the curve-component is consistent.
2. The sign of the slope change along the curve-component is consistent.

A curve-point is reached when either of the above conditions is not met. This idea is best illustrated by a figure as shown in Figure 2.10.

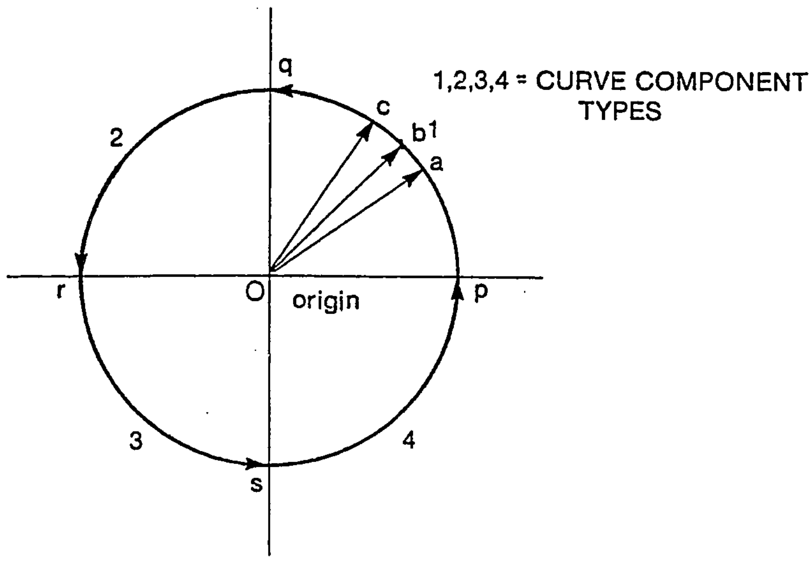


Figure 2.10 Illustration of curve-components

The origin is shown shifted to a point o within the pattern space. From this new origin, vectors oa, ob and oc are drawn to points a, b and c on the circumference of the circle. In order to find the curve points, the following steps are performed.

First, find the x and y components of these vectors. Then Δx between oa and ob is - and Δy between oa and ob is +. Likewise, Δx is - and Δy is + between ob and oc.

Next draw tangents to points a, b and c on the curve.

These give the slope along the curve. The sign of slope change is + between a and b (being counter-clockwise). The same is true between points b and c.

These two conditions hold good for all points between p and q on the curve. However, beyond p and q the above conditions don't hold. Therefore, pq constitutes a curve-component and p and q are curve-points. Similarly, qr, rs and sp are curve-components.

In light of the distinction already made between straight lines and curves, there are only 4 curve component types possible. These correspond to the types indicated in Figure 2.12 when a curve is traversed around its periphery in a counter-clockwise direction and their negative counterparts when traversed in a clockwise direction.

In this formalism, all curve patterns are described in terms of these four curve-component types. One should be careful not to misread this statement to mean that a curve is made up of an arbitrary combination of arcs of a circle, but go back to the definition of the curve components.

2.10 Curve Grammar

The following grammar, referred to as "curve grammar" describes all curve patterns as arbitrary combination of curve component types 1 - 4 as defined in section 2.9.

Curve Grammar

1. $P \; ::= [QP] \mid (QP) \mid [Q]P \mid (Q)P \mid QP \mid [Q] \mid (Q) \mid Q$

2. $Q \; ::= S \mid D$

3. $D \; ::= [C_i]D \mid [C_i] \qquad i = 1,2,3,4$

4. $S \; ::= (C_i)S \mid (C_i)$

5. $C_i \; ::= f(h) \; \{v_{(1,n)}\} \mid f(h) \; \{v_{(1,2)}\}$

6. $\{v_{(1,n)}\} \; ::= \{v_{(1,n-1)}\} \; (v_n)$

7. $\{v_{(1,2)}\} \; ::= (v_1 v_2)$ (2.17)

Discussion

Productions 1 and 2 state that a curve pattern is an arbitrary combination of statically and dynamically chained curve sub-patterns. Production 3 shows a dynamically chained curve pattern to be an arbitrary number of curve component types 1,2,3 and 4 dynamically chained together. Production 4 is the same as production 3, except that it applies to statically chained curve patterns. Production 5 states that a curve component is an elemental curve (the right alternative) or a series of elemental curves (the left alternative), each with an associated color function f(h). Production 6 shows the curve to be composed of a series of elemental curves. Production 7 shows an elemental curve to be the resultant of an incremental vector pair that are chained together statically. As before, this grammar derives the form of curve patterns. Specific patterns are derived through parametrization of the form obtained.

2.11 Curve Grammar Examples

Example #1

Consider the following derivation of the curve grammar given in section 2.10.

$$P \Rightarrow Q \Rightarrow D \Rightarrow [C_1]D \Rightarrow \Rightarrow [C_1C_2C_3C_4]$$

$$C_1 \Rightarrow \{v_{(1,n)}\}$$

$$\Rightarrow \{v_{(1,n-1)}\}\ (v_n)$$

$$\Rightarrow \{v_{(1,n-2)}\}\ (v_{n-1})\ (v_n)$$

$$\Rightarrow \Rightarrow \Rightarrow \qquad (v_1v_2v_3\ldots v_n)$$

Consider the following parameters.

Choose $q_1 = q_2 = \ldots = q_n = 1$ (unit length) and

$$\delta\Theta = +(\Pi/2)/n.$$

The pattern obtained is shown in Figure 2.11. (The derivation for curve components 2,3 and 4 are not shown.)

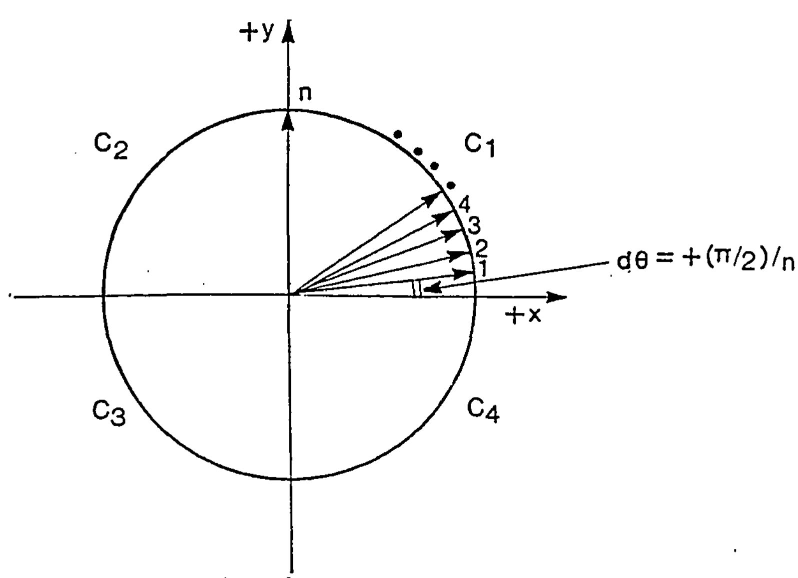


Figure 2.11 Curve grammar example #1

Example #2 Use the same derivation as before, but choose the following parameters

$$q_{i+1} = q_i - (d/2\Pi) \times \delta\Theta$$

The pattern obtained is a spiral as shown in Figure 2.12 in which the radius decreases by "d" units per revolution.

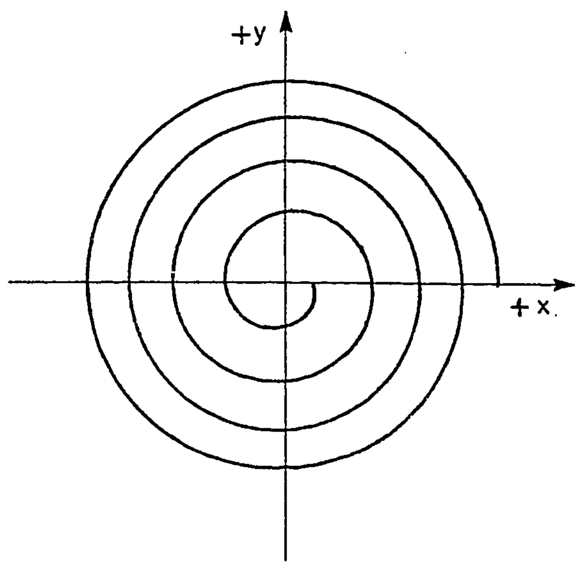


Figure 2.12 Curve grammar example #2

2.12 Third Set of Operations on Unit Vector

The ideas expressed in this section for areas are analogous to those already expressed for curves in section 2.8. Consider the following derivation of the straight line grammar.

$$P \Rightarrow Q \Rightarrow S \Rightarrow (V_1)S \Rightarrow (V_1V_2)$$

The graphical representation for the above derivation is as shown in Figure 2.13.

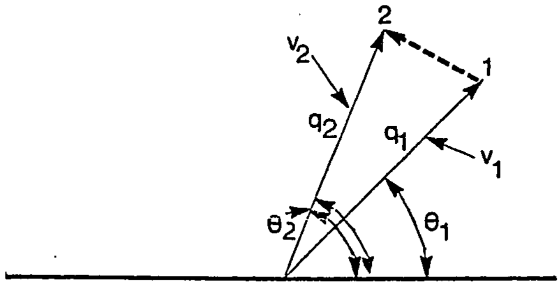


Figure 2.13 Incremental vector pair for areas

For small increments in the value of q and Θ, the vectors V_1 and V_2 are replaced by the incremental vector pair v_1 and v_2. They may be joined together by the resultant vector, $v_{(1,2)}$ thereby forming an elemental area. A new distinguished symbol, "Δ," is introduced at this point to represent this elemental area. The operation on the incremental vector pair described above may be symbolically expressed as follows.

$$\{\Delta_{(1,2)}\} ::= (v_1 v_2) \tag{2.18}$$

As with curve-components, where more than one incremental vector pair is involved, the above expression may be written in the general form as

$$\{\Delta_{(i,i+2)}\} ::= \{\Delta_{(i,i+1)}\} (v_{i+2}) \tag{2.19}$$

2.13 Area Grammar

In order to retain the consistency in the formalism developed, it is logical to think of an area as being made up of "area-components," similar to a curve being made up of curve-components.

An area-component of an area is one that is subtended by a portion of the area periphery at the origin. It seems a natural extension of the ideas expressed thus far to associate an area-component with the curve type that subtends the area at the origin, i.e., the total area is composed of individual area-components, which are identified by the curve points on the periphery of the area. There are, therefore, four area-components corresponding to the four curve-component types as defined earlier.

Additionally, it must be recognized that part of an area periphery may be a straight line. Even though only one straight line-component type was defined in the grammars presented so far, it is logical to define four types of straight lines, corresponding to the four curve-component types identified. Accordingly, vectors are defined as follows.

V_i $\quad$ $i = 1,2,3,4$

where $\quad$ $V_i = q_i\theta_i$

such that $0 \leq q_i \leq q_{max}$

and $\quad$ θ_i is defined as shown.

Value of i	Range of Θ
1	$\Pi/2 < \Theta \leq \Pi$
2	$\Pi < \Theta \leq 3\Pi/2$
3	$3\Pi/2 < \Theta \leq 0$
4	$0 < \Theta \leq \Pi/2$

(2.20)

The above definition adds four more types to the possible types of area-components making it a total of eight.

The letter "A" is used as the distinguished symbol to identify an area-component. The following "area grammar" describes all arbitrary area patterns in terms of the eight area-components.

Area-Grammar

1. $P ::= [QP] \mid (QP) \mid [Q]P \mid (Q)P \mid QP \mid [Q] \mid (Q) \mid Q$
2. $Q ::= S \mid D$
3. $D ::= [A_i]D \mid [A_i] \quad i = 1 - 8$
4. $S ::= (A_i)S \mid (A_i)$
5. $A ::= f(h)\{\Delta_{(1,n)}\} \mid f(h)\{\Delta_{(1,2)}\}$
6. $\{\Delta_{(1,n)}\} ::= \{\Delta_{(1,n-1)}\}(v_n)$
7. $\{\Delta_{(1,2)}\} ::= (v_1 v_2)$ (2.21)

Since this grammar is analogous to the curve grammar, discussion by each production is omitted.

2.14 Area Grammar Examples

Example #1

Consider the following derivation of the area grammar presented in section 2.13.

$$P \Rightarrow Q \Rightarrow D \Rightarrow [A_1]D$$

$$\Rightarrow [\{\Delta_{(1,n)}\}]D$$

$$\Rightarrow [\{\Delta_{(1,n-1)}\} (v_n)]D$$

$$\Rightarrow \Rightarrow \Rightarrow$$

$$\Rightarrow [(v_1 v_2 \ldots v_n) A_2 A_3 A_4]$$

Choosing $q_1 = q_2 = \ldots q_n = 1$ and $\delta\Theta = + (\Pi/2)/n$ for the parameters, the area (shaded quadrant) shown in Figure 2.14 is obtained for the derivation shown. Derivations for A_2, A_3 and A_4 are omitted, which constitute the unshaded portion of the circle.

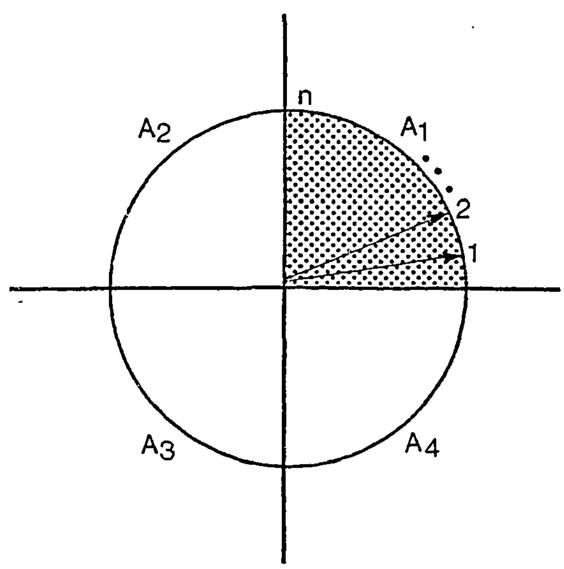


Figure 2.14 Area grammar example #1.

Example #2

Consider the following derivation.

$$P \Rightarrow \Rightarrow \ldots [A_1 A_1']$$
$$\Rightarrow \quad [\{\Delta_{(1,n)}\} A_1']$$
$$\Rightarrow \quad [(v_1 v_2 \ldots v_n) A_1']$$

As before, choosing $q_1 = q_2 = \ldots q_3 = 1$ and $\delta\Theta = +(\pi/2)/n$, for all the vectors generated thus far, the pattern obtained is the top right-hand quadrant in Figure 2.15. In generating the quadrant, the periphery of the area is traversed counter-clockwise and the area computed is positive. Now the rest of the derivation is shown.

$$\Rightarrow \quad [(v_1 v_2 \ldots v_n) A'] \text{ from before}$$

$$\Rightarrow \Rightarrow [v_1 v_2 \ldots v_n) (v'_1 \ldots v_n')]$$

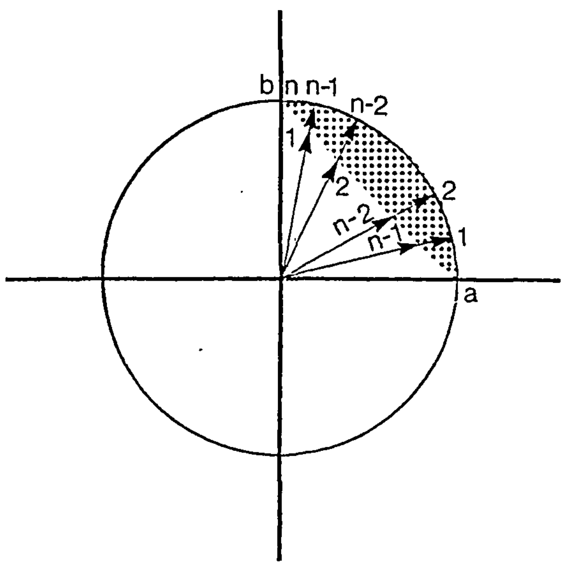


Fig. 2.15 Area grammar example #2

For the second set of vectors derived, for each $\delta\Theta$ choose q such that ba is a straight line. The area generated is the unshaded triangle in the upper right-hand quadrant. Since the periphery of this part of the area is traversed clockwise while generating it, this area is negative and gets subtracted from the area for the first part of the derivation, leaving the shaded segment shown in Figure 2.15.

2.15 Two-Dimensional Pattern Grammar

The grammar presented below describes any arbitrary two-dimensional pattern in terms of dot, curve, straight line and area-components as the primitives. It is given the acronym "D-L-A" grammar and stands for dots, lines and areas grammar.

The D-L-A grammar is a consolidation of the individual grammars presented in the preceding sections. There is a logical subdivision of this grammar into two parts. The first part, referred to as the "Macro" grammar, describes the pattern in terms of the primitives mentioned above. It is important to recognize, that the macro grammar and its parametrization would vary from one problem to another, but the framework would remain the same and cut across problem areas. The second part, referred to as the "Micro" grammar, is problem independent and shows how the primitives may be syntactically described for all problem areas.

D-L-A Grammar For Two-Dimensional Patterns

1. $P ::= [QP] \mid (QP) \mid [Q]P \mid (Q)P \mid QP \mid [Q] \mid (Q) \mid Q$
2. $Q ::= S \mid D$ macro
3. $D ::= [T]D \mid [T]$ grammar
4. $S ::= (T)S \mid (T)$
5. $T ::= W \mid f(h)\ c_i \mid f(h)\ A$ $\left\{ j=1\text{-}8 \right.$
6. $W ::= f(h)\ V_i \mid f(h)\boxdot \mid f(h)\boxplus \mid \Phi$ $\left\{ i=1\text{-}4 \right.$

The following defined for each V_i, C_i, and A_j.

7. $V ::= f(h)\{v_{(1,n)}\} \mid f(h)\{v_{(1,2)}\}$
8. $\{v_{(1,n)}\} ::= \{v_{(1,n-1)}\}(v_n)$
9. $\{v_{(1,2)}\} ::= (v_1 v_2)$
10. $C ::= f(h)\{v_{(1,n)}\} \mid f(h)\{v_{(1,2)}\}$
11. $\{v_{(1,n)}\} ::= \{v_{(1,n-1)}\}(v_n)$
12. $\{v_{(1,2)}\} ::= (v_1 v_2)$
13. $A ::= f(h)\{\Delta_{(1,n)}\} \mid f(h)\{\Delta_{(1,2)}\}$
14. $\{\Delta_{(1,n)}\} ::= \{\Delta_{(1,n-1)}\}(v_n)$ Micro
15. $\{\Delta_{(1,2)} ::= (v_1 v_2)$ Grammar

The following constraints apply to productions 5 and 6 and relate to straight line and curve-component primitives that use the subscript i.

Type	Θ Range	Vector Pair Δx Δy	Sign of slope change
V_1	$\pi/2 < \Theta \leq \pi$	$- \Delta x, + \Delta y$	0
V_2	$\pi < \Theta \leq 3\pi/2$	$- \Delta x, - \Delta y$	0
V_3	$3\pi/2 \leq \Theta < 0$	$+ \Delta x, - \Delta y$	0
V_4	$0 < \Theta \leq \pi/2$	$+ \Delta x, + \Delta y$	0
C_1		$- \Delta x, + \Delta y$	+
C_2		$- \Delta x, - \Delta y$	+
C_3		$+ \Delta x, - \Delta y$	+
C_4		$+ \Delta x, + \Delta y$	+

The area-component primitives shown in production 5 map into straight line-component and curve-component primitives as given below.

$$A_j = V_i \qquad j = 5,8;\ i = 1,4$$

$$A_j = C_i \qquad j = 1,4;\ i = 1,4 \tag{2.22}$$

Since this grammar is a consolidation of the individual grammars presented earlier, discussion by each production is omitted.

CHAPTER III

SYNTACTIC PATTERN RECOGNITION

3.0 Concept of A Two-Dimensional Pattern Recognizer

The proverb "a picture paints a thousand words" is familiar to most of us. In line with this maxim, the concept of the recognizer within this formalism is best presented in the form of a picture as seen in Figure 3.1. It is hoped that the levity of this characterization will not detract from the seriousness of this study.

The recognition scheme may be thought of as being composed of three distinct logical steps. In step 1, the scanner receives impulses of reflected light from the two-dimensional pattern to be recognized and converts them into signals that can be processed by the recognizer. Step 2 accepts the signals from the scanner and converts them into dot, straight line, curve and area-component primitives in terms of which the pattern is defined. This step is given the name "Micromaton," since it is an automaton that is driven by the micro grammar component of the D-L-A grammar. Step 3 uses these primitives for carrying out the recognition and is named "macromaton." This phase may be thought

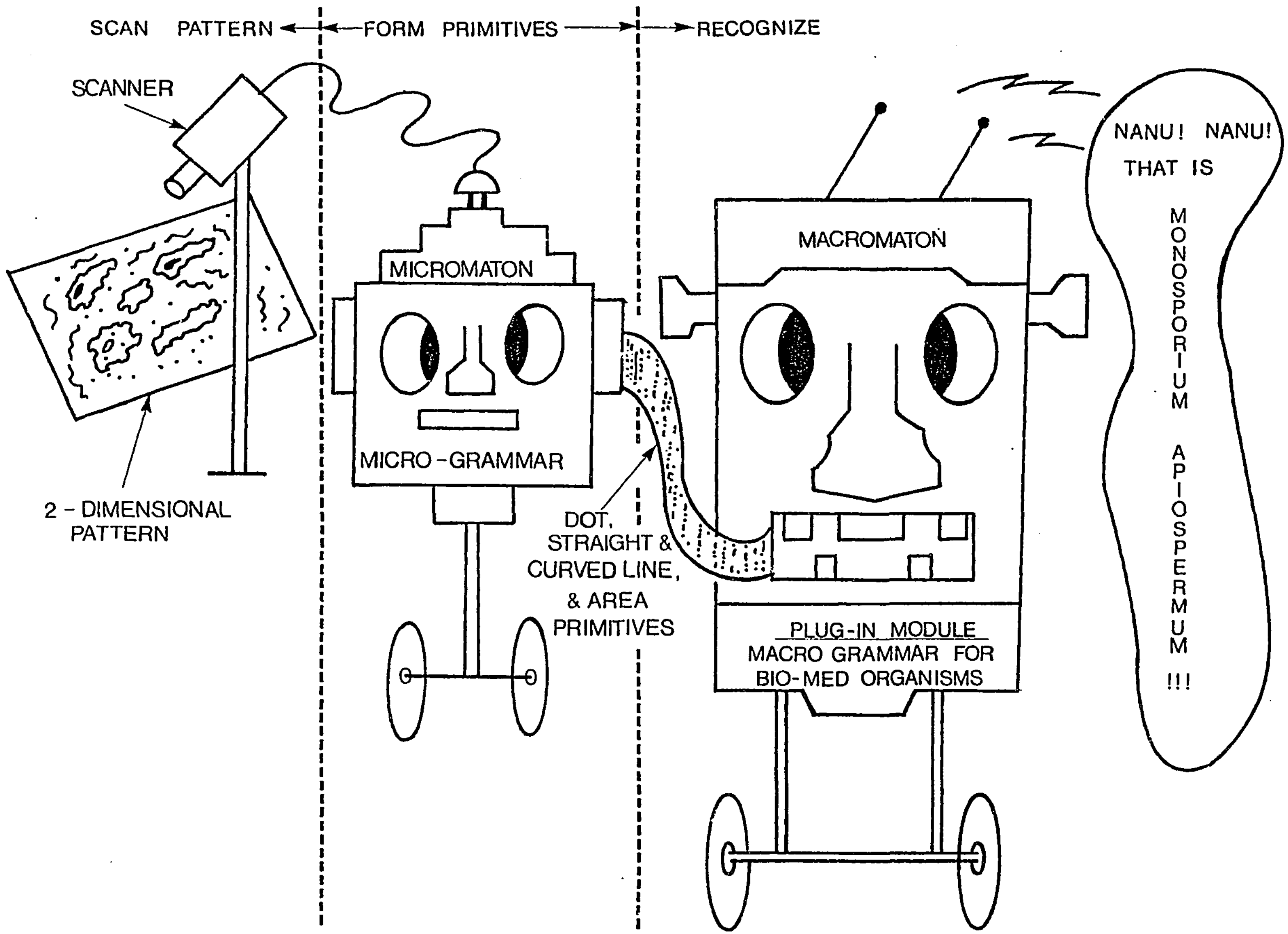


Fig. 3.1 The two-dimensional pattern recognition system

of as being driven by the macro grammar component of the D-L-A grammar.

3.1 Scanner Construction and Function

The method of scanning the pattern to provide input to the recognizer must be compatible with the formalism proposed. A conceptual diagram of the scanner is presented in Figure 3.2.

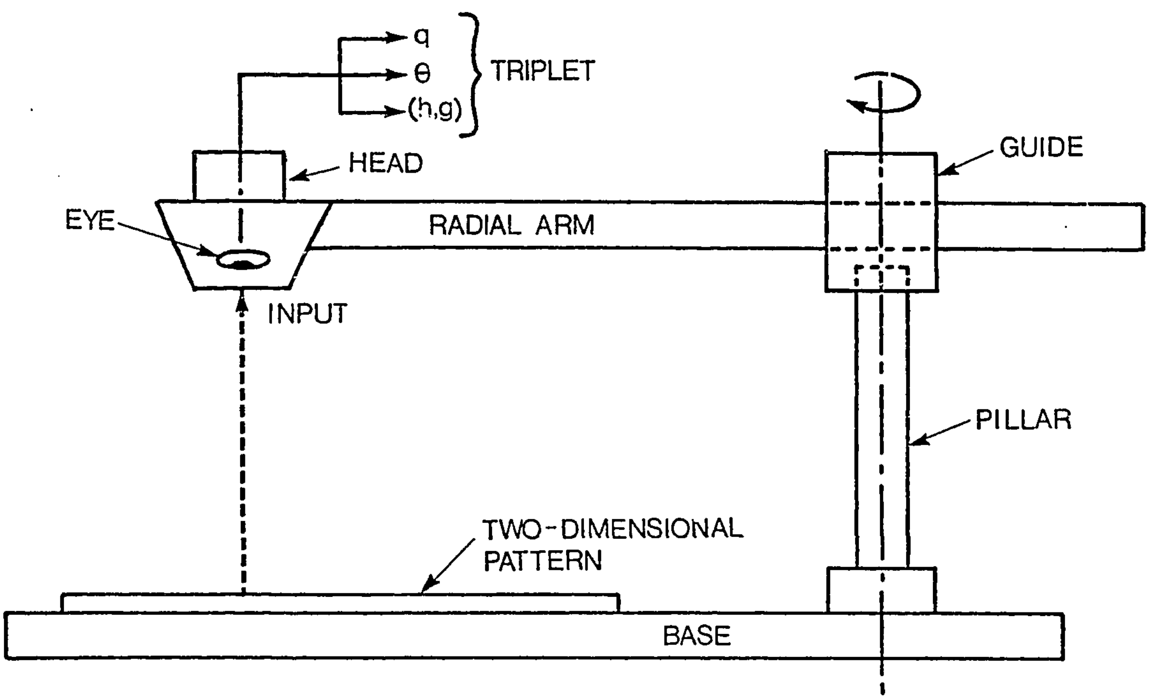


Fig. 3.2 Scanner assembly

The scanner consists of an eye that is capable of focussing its sight on a point in the pattern mounted below. The head, housing the eye, is attached to a radial arm that can move back and forth in a guide. The guide itself is mounted on a pillar in such a way that it can rotate about the center-line of the pillar.

From the arrangement just described, it is clear that with the radial motion of the head coupled with the rotation of the guide about the center-line of the pillar, the eye can effectively cover a circular area, whose center is the center-line of the pillar and whose radius is the maximum outward extension of the radial arm. The two-dimensional pattern to be recognized is mounted on the base of the scanner assembly as shown in Figure 3.3.

The input to the eye is a beam of light reflected off the pattern. At the issuance of a signal, the scanner samples the input to the eye, which consists of the color (h) and its associated intensity level (g). The sole purpose of the scanner is to sample this input from the pattern, make certain decisions and put out data, which in essence represent the pattern. This then forms the input to the recognizer.

In what follows, the arm-eye assembly is referred to as the "sweep-vector." The location of the eye along the arm measures the distance of points on the pattern from the

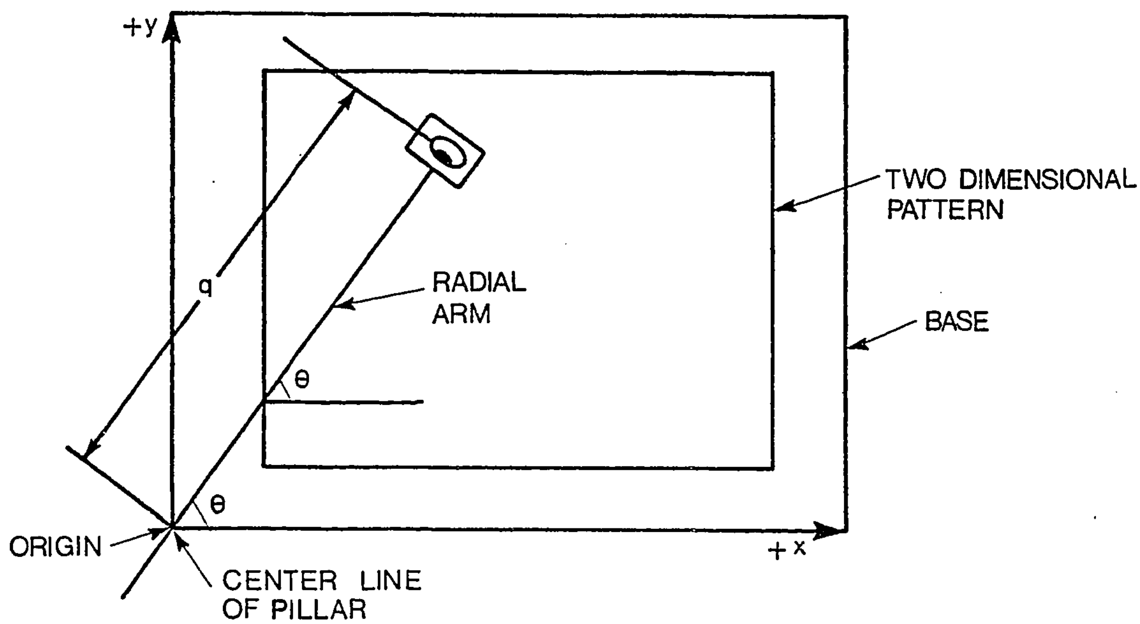


Fig. 3.3 Pattern location in scanner assembly

origin, while the position of the arm measures the angle of the line joining the point and the origin with the + x-axis. The arm-eye assembly therefore gives the vectors defining the points on the pattern as it sweeps across the pattern. Hence the name. Further, the movement of the eye radially outward for any given angular position of the arm is referred to as a "probe."

In practice, it is convenient to think of the scanner as a self-contained unit that performs its function with little or no external intervention. The only outside intervention is in the form of a set of parameters supplied to it that govern its actions and are as follows.

1. Incremental distance along the probe at which the pattern is to be sampled.
2. Angular increment of the arm from one probe to the next.
3. A set of color functions that differentiate between those aspects of the pattern that are of interest from those that are not. Also, for each color of interest, a set of colors and threshold intensities, which may be considered the same as the color of interest.

3.2 Scanner Structure

The structure of the scanner may be formally described by a deterministic finite transducer. It is defined by an 8-tuple-

$$T = (Q, \Sigma, F(c), S, F, I, \Delta, \delta)$$

Where

Q = Set of states $\{S, A, D, F\}$

where S = Start state

A = Active state

D = dormant state

F = Final state

Σ = Domain of the scanner

= Set of inputs $(q_i, \Theta, h_i g_i)$ $\quad i = 1,2...n$

where q_i = distance of point sampled from origin with $q_0 = 0$ and $q_n = q_{max}$ for any probe. $(q_{i+1} - q_i) = d$ the distance between samples along the probe.

Θ = angle of the arm with the +x-axis with $\Theta_{min} = 0$ and $\Theta_{max} = \pi/2$.

h_i = color of point sampled

g_i = intensity of h_i

$F(c) = \{f_i(c)\} \cup \{f_0(c)\}$

where $\{f_i(c)\}$ = set of color functions defined for the active state, where each $f_i(c)$ is defined as

$$= \{c_i, (c_{i_1}, t_{i_1}), (c_{i_2}, t_{i_2}), \ldots \ldots (c_{i_n}, t_{i_n})\}$$

In the above set, c_i denotes the color and (c_{i_j}, t_{i_j}) denote the colors and threshold intensity values assumed to represent the same value as c_i. Each $f_i(c)$ is distinct from the other. $\{f_0(c)\}$ is the complement of $\{f_i(c)\}$ and is defined for the dormant state for all colors of no interest. Its form is the same as shown for $\{f_i(c)\}$.

S, $F \varepsilon Q$ as described above

I = Set of internal configurations of three types identified by G H and J where

$G = ((q_i,\Phi),f_i(c),\ \Theta,\ (n_1 n_2),J)$

$H = ((q_i,q_j),f_i(c),\ \Theta,\ (n_1 n_2),J)$

$J = (\Phi,\Phi,\Phi,\Phi,J')$

Type G is defined for a point q_i and angle Θ with an associated color function $f_i(c)$ while type H is defined for a series of consecutive points starting at q_i and ending at q_j with a probe angle of Θ and color function $f_i(c)$. q_m = maximum length of probe to the pattern boundary. n_1 indicates the "transition from" color, while n_2 indicates the "transition to" color during the scanning process. This is used to indicate the overlap of primitives and is defined as shown. $n_1,n_2 \varepsilon \{0,1\}$ where

0 = transition from or to the background color which is not of interest.

1 = transition from or to a color of interest.

J assumes values from the positive index set and identifies the probe number.

Type J is a dummy type defined to indicate the end of scan to the Micromaton and only has the probe number J' in it.

Δ = Range of the scanner

= Set of outputs that is the same as one of the three internal types G, H or J defined above.

δ = Mapping from finite subsets of $Q \times \Sigma \times I^* \times F(c)$ to finite subsets of $Q \times I^* \times \Delta^*$ and specified as shown, for any Θ.

1. $\delta(S,(q_i,\Theta, h_ig_i),\Phi,f_0(c))$
   $= (D,\Phi,\Phi)$

2. $\delta(S,(q_i,\Theta,h_ig_i),\Phi,f_i(c))$
   $= (A,((q_i,\Phi),f_i(c),\Theta,(0,0),J),\Phi) \mid$
   $= (S,\Phi,((q_i,\Phi),f_i(c),\Theta,(0,0),J')q_i=q_{max}$

3. $\delta(D,(q_i,\Theta,h_ig_i),\Phi,f_0(c))$
   $= (D,\Phi,\Phi) \mid$
   $= (S,\Phi,(\Phi,\Phi,\Phi,\Phi,J')q_i = q_{max}$

4. $\delta(D,(q_i,\Theta,h_ig_i),\Phi,f_i(c))$
   $= (A,((q_i,\Phi),f_i(c),\Theta,(0,0),J),\Phi) \mid$
   $(S,\Phi,((q_i,\Phi),f_i(c),\Theta,(0,0),J'))q_i=q_{max}$

5. $\delta(A,(q_i,\Theta,h_jg_j),((q_i,\Phi),f_i(c),\Theta,(0,0),J),f_i(c))$
   $= (A,((q_i,q_j),f_i(c),\Theta,(0,0),J),\Phi) \mid$
   $(S,\Phi,((q_i,q_j),f_i(c),\Theta,(0,0),J'))q_j=q_{max}$

6. $\delta(A,(q_j,\Theta,h_jg_j),((q_i,\Phi),f_i(c),\Theta,(0,0),J),f_0(c))$
   $= (D,\Phi,((q_i,\Phi),f_i(c),\Theta,(0,0),J)) \mid$
   $(S,\Phi,((q_i,\Phi),f_i(c),\Theta,(0,0),J'))q_j=q_{max}$

7. $\delta(A,(q_j,\Theta,h_jg_j),((q_i,\Phi),f_i(c),\Theta,(0,0),J),f_k(c))$
   $= (A,((q_j,\Phi),f_k(c),\Theta,(1,0),J),$

$$((q_i,\Phi),f_i(c),\Theta,(0,1),J))\,|$$

$$(S,\Phi,((q_i,\Phi),f_i(c),\Theta,(1,0),J),$$

$$((q_j,\Phi),f_k(c),\Theta,(0,1),J'))q_j=q_{max}$$

8. $$\delta(A,(q_\ell,\Theta,h_\ell g_\ell),((q_i,q_j),f_i(c),\Theta,(0,0),J),f_i(c))$$

$$= (A,((q_i,q_\ell),f_i(c),\Theta,(0,0),J)\ \ |$$

$$(S,\Phi,((q_i,q_\ell),f_i(c),\Theta,(0,0),J'))q_\ell=q_{max}$$

9. $$\delta(A,(q_\ell,\Theta,h_\ell g_\ell),((q_i,q_j),f_i(c),\Theta,(0,0),J),f_0(c))$$

$$= (D,\Phi,((q_i,\ q_j),f_i(c),\Theta,(0,0),J)$$

$$(S,\Phi,((q_i,q_j),f_i(c),\Theta,(0,0),J')q_\ell=q_{max}$$

10. $$\delta(A,(q_\ell,\Theta,h_\ell g_\ell),((q_i,q_j),f_i(c),\Theta,(0,0),J),f_k(c))$$

$$= (A,((q_\ell,\Phi),f_\ell(c),\Theta,(1,0),J),$$

$$((q_i,q_j),f_i(c),\Theta,(0,1),J))\ \ |$$

$$(S,\Phi,\ \{((q_i,q_j),f_i(c),\Theta,(0,1),J'),$$

$$((q_\ell,\Phi),f_\ell(c),\Theta,(1,0),J')\})q_\ell=q_{max}$$

In all the above mappings, when $q = q_{max}$, replace S by F if $\Theta = \pi/2$; output type J, with J' = J" and stop. (3.1)

<u>Discussion of Mappings</u>. Note. Each mapping is explained below by its number. In the above mappings, J' indicates end of probe.

1. Move from start state to dormant state if the input color and intensity level are defined by a color function that is not of interest.
2. Move from start state to active state if input color and intensity are defined by a color function of interest. Store type G of internal configuration.

However, if this happened at the end of a probe, output type G and return to start state.

3. Stay in the dormant state as long as input color and intensity levels are defined by a color function that is not of interest. If end of probe is reached, revert to start state and output a null value.

4. Move from dormant state to active state if input color and intensity are defined by a color function of interest, store type G internal configuration. If this happens at the end of a probe, output type G and revert to start state.

5. Stay in the active state as long as the input color and intensity is defined by the same color function. However, go from internal configuration type G to type H. Output type H and return to start state if end of probe is reached.

6. Move from active state to dormant state if input color and intensity are defined by a color function not of interest; output type G. If end of prove is reached, output type G and return to start state.

7. Stay in the active state if input color and intensity level are defined by a color function different to the current one, with type G internal configuration for the new color. Indicate

color transition $n_2 = 1$ for current configuration and $n_1 = 1$ for the new color. Output type G and active state for the current color. However, if end of probe is reached, output type G and start state for the current color and new color with the same values for n_1 and n_2; return to start state.

8, 9 and 10 are repetitions of 5, 6 and 7, but type H is considered instead of type G.

3.3 Micromaton Structure

The function of the Micromaton is to map the set of vectors with their associated colors received from the scanner, to a set of dot, straight line, curve and area-component primitives. The domain of the Micromaton is the range of the scanner. The range of the Micromaton is the set of dot, straight line, curve and area component primitives that comprise the pattern. Figure 2.3 presents the logical components of the Micromaton.

The Micromaton is, therefore, in a formal sense a transducer. It is characterized as a series of automata which are driven by a common set of states. In some states, it acts as the controlling element performing its overall function; in others, it acts in the capacity of one of its logical components to accomplish specific functions. In its overall function, it has one set of input (the data from the scanner) and one set of output (the primitives formed, output to the Macromaton). In each of its component states, it has

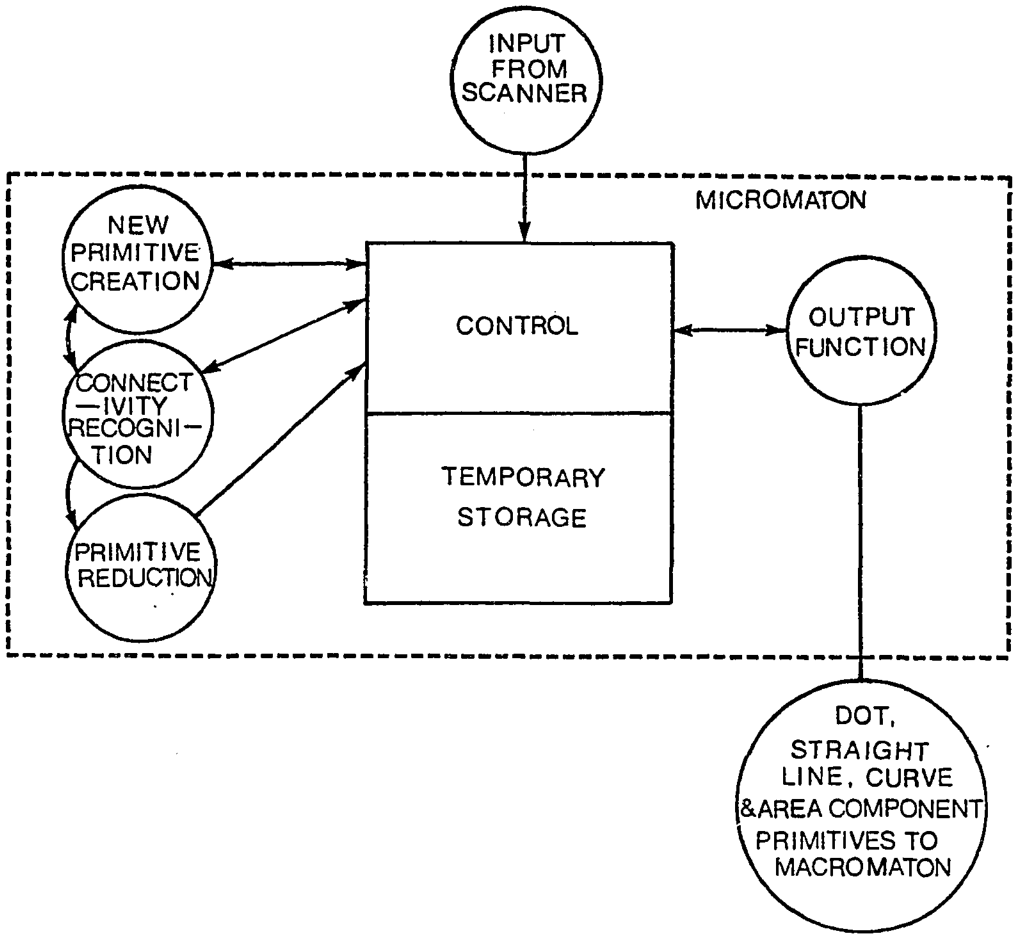


Fig. 3.4 Micromaton structure

a set of input and output which are internal to it.

This section presents the description of its overall function. A recap of the discussion on the Micromaton is presented in section 3.8 with a state transition diagram. In order to gain a general understanding of the Micromaton action, it might be advantageous to review section 3.8 before proceeding further.

The structure of the Micromaton is described by a deterministic finite transducer. It is a 10-tuple

$T = (Q,\Sigma,\lambda,D',N,O,\Delta,S,F,\delta)$ where

Q = Set of common states

$\{S_1, S_2, S'_2, S_3, S_4, W, E, Z\}$ defined as shown.

S_1 = New primitive creation state

S_2 = Connectivity recognition state

S'_2 = Connectivity recognition return state

S_3 = Reduction state

S_4 = Output state

W = Wait state

E = End State

Z = Terminate state

In the above, W,E and Z are the controlling states. The rest are component states.

Σ = Input received from the scanner

Type G,H or J as described in section 3.2

λ = Primitive set in Micromaton internal storage.

$(P,(\Omega,\Psi))$ in which

P = Set of primitives.

$= \{p_i\} = \{p_d\} \cup \{p_\ell\}$

p_d above represent the unlinked dot primitives and p_ℓ the linked straight line, curve and area-component primitives. Each p_i above is either p_O or p_N. P_O is a primitive which is overlapped with others while P_N are the non-overlapped primitives.

Ω = Set of pointers to all the primitives that are "active" and eligible for reduction.

= $\{r\}$ where each r points to one $p_i \varepsilon P$. All r are linked together in Ω.

Ψ = Set of pointers to all primitives that are "inactive" and not eligible for reduction.

= $\{d, \ell_i, c_i, a_j\}$ in which i=1-4; j=1,8 and defined as shown.

$d = \{r_d\}$ where each r_d points to a dot primitive $p \varepsilon P$. All r_d are linked together.

$\ell_i = \{r_{\ell_i}\}$ where each r_{ℓ_i} points to a straight line primitive $p \varepsilon P$ of type i. All r_{ℓ_i} are linked together.

$c_i = r_{c_i}$ where each r_{c_i} points to a curve component primitive $p \varepsilon P$ of type i. All r_{c_i} are linked together.

$a_j = r_{a_j}$ where each r_{a_j} points to an area component primitive $p \varepsilon P$ of type j. All r_{a_j} are linked together.

The following notations are introduced here and have the meaning shown.

Notation	Meaning
$\Omega <= r_{p_i}$	Add a pointer to the list of pointers to the active primitive set pointing to primitive $p_i \varepsilon P$.
$\Omega => r_{p_i}$	Remove a pointer from the list of pointers to the active primitive set pointing to primitive $p_i \varepsilon P$.
$\Psi <= r_{p_i}$	Add a pointer to the list of pointers to the inactive primitive set pointing to primitive $p_i \varepsilon P$. The list corresponds to the type of p_i.
$\Psi => r_{p_i}$	Remove a pointer from the list of pointers to the inactive primitive set pointing to primitive $p_i \varepsilon P$. The list corresponds to the type of p_i.
$P = P \cup \{p_{d_i} \rightleftarrows p_{\ell_4} \rightleftarrows p_{d_j}\}$ (Other notations similar to the one above are easily understood and not	Add 3 primitives p_{d_i}, p_{ℓ_4} and p_{i_i} to the primitive set P. p_{d_i} and p_{d_j} correspond to dot primitives for q_i and q_i of Σ and p_{ℓ_4} is a straight line

Notation	Meaning
explicitly shown here.)	primitive of type 4 corresponding to q_i, q_j... doubly link the primitives as shown by the arrows.

D' = Distance criterion.

= $\{\Phi, 0, 1\}$ and defined as shown.

$D = \Phi$ undefined (don't care)

$D = 0$ if $(q_j - q_i) > d$

$D = 1$ if $(q_j - q_i) \leq d$

$D = 1$ if $(q_i - \Phi)$

In the above, q_i, q_j are elements in G and H of Σ and d is the connectivity distance used in scanning the pattern.

N = New primitive creation index.

$\{\Phi, 1, 2, 3\}$ and defined as shown.

Φ = Undefined (don't care)

1 = Create new primitive corresponding to q_i of Σ.

2 = Create new primitive corresponding to q_j of Σ.

3 = Create new primitive corresponding to q_i and q_j of Σ.

4 = Create new primitive corresponding to q_i and q_j and a straight line primitive corresponding to q_i, q_j.

In the above q_i and q_j are elements in G and H of Σ.

O = Output internal to the Micromaton.

(λ, Σ, N, S') in which

λ, Σ and N are as defined. S' is the state to which return should be made upon completion of the state being entered. $S' \varepsilon$ Q or Φ, Φ being undefined.

Δ = The final output of the Micromaton.

$\lambda' = (P, (\Phi, \Psi))$ in which P and Ψ are as defined.

S = Start state of Micromaton.

= $W \varepsilon Q$ as defined

F = Final state of Micromaton.

= $Z \varepsilon Q$ as defined

δ = Mapping from finite subsets of $Q \times \Sigma^* \times D'^* \times \lambda^*$ to finite subsets of $Q \times O^* \times \Delta^*$ and is defined as shown.

1. $\delta(W, \Phi, \Phi, \Phi) = (W, \Phi, \Phi)$
2. $\delta(W, \Phi, \Phi, \Omega) = (W, \Phi, \Phi)$
3. $\delta(W, G, 1, \Phi) = (S_1, (\Phi, G, 1, W), \Phi)$
4. $\delta(W, H, 1, \Phi) = (S_1, (\Phi, H, 3, W), \Phi)$
5. $\delta(W, H, 0, \Phi) = (S_1, (\Phi, H, 4, W), \Phi)$
6. $\delta(W, J, 0, \Omega) = (S_4, (\lambda, \Phi, \Phi, W), \Phi)$
7. $\delta(W, G, \Phi, \Omega) = (S_2, (\lambda, G, \Phi, \Phi), \Phi)$
8. $\delta(W, H, \Phi, \Omega) = (S_2, (\lambda, H, \Phi, \Phi), \Phi)$
9. $\delta(W, J'', \Phi, \Omega) = (S_4, (\lambda, \Phi, \Phi, E), \Phi)$
10. $\delta(E, \Phi, \Phi, \Omega) = (Z, \Phi, \lambda')$ (3.2)

Discussion of mappings.

1. Continue in the wait state as long as there is no input from scanner and the active primitive set is empty.
2. Same as 1 except, the active primitive set is not empty.
3. For type G input with the active primitive set empty, move to new primitive create state; request new primitive creation for q_i and return to wait state.
4. Same as 3 except, request new primitive creation for q_i and q_j.
5. Same as 4 with the addition of request for creation of a straight line primitive if points q_i and q_j are farther apart than d.
6. When there is a type J input from the scanner, move to output state with a request to return to wait state. This is also done in cases of input types G and H where J is J' indicating the end of probe. This has not been explicitly shown.
7. With active primitive set not empty and an input of type G, move to connectivity check state. Pass primitive set and input type G.
8. Same as 7 except type H is involved.
9. When the scanner has reached its terminating

state, pass primitive set and enter output state, requesting return to end state.

10. In the end state, output primitive set representing the pattern and terminate.

3.4 New Primitive Creation Function

This component of the Micromaton creates new primitives when an input from the scanner is not connected to any of the currently active primitives in Micromaton's temporary storage.

This function is characterized by a deterministic finite automaton. It is a 6-tuple -

$T = (Q', I, O, S, F, \delta)$ where

Q' = Set of states

$Q' \subseteq Q$ defined in section 3.3.

I = Input to this component and internal to Micromaton.

= (λ, Σ, N, S'). This is the output O defined in section 3.3.

O = Output of this component; internal to Micromaton.

= λ as defined in section 3.3.

S = Start state of this component.

= $S_1 \varepsilon Q$ as defined in section 3.3.

F = Final states of this component.

= $\{W, S_2\} \subseteq Q$ as defined in section 3.3.

δ = Mapping from finite subsets of $Q \times I$ to finite subsets of $Q \times O$ and is defined as shown.

1. $\delta(S_1, (\Phi, G, 1, W))$

   $= (W, (P = \{p_{d_i}\}, \Omega = r_{p_{d_i}}))$

2. $\delta(S_1, (\Phi, H, 2, W))$

   $= (W, (P = \{p_{d_i} \rightleftarrows p_{d_j}\}, \Omega = r_{p_{d_i}} <= r_{p_{d_j}}))$

3. $\delta(S_1, (\Phi, H, 3, W))$

   $= (W, (P = \{p_{d_i} \rightleftarrows p_{\ell_4} \rightleftarrows p_{d_j}\}, \Omega = r_{p_{d_i}} <= r_{p_{d_j}}, \Psi <= r_{p_{\ell_4}}))$

4. $\delta(S_1, (\lambda, G, 1, S_2))$

   $= (S_2, (P = P \cup \{p_{d_i}\}, \Omega <= r_{p_{d_i}}))$

5. $\delta(S_1, (\lambda, H, 2, S_2))$

   $= (S_2, (P = P \cup \{p_{d_i} \rightleftarrows p_{d_j}\}, \Omega <= r_{p_{d_i}} <= r_{p_{d_j}}))$

6. $\delta(S_1, (\lambda, H, 3, S_2))$

   $= (S_2, (P = P \cup \{p_{d_i} \rightleftarrows p_{\ell 4} \rightleftarrows p_{d_j}\}, \Omega <= r_{p_{d_i}} <= r_{p_{d_j}}, \Psi <= r_{p_{\ell_4}}))$

<u>Discussion of Mappings</u> (3.3)

1. Create a new dot primitive corresponding to q_i of G. Make this dot primitive the primitive set. Create a pointer to this primitive and make this the new active primitive pointer list.

2. Same as 1 except, two dot primitives are created corresponding to q_i and q_j of H. The two dot primitives are linked together pointing to each other to show connectivity. Pointers corresponding to these two primitives are added to the active primitive pointer list as in 1.
3. Here a straight line primitive is involved in addition to the two dot primitives. The two dot primitives are linked to the straight line primitive. The primitive set and pointers to the active primitive set are created as described for mapping 2. The straight line primitive type 4 is added to the appropriate list of pointers in the inactive primitive set. In all three mappings above, return is made to the wait state after this state.

4, 5 and 6 are a restatement of 1, 2 and 3, except that the primitive set is not empty and request is made for return to the connectivity check state.

3.5 Connectivity Recognition Function

Under this scheme, the concept of connectivity needs special mention. In an x-y raster scanning scheme, connectivity is established by virtue of adjacency in a two-dimensional matrix, provided the squares of the matrix are color compatible. This is illustrated in Figure 3.5.

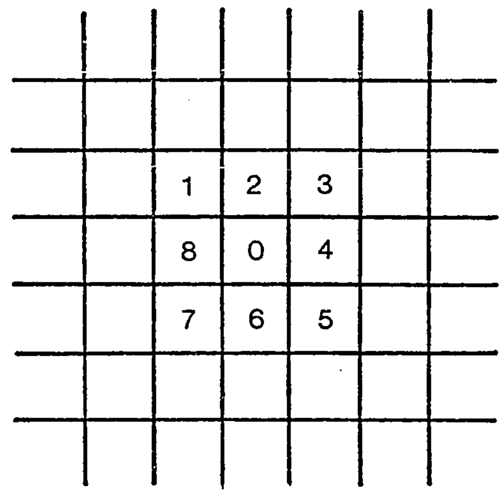


Fig. 3.5 Connectivity of points in raster scanning

In Figure 3.5, those squares numbered 1 through 8 are connected to square 0 if they are color compatible. In the present formalism, the idea of connectivity is different in view of the method by which the pattern is scanned. Here, the notion of connectivity is in the form of a circle that surrounds the point in question as shown in Figure 3.6. The connectivity distance "d" may be arbitrarily chosen and it determines how finely or coarsely a pattern is scanned. The end points of the vectors are said to be connected if the length of the resultant vector is $\leq d$ and the points are color compatible, otherwise not.

The connectivity recognizer is a deterministic finite automaton and is an 11-tuple -

$$T = (Q', I, D', K, C, \gamma, O_S, O, S, F, \delta) \text{ where}$$

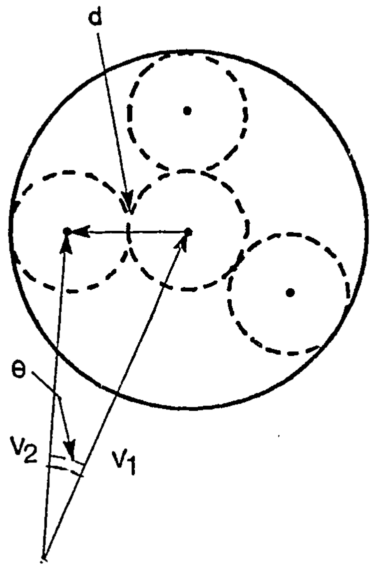


Fig. 3.6 Connectivity of points in radial scanning

Q' = Set of states

$Q' \subseteq Q$ defined in section 3.3.

I = Input to this component and internal to Micromaton.

= (λ,Σ,N,S). This is the output O defined in section 3.3.

D' = Distance criterion

= $\{\phi,0,1\}$ as defined in section 3.3

K = Connectivity check outcome

= (k_1,k_2), $k_1,k_2 \varepsilon \{0,1\}$ and defined as shown.

k_1 = Outcome of connectivity check between q_i of Σ and the last vector defining the primitive p in the active primitive set.

k_2 = Same as k_1 and applies to q_j of Σ.

C = Count of the number of primitives that satisfied the connectivity criterion.

= (c_1, c_2) where

c_1 = Number of primitives p in the active primitive set for which connectivity criterion was satisfied for q_i of Σ.

c_2 = Same as c_1 above but applies to q_j.

At start $c_1 = c_2 = 0$.

γ = Next selection function for the next primitive to be checked in the active primitive set for connectivity and defined as shown.

$\gamma(\Omega)$ = The primitive p pointed to by r_{i+1}; the current value in Ω being r_i.

$\gamma(\Omega)$ = Φ when there are no more pointers in the list representing the active primitive set:

O_S = Output status

= $\{0,1,2\}$ and defined as shown.

0 = Hold output

1 = Output O_1

2 = Output O_2

O = Output internal to the Micromaton defined in two forms corresponding to two states that are entered from the connectivity check state.

$O_1 = (\lambda, \Sigma, N, S')$. This is the same as O in section 3.3 passed to the new primitive creation state.

$O_2 = (P_R, \Sigma, S')$ where

P_R = Set of primitives that need to undergo reduction with the input Σ from the scanner.

= $\{(p_i K_i)\}$ in which p_i is an active primitive and K_i is the connectivity established for p_i with type G or type H input from scanner.

Σ = Input from scanner.

S' = State to which return is to be made after completion of the state being entered.

S = Start State

= $S_2 \varepsilon Q$ as defined in section 3.3

F = Final state

= $\{S_3, W\} \subseteq Q$ as defined in section 3.3

δ = Mapping from finite subsets of $Q \times I^* \times K^* \times C^* \times D'^*$ to finite subsets of $Q \times I^* \times C \times O_S \times O_1 \times O_2$ and specified as shown.

1. $\delta(S_2, (p,G), (0,\Phi), (0,0), \Phi)$
$= (S_2, \gamma(\Omega), (0,0), 0, \Phi, \Phi)$

2. $\delta(S_2, (p,H), (0,0), (0,0), \Phi)$
$= (S_2, \gamma(\Omega), (0,0), 0, \Phi, \Phi)$

3. $\delta(S_2, (p,G), (1,\Phi), (c_1,c_2), \Phi)$

$= (S_2, \gamma(\Omega), (c_1 = c_1 + 1, c_2), 0, \Phi, (P_R = P_R \cup (p,K), G, W))$

4. $\delta(S_2, (p,H), (1,0), (c_1,c_2), \Phi)$

$= (S_2, \gamma(\Omega), (c_1 = c_1 + 1, c_2), 0, \Phi, (P_R = P_R \cup (p,K), H, W))$

5. $\delta(S_2, (p,H), (0,1), (c_1,c_2), \Phi)$

$= (S_2, \gamma(\Omega), (c_1, c_2 = c_2 + 1), 0, \Phi, (P_R = P_R \cup (p,K), H, W))$

6. $\delta(S_2, (p,H), (1,1), (c_1,c_2), \Phi)$

$= (S_2, \gamma(\Omega), (c_1 = c_1 + 1, c_2 = c_2 + 1), 0, \Phi, (P_R = P_R \cup (p,K) H, W))$

7. $\delta(S_2, (\Phi,G), \Phi, (0,0), \Phi)$

$= (S_1, \Phi, \Phi, 1, (\lambda, G, 1, W), \Phi)$

8. $\delta(S_2, (\Phi,H), \Phi, (0,0), 1)$

$= S_1, \Phi, \Phi, 1, (\Omega, H, 3, W), \Phi)$

9. $\delta(S_2, (\Phi,H), \Phi, (0,0), 0)$

$= (S_1, \Phi, \Phi, 1, (\Omega, H, \;, W), \Phi)$

10. $\delta(S_2, (\Phi,H), \Phi, (c_1,0), \Phi)$

$= (S_1, \Phi, \Phi, 1, (\Omega, H, 2, S_2'), O_2)$

11. $\delta(S_2, (\Phi,H), \Phi, (0,c_2), \Phi)$

$= (S_1, \Phi, \Phi, 1, (\Omega, H, 1, S_2'), O_2)$

12. $\delta(S_2', (\Phi,\Phi), \Phi, \Phi, \Phi)$

$$= (S_3, \Phi, \Phi, 2, \Phi, O_2) \qquad (3.4)$$

Discussion of mappings.

1. With type G input, if connectivity is not established with the current primitive, select the next active primitive.

2. Same as 1, but type H is shown.

3. If connectivity is established for type G input with an active primitive, add to it the set of primitives to be reduced. Add 1 to the number of primitives satisfying connectivity check for q_i. (No output is made at this point.)

4., 5 and 6 are a repeat of 3 but for type H input and different combinations of connectivity for q_i and q_j.

7. If all active primitives have been checked for connectivity and none of them are connected to type G input, then request primitive creation for q_i and return to wait state.

8 and 9 are a restatement of 7, but for type H input and different values of distance criteria.

10 and 11. Here, either q_i or q_j is connected to one or more primitives in the active set for input type H, but not both. Therefore, create a new primitive for q_i or q_j for which connectivity is not established and return made to the connectivity recognition state in preparation for entering the reduction state.

12. Pass the set of primitives for which connectivity is established, to the reduction state, requesting return to the wait state.

3.6 Micromaton Reduction Function

A few preliminary comments are in order before describing the reduction function of the Micromaton. The recognition of curve-components needs special mention. The reduction function needs to know when to stop reduction of the input from the scanner with one curve component type and start reduction with another type. Consider the circle in Figure 3.7 with the origin located within the circle.

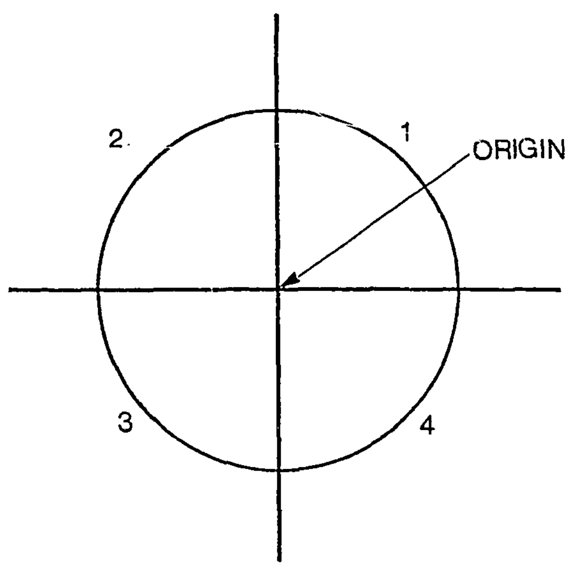


Fig. 3.7 Origin within the closed curve

As the sweep-vector rotates in a counter-clockwise direction, if the change in its x and y components where it intersects the curve-component type 1 are computed, the relations $\Delta x < 0$ and $\Delta y > 0$ hold. Similarly, for curve-component type 2 $\Delta x < 0$ and $\Delta y < 0$; for curve-component type 3 $\Delta x > 0$ and $\Delta y < 0$ and for curve-component type 4 $\Delta x > 0$ and $\Delta y > 0$. In all these cases, the periphery of the circle is traversed in a counter-clockwise direction by the sweep-vector, where it makes contact with it.

The above relations don't hold if the origin is shifted away from within the circle as shown in Figure 3.8.

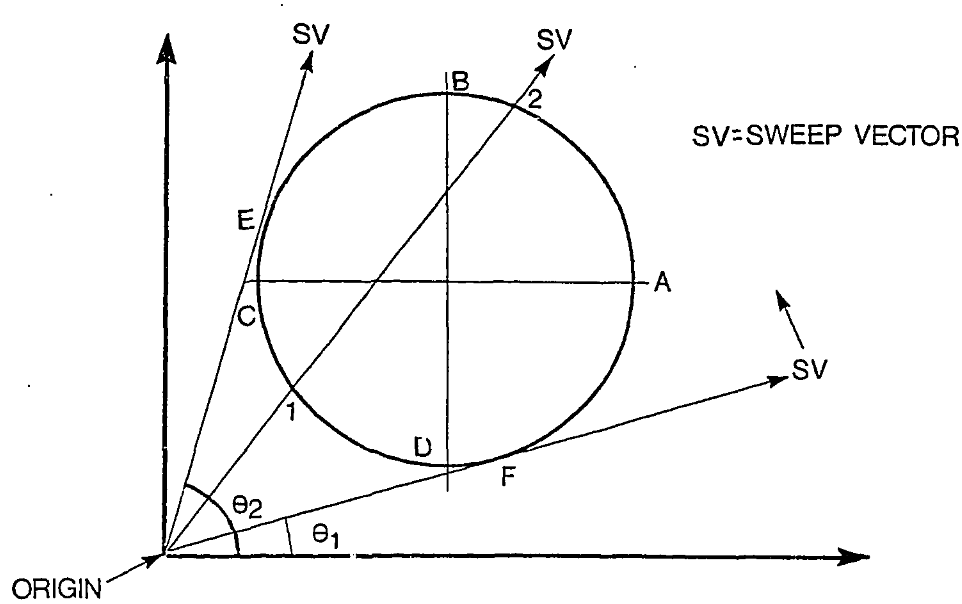


Fig. 3.8 Origin outside the closed curve

As the sweep-vector rotates counter-clockwise, it makes contact with the circle at point F and leaves contact at point E. The arc FABE is intersected by the sweep-vector in a counter-clockwise direction, while, the arc FDCE is intersected in a clockwise direction along the periphery of the circle. This results in curve-components C_4(FA), C_1(AB), C_2(BE) for arc FABE and $- C_4$(FD), $- C_3$(DC) and $- C_2$(CE) for arc FDCE.

If the Δx and Δy for the various curve-components are computed, the results summarized in Table 3.1 is obtained.

Table 3.1

Table of curve-component types with origin outside closed curve.

No.	Arc	Curve-component	Δx	Δy	Sense of Rotation
1	FA	C_4	+	+	+
2	AB	C_1	-	+	+
3	BE	C_2	-	-	+
4	FD	$-C_4$	-	-	-
5	DC	$-C_3$	-	+	-
6	CE	$-C_2$	+	+	-

From an examination of the above table it is clear that, for correctly identifying the curve-component types, the direction in which the sweep-vector intersects the periphery of the curve needs to be considered in addition to the sign of the change in the values of the x and y components at the points of intersection. Table 3.1 may be restated to aid the reduction function in correctly identifying the curve-component types. This is shown in Table 3.2. Because of the manner in which area-components are defined in relation to straight line and curve-components, the above discussion holds for them as well.

The reduction process makes use of two types of signals from the scanner. They are -

Table 3.2

Table of relations for deducing curve-component types

No.	Δx	Δy	Sense of Rotation	Curve-Component Type
1	-	+	+	C_1
2	-	+	-	C_3
3	+	+	+	C_4
4	+	+	-	C_2
5	-	-	-	C_4
6	-	-	+	C_2

1. Type G given by $((q_i,\Phi),\ f_i(c),\Theta,(n_1,n_2),J)$ and
2. Type H given by $((q_i,q_j),f_i(c),\Theta,(n_1,n_2),J)$ (3.5)

Type G may be rewritten as $((q_i,\Theta_j),f(c),(n_1,n_2),J)$ which in turn may be rewritten as $(v_i,f(c),(n_1,n_2),J)$ since there is only one q_i to be dealt with. Type H may similarly be written as $((v_i,v_j),f(c),(n_1,n_2),J)$.

In general, type G input defines dots and lines, whereas, type H defines areas. (One exception is the case where type H defines a straight line that coincides with the sweep-vector.) A sequence of type G and type H inputs defining portions of a curve and an area are illustrated in Figure 3.9.

The reduction process makes use of incremental vector pairs defined earlier. It computes the Δx and Δy between the vector pairs as well as the sign of the angle change between

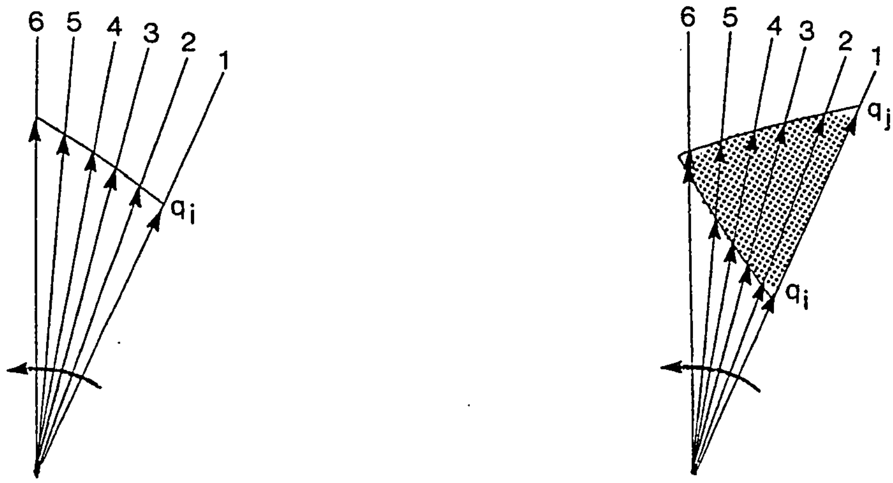


Fig. 3.9 Input types defining portions of curve and area

consecutive resultant vectors. It compares the computed values from the previous step with those of the present step in its reduction decision. Additionally, it computes the cumulative value of the resultant vector length as well as the area subtended by the area-component at the origin. Even though length and area do not play any role in the reduction process, they are passed as data that characterize the primitive, to the Macromaton.

Let $v_1, v_2, \ldots, v_n$ be the consecutive vectors making up the incremental vector pairs that need to be reduced by the reduction process. The following sets are defined.

1. Set of incremental vector pairs

   $= \{(v_i, v_{i+1})\} = \{(\Phi, v_1), (v_1, v_2), \ldots, (v_n, v_{n+1} = \Phi)\}$

2. Set of changes in x and y components of

incremental vector pairs

$= (\Delta xy_i) = \{\Delta xy_1 = \Phi, \Delta xy_2, \Delta xy_3, \ldots, \Delta xy_{n+1} = \Phi\}$

3. Set of resultant vectors

$= \{R_i\} = \{R_1 = \Phi,\ R_2,\ R_3, \ldots, R_{n+1} = \Phi\}$

4. Set of angles of resultant vectors with +x-axis

$= \{S_i\} = \{S_1 = \Phi,\ S_2, S_3, \ldots, S_{n+1} = \Phi\}$

5. Set of sign change between consecutive resultant vectors

$= \{\Delta S_i\} = \{\Delta S_1 = \Phi,\ \Delta S_2 = \Phi,\ \Delta S, \ldots, \Delta S_{n+1} = \Phi\}$ (3.6)

Δxy_i defined in 2 above actually contains a pair, i.e., Δx and Δy. Each may assume any value from the set $\{<0, =0, >0\}$. In particular, the following combinations of Δx and Δy are defined as follows.

$\alpha = -\Delta x,\ +\Delta y$ (i.e. $\Delta x < 0$ and $\Delta y > 0$)

$\beta = -\Delta x,\ -\Delta y$

$\gamma = +\Delta x,\ +\Delta y$ (3.7)

The reduction process itself may be described by a deterministic finite automaton. To keep the discussion simple, only the mappings are described. The mappings use the symbols and their associated meanings as shown below.

P = Primitive type set

$= \{D, L_i, C_i, A_j\}$

where D = Dot primitive

L_i = straight line $i = 1,4$

C_i = curve-component $i = 1,4$

A_j = area-component $j = 1,8$

VP = Set of incremental vector pairs- Item 1 (3.6)

Δxy = Set of x-y component changes - Item 2 (3.6)

R = Set of resultant vectors - Item 3 (3.6)

S = Set of resultant vector angles - Item 4 (3.6)

ΔS = Set of resultant vector slope changes

Item 5 (3.6)

I = Type G or H input from Scanner See (3.5)

O = Set of intermediate results describing the primitive reduced up to this step.

The intermediate primitive is described by the following elements.

1. (v_1, v_i) where v_1 defines the starting point of primitive and v_i its current ending point
2. f(c) the color function of this primitive
3. L' showing the link of this primitive with the one that precedes or follows it.
4. R' showing the cumulative length of the resultant vectors defining this primitive.
5. A' showing the cumulative area subtended by this primitive at the origin.
6. t the tag number identifying the probe number for which the primitive underwent reduction.
7. # the reduction id. that signifies whether the primitive is to be reduced with q_i or

q_j of scanner input Σ.

Please Note. In order to keep the mappings from getting cumbersome, only element number 1 of the intermediate result above is shown in the mappings that follow.

δ = Mapping from finite subsets of

$P \times O \times VP \times VP \times \Delta xy \times \Delta xy \times \Delta S \times \Delta S \times I$

into finite subsets of

$P \times O \times VP \times \Delta xy \times \Delta S \times O^*$

and is defined as follows.

1. $\delta(D, (v_1, \Phi), (\Phi v_1)(v_1 v_2), \Phi, \Delta xy_2, \Phi, \Phi, G)$
   $= (D, (v_1 v_2), (v_1 v_2), \Delta xy_2, \Phi, \Phi)$
2. $\delta(D, (v_1 v_2), (v_1 v_2)(v_2 v_3), \Delta xy_2, \Delta xy_3, \Phi, \Delta S_3, G)$
   $= (L, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3$ and $\Delta S_3 = 0$
3. $= (C_1, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \alpha$ and $\Delta S_3 = +$
4. $= (C_2, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \beta$ and $\Delta S = +$
5. $= (C_4, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \beta$ and $\Delta S_3 = -$
6. $= (C_3, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \alpha$ and $\Delta S_3 = -$
7. $= (C_4, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \gamma$ and $\Delta S_3 = +$
8. $= (C_2, (v_1 v_3), (v_2 v_3), \Delta xy_3, \Delta S_3, \Phi)$
   if $\Delta xy_2 = \Delta xy_3 = \gamma$ and $\Delta S_3 = -$

9. - 14. are repetition of mappings 3 - 8 for input

type H. The states shown on the right should be replaced as follows. $C_1 = A_1$; $C_2 = A_2$; $C_3 = A_3$; $C_4 = A_4$.

15. $\delta(L,(v_1v_3),(v_2v_3)(v_iv_{i+1}),\ \Delta xy_i,\ \Delta xy_{i+1},\ \Delta S_i,\ \Delta S_{i+1}G)$

$= (L,(v_1v_i),(v_iv_{i+1}),\ \Delta xy_{i+1},\ \Delta S_{i+1},\Phi)$

for $i = 3,4,\ldots,m$; $m \neq n$

and $\Delta xy_i = \Delta xy_{i+1}$ and $\Delta S_i = \Delta S_{i+1} = 0$

16. $= (L,\Phi,\Phi,\Phi,\Phi,\ (L,(v_1v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i$

and $\Delta S_i = 0$

17. $= (D,(v_i,v_{i+1}),(v_iv_{i+1}),\ \Delta xy_{i+1},\Phi,(L,(v_1,v_i)))$

for $i = 3,4,\ldots,m$; $m \neq n$

and $\Delta xy_i = \Delta xy_{i+1}$ and $\Delta S_i = \Delta S_{i+1} = 0$

18. $\delta(C_1,(v_1v_3),(v_2v_3)(v_iv_{i+1}),\Delta xy_i,\Delta xy_{i+1},\Delta S_i,\Delta S_{i+1},G)$

$= (C_1,(v_1v_i),(v_iv_{i+1}),\ \Delta xy_{i+1},\ \Delta S_{i+1},\Phi)$

for $i = 3,4,\ldots,m$; $m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \alpha$ and $\Delta S_i = \Delta S_{i+1} = +$

19. $= (C_1,\Phi,\Phi,\Phi,\Phi,\ (C_1,(v_1v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \alpha$

and $\Delta S_i = +$

20. $= (D,(v_i,v_{i+1}),(v_iv_{i+1}),\ \Delta xy_{i+1},\Phi,(C_1,(v_1,v_i)))$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \alpha \neq \Delta xy_{i+1}$

or $\Delta S_i = + \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

21. $\delta(C_2,(v_1v_3),(v_2v_3)(v_iv_{i+1}),\Delta xy_i,\Delta xy_{i+1},\Delta S_i,\Delta S_{i+1},G)$

$= (C_2,(v_1v_i),(v_iv_{i+1}),\ \Delta xy_{i+1},\ \Delta S_{i+1},\Phi)$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \beta$ and $\Delta S_i = \Delta S_{i+1} = +$

22. $= (C_2,\Phi,\Phi,\Phi,\Phi,(C_2,(v_1v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \beta$

and $\Delta S_i = +$

23. $= (D,(v_i,v_{i+1}),(v_iv_{i+1}),\ \Delta xy_{i+1},\Phi,(C_2,(v_1,v_i)))$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \beta \neq \Delta xy_{i+1}$

or $\Delta S_i = + \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

24. $\delta(C_4,(v_1v_3),(v_2v_3)(v_iv_{i+1}),\Delta xy_i,\Delta xy_{i+1},\Delta S_i,\Delta S_{i+1},G)$

$= (C_4,(v_1v_i),(v_iv_{i+1}),\ \Delta xy_{i+1}\ ,\ \Delta S_{i+1},\Phi)$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \beta$ and $\Delta S_i = \Delta S_{i+1} = -$

25. $= (C_4, \Phi, \Phi, \Phi, \Phi, (C_4, (v_1 v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \beta$

and $\Delta S_i = -$

26. $= (D, (v_i, v_{i+1}), (v_i v_{i+1}), \Delta xy_{i+1}, \Phi, (C_4, (v_1, v_i)))$

for $i = 3, 4, \ldots, m$; $m \neq n$

and $\Delta xy_i = \beta \neq \Delta xy_{i+1}$

or $\Delta S_i = - \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

27. $\delta(C_3, (v_1 v_3), (v_2 v_3) (v_i v_{i+1}), \Delta xy_i, \Delta xy_{i+1}, \Delta S_i, \Delta S_{i+1}, G)$

$= (C_3, (v_1 v_i), (v_i v_{i+1}), \Delta xy_{i+1}, \Delta S_{i+1}, \Phi)$

for $i = 3, 4, \ldots, m$; $m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \alpha$ and $\Delta S_i = \Delta S_{i+1} = -$

28. $= (C_3, \Phi, \Phi, \Phi, \Phi, (C_3, (v_1 v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \alpha$

and $\Delta S_i = -$

29. $= (D, (v_i, v_{i+1}), (v_i v_{i+1}), \Delta xy_{i+1}, \Phi, (C_2, (v_1, v_i)))$

for $i = 3, 4, \ldots, m$; $m \neq n$

and $\Delta xy_i = \alpha \neq \Delta xy_{i+1}$

or $\Delta S_i = - \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

30. $\delta(C_4, (v_1 v_3), (v_2 v_3) (v_i v_{i+1}), \Delta xy_i, \Delta xy_{i+1}, \Delta S_i, \Delta S_{i+1}, G)$

$= (C_4, (v_1 v_i), (v_i v_{i+1}), \Delta xy_{i+1}, \Delta S_{i+1}, \Phi)$

for $i = 3, 4, \ldots, m$; $m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \gamma$ and $\Delta S_i = \Delta S_{i+1} = +$

31. $= (C_4, \Phi, \Phi, \Phi, \Phi, (C_4, (v_1 v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \gamma$

and $\Delta S_i = +$

32. $= (D, (v_i v_{i+1}), (v_i v_{i+1}), \Delta xy_{i+1}, \Phi, (C_4, (v_1 v_i)))$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \gamma \neq \Delta xy_{i+1}$

or $\Delta S_i = + \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

33. $\delta(C_2, (v_1 v_3), (v_2 v_3)(v_i v_{i+1}), \Delta xy_i, \Delta xy_{i+1}, \Delta S_i, \Delta S_{i+1}, G)$

$= (C_2, (v_1 v_i), (v_i v_{i+1}), \Delta xy_{i+1}, \Delta S_{i+1}, \Phi)$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \Delta xy_{i+1} = \gamma$ and $\Delta S_i = \Delta S_{i+1} = -$

34. $= (C_2, \Phi, \Phi, \Phi, \Phi, (C_2, (v_1 v_n)))$

for $i = n$

and $\Delta xy_{i-1} = \Delta xy_i = \gamma$

and $\Delta S_i = -$

35. $= (D, (v_i v_{i+1}), (v_i v_{i+1}), \Delta xy_{i+1}, \Phi, (C_2, (v_1, v_i)))$

for $i = 3,4,\ldots,m;\ m \neq n$

and $\Delta xy_i = \gamma \neq \Delta xy_{i+1}$

or $\Delta S_i = - \neq \Delta S_{i+1}$

set $i = 1$ for dot primitive part

36. - 52. are repetition of mappings 18 - 35 for input type H, in which v_j is considered instead of v_i. The states shown on the right should be replaced as follows.

Please Note. $A_1 = C_1$; $A_2 = C_2$; $A_3 = C_3$; $A_4 = C_4$. (3.8)

In the mappings shown, only one type is shown for the straight line primitive. It should be replaced by the appropriate type based on the Δx and Δy values for the primitive.

Discussion of Mappings.

1. A dot primitive (v_1) and a vector defining a connected point (v_2) are reduced to a dot primitive.
2. A dot primitive defined by two points (v_1 and v_2) are reduced with a third point (v_3) to form a straight line if the change in the x and y components are consistent and there is no change in the angle between the resultant vectors.
3. If $\Delta x < 0$ and $\Delta y > 0$ and there is a positive change in slope then the three points (v_1,v_2 and v_3) are reduced to form a curve-component type 1.

4\. - 8. do the same as 3 for different combinations of Δx and Δy and sign of slope changes to define curve-component types 2, 3 and 4.

9\. - 14. do the same as 3 - 8 for input type H from the scanner. This results in area-components, rather than curve-components.

15\. Shows the reductions for a straight line. A series of incremental vector pairs are reduced to a straight line primitive if the Δx and Δy are consistent and change in the angle between the resultant vectors is zero.

16. If all vector pairs are exhausted, then the final state is entered and the primitive is a straight line.

17. If before all vector pairs are exhausted, a curve point is reached (which is determined by the Δx and Δy and the sign of the angle change between the resultant vectors), a new dot primitive is spawned at the curve point and further reductions with the straight line is ceased.

18. - 35. express the same principles as discussed in 15, 16 and 17 for a straight line, but pertain to curve-components.

36. - 52. are a repetition of 18 - 35, but for type H input from the scanner and pertain to area-components.

Please note. In the above discussion, two elements have not been shown, though important. The first one pertains to the color transition values obtained from the scanner. When a new dot primitive is created, it assumes the color transition value of the scanner input corresponding to q_i or q_j for which the dot primitive is created. From then on, reduction with that primitive is carried out only if this color transition value is compatible. If this changes, the reduction for the primitive is terminated and a new dot primitive for the new value is started. This ensures that the primitives are separated into those that overlap with others and those that do not. The second point to be made is that a primitive can undergo reduction with either q_i or q_j, but not both. Under certain conditions, connectivity for a primitive is established with both q_i and q_j. In order to keep the reduction proceeding properly, each primitive is assigned a #. This is the reduction identification number, depending upon whether the primitive is to undergo reduction with q_i or q_j. These are shown in the mappings that follow.

The reduction function makes use of the reduction process described above to decide if the input from the scanner is to be reduced with the current primitive or a new primitive is to be created. The reduction function is characterized by a deterministic finite automaton. It is described by an 8-tuple -

$T = (Q', I, \Upsilon, \xi, O, S, F, \delta)$ where

$Q' \subseteq Q$ the set of states as defined in section 3.3

I = The input to this state and internal to the Micromaton.

= (P_R, Σ, S') as defined by the output O of the connectivity check state in section 3.5.

Υ = The next primitive to be reduced and defined as follows.

if the ith member of P_R is (p_i, K_i) then the next one to be tried for reduction is (p_{i+1}, K_{i+1}). The notation used to indicate the above is $\gamma(P_R)$.

p_i is of the form $(p_i,\#)$ where # refers to whether the primitive undergoes reduction with q_i or q_j. # assumes values from the set $\{0,1,2\}$. A value of 0 or 1 signify that it can undergo reduction with q_i. 2 indicates reduction with q_j.

ξ = Outcome of the reduction process

= $\{0,1\}$ where

0 = No new primitive was created, but current primitive was reduced.

1 = Reduction with current primitive was terminated and new dot primitive was formed.

O = Output of the reduction state and is internal to the Micromaton.

= (P,Ω) which are elements of λ as defined in section 3.3.

S = Start state

= $S_3 \varepsilon Q$ as defined in section 3.3.

F = Final state

= $W \varepsilon Q$ as defined in section 3.3.

δ = Mappings from finite subsets of $Q \times I^* \times \xi^*$ to finite subsets of $Q \times I^* \times O$ and defined as shown.

1. $\delta(S_3,(((p_i,0),(1,0)),\Sigma,W),0)$

$= (S_3, \gamma(P_R),(P,\Omega))$

2. $\delta(S_3,(((p_i,1),(1,0)),\Sigma,W),0)$
$= (S_3,\gamma(P_R),(P,\Omega))$
3. $\delta(S_3,(((p_i,2),(0,1)),\Sigma,W),0)$
$= (S_3,\gamma(P_R),(P,\Omega))$
4. $\delta(S_3,(((p_i,0),(1,1)),\Sigma,W),\Phi)$
$= (S_3,((p_i,1),(1,0)),(P = P \cup \{(p_d,2)\} \rightleftarrows (p_i,1),\Omega <= r_{p_d})$
5. $\delta(S_3,(((p_i,1),(1,0)),\Sigma,W),1)$
$= (S_3,\gamma(P_R),(P = P \cup \{(p_d,1)\} \rightleftarrows (p_i,1),\Omega <= r_{p_d}))$
6. $\delta(S_3,(((p_i,2),(0,1)),\Sigma,W),1)$
$= (S_3,\gamma(P_R),(P = P \cup \{(p_d,2)\} \rightleftarrows (p_i,2),\Omega <= r_{p_d}))$
7. $\delta(S_3,\Phi,\Phi) = (W,\Phi,(P,\Omega))$ (3.9)

Discussion of mappings.

1. If a primitive reduction id. is zero and connectivity is established with q_i and the reduction process does not terminate reduction of the current primitive, get the next primitive that has to be reduced.

2. and 3. are a restatement of 1 except that the reduction id is 1 or 2 and connectivity is established with q_i or q_j and reduction is not terminated with the current primitive.

4. If the primitive reduction id. is zero and connectivity is established with q_i and q_j, create a new dot primitive with a reduction id. of 2 corresponding to q_j, link it to the current primitive and add it to the primitive set.

Add a pointer to it in the active primitive pointer list. Change the current primitive's reduction id. to 1 and carry our reduction with q_i.

5. and 6. are mappings in which the reduction process terminates reduction with the current primitive and starts a new dot primitive. Mapping 5 pertains to reduction with q_i and 6 pertains to q_j. In each case, assign the new dot primitive the same reduction id. as the one for which reduction is terminated, link the two and add the new one to the primitive set. Add a pointer to the active primitive list for the new primitive.

7. When all primitives are reduced, return is made to the wait state.

3.7 Micromaton Output Function

The role of the output function component is to look at every primitive in the Micromaton temporary storage and output those that are eligible. The candidates for output are those that have a tag number identity less than the current probe number.

The output function is described by a deterministic finite automaton. It is an 8-tuple -

$$T = (Q', I, R, \Upsilon, O, S, F, \delta) \text{ where}$$

Q' = Set of states

$Q' \subseteq Q$ defined in section 3.3.

I = Input to this component and internal to Micromaton.

= (λ, Σ, N, S). This is the output O defined in section 3.3.

The active primitive set pointed to by Ω is represented here as $\{(p_i, t_i)\}$ where p_i is the primitive and t_i is its associated tag number. t represents the probe number for which p_i underwent reduction last or when it was created.

R = Set of relational values between J (the current probe number from scanner input Σ) and t_i of p_i.

= $\{0,1\}$ and is defined as shown.

$R = 0$ if $t_i = J$

$R = 1$ if $t_i < J$

γ = Next choice function as defined in section 3.5.

O = Output internal to the Micromaton

= (Ω, Ψ) which are elements of λ as defined.

δ = Mapping from finite subsets of

$Q \times I \times R$ to finite subsets of $Q \times I^* \times O$, and defined as shown.

1. $\delta(S_4, (p_i, W), 0) = (S_4, (\gamma(\Omega), W), (\Omega, \Psi))$
2. $\delta(S_4, (p_i, W), 1) = (S_4, (\gamma(\Omega), W), (\Omega \Rightarrow r_{p_i}, \Psi <= r_{p_i}))$
3. $\delta(S_4, (\Phi, W), 1) = (W, (\Phi, W), (\Omega, \Psi))$

4. $\delta(S_4,(p_i,E),\Phi) = (S_4,(\Upsilon(\Omega),E),(\Omega \Rightarrow r_{p_i},\Psi \Leftarrow r_{p_i}))$

5. $\delta(S_4,(\Phi,E),\Phi) = (E,(\Phi,E), (\Omega = \Phi,\Psi))$ (3.10)

Discussion of mappings.

1. If an active primitive's tag number is equal to the current probe number, select the next primitive from the active set for examination.
2. If an active primitive's tag number is less than the current probe number, remove the pointer to it from the active list and add it to the inactive set, the list chosen depending upon the primitive type.
3. If all active primitives have been checked, return to wait state if that is the return state that is requested.
4. If return to end state is requested, it signals the completion of input from the scanner. Remove pointers from the active primitive list and add them to the inactive primitive list, the list chosen based on the primitive type.
5. Return to end state after setting the active primitive pointer list to a null value.

3.8 Micromaton State Transitions

The discussion of the Micromaton is concluded with a brief review of its function in converting the input data from the scanner to a set of primitives suitable for use by the Macromaton. This is best presented in the form of a state transition diagram as seen in Figure 3.10.

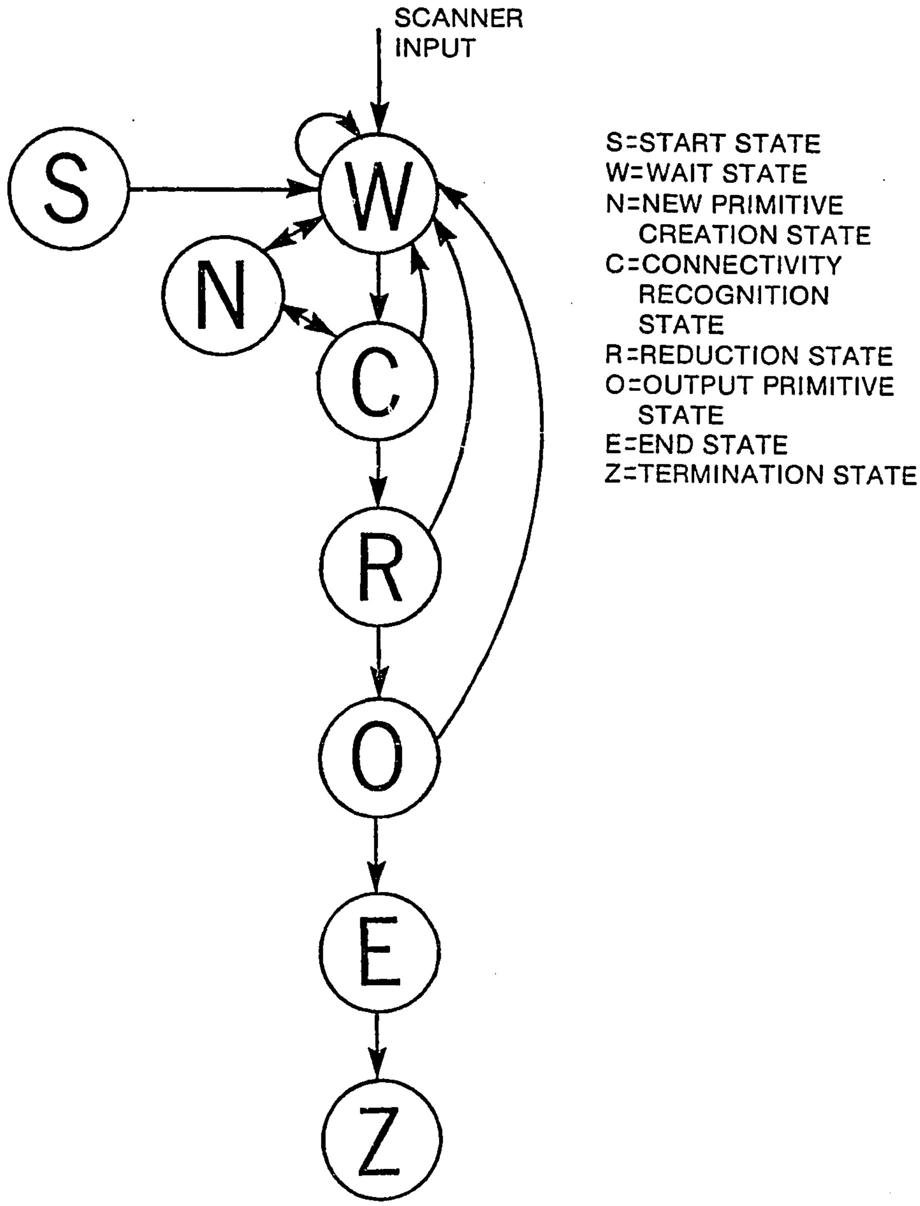


Fig. 3.10 Micromaton state transition diagram.

After initialization, the Micromaton moves from the start state to a wait state. If no input is available from the scanner, it continues in this state. When an input is received, if the active primitive set is empty, it moves to the new primitive creation state. After creating the necessary primitives and adding them to the active primitive set, it returns to the wait state. However, if the active primitive set is not empty, it moves to the connectivity recognition state. In this state, connectivity is determined for the existing active primitives with the scanner input. If no connectivity is established for the input signal, it moves to the new primitive creation state. After creating the required new primitives and adding them to the active primitive set, it returns to the wait state. If Connectivity is partially established for the input signal, it first moves to the new primitive creation state. After creating the required new primitives and adding them to the active primitive set, it returns to the connectivity recognition state before going to the reduction function state.

In the reduction function state, reduction of the input signal is achieved with the primitives for which connectivity is established. If the end of a probe is not reached, the Micromaton returns to the wait state. When the end of a probe is reached, it moves to the output processor state. Here, all primitives whose tag numbers are less than the current scanner probe number, are removed from the active primitive set and added to the inactive primitive set. The inactive primitive set consists of primitives that are fully identified, such that they do not undergo any further reduction with input from the scanner. The inactive primitive set forms the output of the Micromaton. If the end of scan is not reached, it returns to the wait state. When scanning is complete, it moves to the output processor state and outputs all the remaining active primitives as described above. The Micromaton then moves to the final or end state.

This completes the discussion of the Micromaton phase of the recognizer.

3.9 Introduction to Macromaton

In a general sense, a two-dimensional pattern consists of all the objects within the two-dimensional pattern space. The total pattern may be viewed as being made up of subpatterns or shapes, some of which are of interest, while others are not. In what follows, the term "pattern recognition" refers to the recognition of sub-patterns or individual shapes within the two-dimensional pattern space. Instead of referring to them as individual shapes or subpatterns, they are referred to as patterns. The collection of all patterns within the two-dimensional space is referred to as the "scene."

The set of primitives identified by the Micromaton is hereafter referred to as the "source" primitive set. This represents the domain of the Macromaton. The set of possible primitives comprising the patterns of interest is referred to as the "target" primitive set and represents the range of the Macromaton. The process of identifying the subset of the source primitive set as a subset of the target primitive set is referred to as "parsing" in the spirit of formal language theory. The function of the Macromaton is, therefore, to partially map the source primitive set into the target primitive set.

Before proceeding with the description of the parsing process, a few preliminary comments are in order. A pattern form defined using the D-L-A grammar has an implicit orientation associated with it. This is illustrated in Figure 3.11. Starting at a point "a," the area pattern form $P = [A_1A_2A_6A_3A_4A_8]$ is shown in solid line while the pattern form $P = [A'_4A'_1A'_5A'_2A'_3A'_7]$ is shown in dotted line. The dotted pattern is obtained by rotating the solid pattern by 90° clockwise, keeping the point "a" fixed.

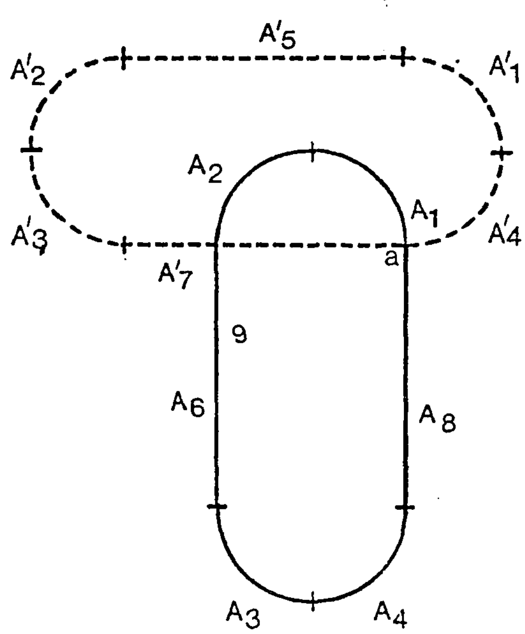


Figure 3.11 Pattern representation due to orientation.

In a general recognition problem, it is necessary to recognize both of the patterns shown in Figure 3.11 as the same. Therefore, if the D-L-A grammar is used for defining the pattern form, certain additional considerations are required to identify a pattern as being the same for different orientations. The pattern form derived by using the D-L-A grammar may be referred to as a "cannonical" one. The objective is to go from the cannonical pattern form to a "free-form," which represents the cannonical pattern form for all orientations.

Consider Figure 3.12a showing three representations of curve-component type 1. #1 spans the whole range (90°), while, #2 and #3 span approximately 30° at either end. Figure 3.12b shows the same figure rotated counter-clockwise by 45°.

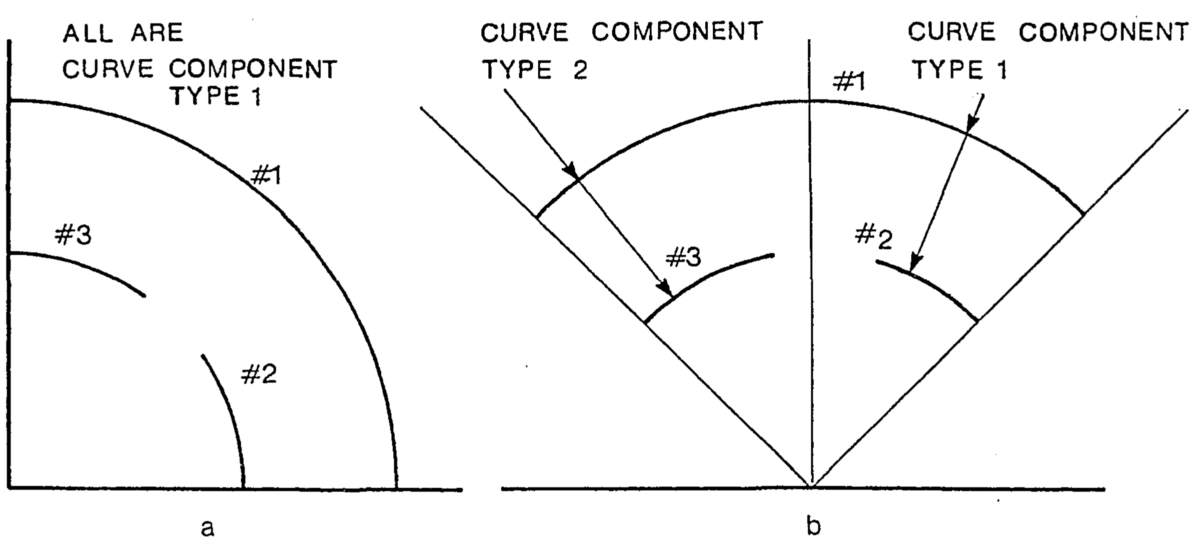


Figure 3.12 Effect of rotation on primitive type.

Comparing Figure 3.12a and Figure 3.12b, the following observations may be made. #1 started as curve-component type 1 and ended up as curve-component type 2. #2 started and ended the same; as type 1. #3 started as type 1 and ended as type 2. If Figure 3.12a had been rotated clockwise by 45°, the following results would have been obtained.

Curve#	Curve-component type	
	Start	End
1	1	1 and 4
2	1	4
3	1	1

Based on the above, when a segment of a curve which constitutes a curve-component is rotated, one of the following takes place.

1. It retains its curve-component type.
2. It straddles its type and one of its adjacent types.

It is worthy of note that a curve-component, when rotated, does not straddle more than one of its adjacent types. Using the above facts, a cannonical pattern form representation may be transformed into a free-form by choosing columns 1 and 2 or columns 2 and 3 of (3.7) as alternates in the parsing process.

$$
\begin{array}{lccc}
 & \multicolumn{3}{c}{\underline{\text{C O L U M N \#}}} \\
 & \underline{1} & \underline{2} & \underline{3} \\
C_1 = & C_4C_1 & | \; C_1 \; | & C_1C_2 \\
C_2 = & C_1C_2 & | \; C_2 \; | & C_2C_3 \\
C_3 = & C_2C_3 & | \; C_3 \; | & C_3C_4 \\
C_4 = & C_3C_4 & | \; C_4 \; | & C_4C_1 \\
 & & & \\
A_1 = & A_4A_1 & | \; A_1 \; | & A_1A_2 \\
A_2 = & A_1A_2 & | \; A_2 \; | & A_2A_3 \\
A_3 = & A_2A_3 & | \; A_3 \; | & A_3A_4 \\
A_4 = & A_3A_4 & | \; A_4 \; | & A_4A_1
\end{array} \tag{3.7}
$$

3.10 Partial Patterns

One of the more difficult problems associated with pattern recognition has to do with patterns that are partially obscured by others overlaying them. For purposes of this study, patterns are grouped into three classes as shown in Figure 3.13. Figure 3.13a shows two patterns that do not overlap one another. This is referred to as "class A" patterns. In Figure 3.13b, the circle overlays and obscures part of a rectangle. This is referred to as "class B" patterns. In Figure 3.13c the circle overlays and bifurcates the rectangle into two parts. This is referred to as "class C" patterns.

This study deals with the recognition of class A and class B patterns. Class C problem is beyond the scope of

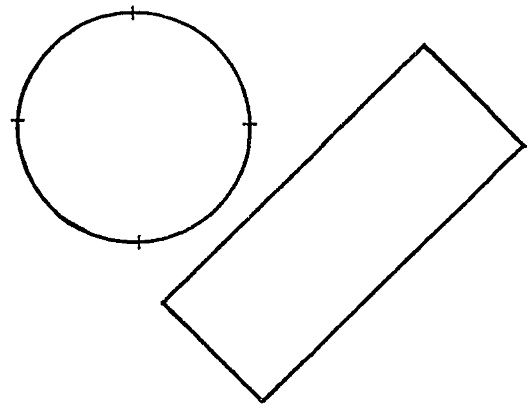


Figure 3.13a Class A patterns (non-overlapped)

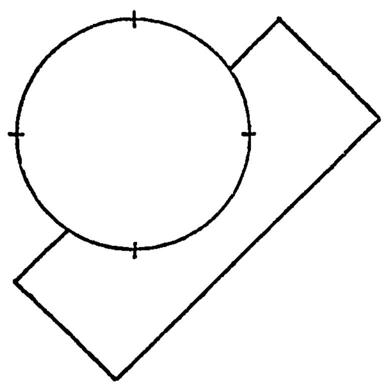


Figure 3.13b Class B patterns (overlapped, non-bifurcated)

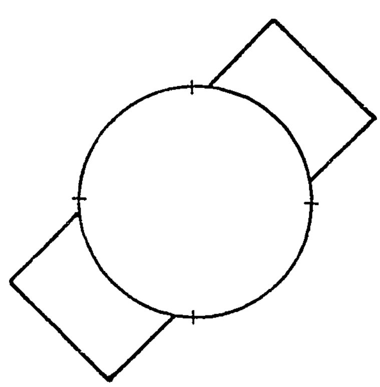


Figure 3.13c Class C patterns (overlapped, bifurcated)

Figure 3.13 Classes of two-dimensional patterns.

this work and has not been dealt with. From hereon, the term "non-overlapped patterns" implies class A type and "overlapped patterns" implies class B type as described above.

Consider the scene in Figure 3.14. It shows two circles overlapped as shown, each circle being an area pattern.

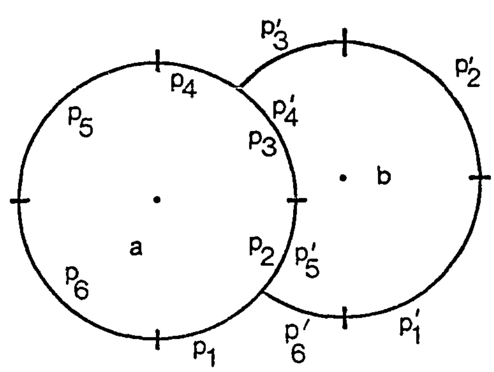


Figure 3.14 Overlapped patterns

Circle a is composed of the dynamic chain $[p_1p_2p_3p_4p_5p_6]$ while circle b is composed of the dynamic chain $[p_1'p_2'p_3'p_4'p_5'p_6']$, each p_i, $p_i' \varepsilon \{A_1, A_2, A_3, A_4\}$ where each A_i is an area component. The primitives p_2 and p_3 of circle a are overlapped with primitives p_5' and p_4' of circle b. In order to correctly determine that the two patterns are circles, it is necessary to recognize that primitives p_2 and p_3 are valid primitives that should participate in the parse for circle a, while, primitives p_3' and p_4' for circle b should not. Otherwise, the parse for circle b will be erroneously rejected as being invalid for a circle from the chain of primitives shown above. One method of accomplishing this is to first find the full circle a and mark the primitives p_5' and p_4' of circle b that are overlapped with the primitives p_2 and p_3 of circle a as "unusable" in the parse for circle b.

3.11 Macromaton Structure

The function of the Macromaton is to map a subset of the source primitive set into a subset of the target primitive set. In this process, the Macromaton subdivides the source primitive set into four disjoint subsets as follows.

1. A subset that corresponds to fully visible target patterns.
2. A subset that corresponds to partially visible target patterns.
3. A subset for which it is not possible to uniquely identify the target pattern.
4. A subset for which mapping into the chosen target pattern set does not exist.

Figure 3.15 shows the logical components of the Macromaton.

The treatment of the Macromaton is analogous to that of the Micromaton. It is characterized as a series of automata driven by a common set of states. In some it performs specific functions, while in others it acts as the controlling element, directing the action of its components. A recap of

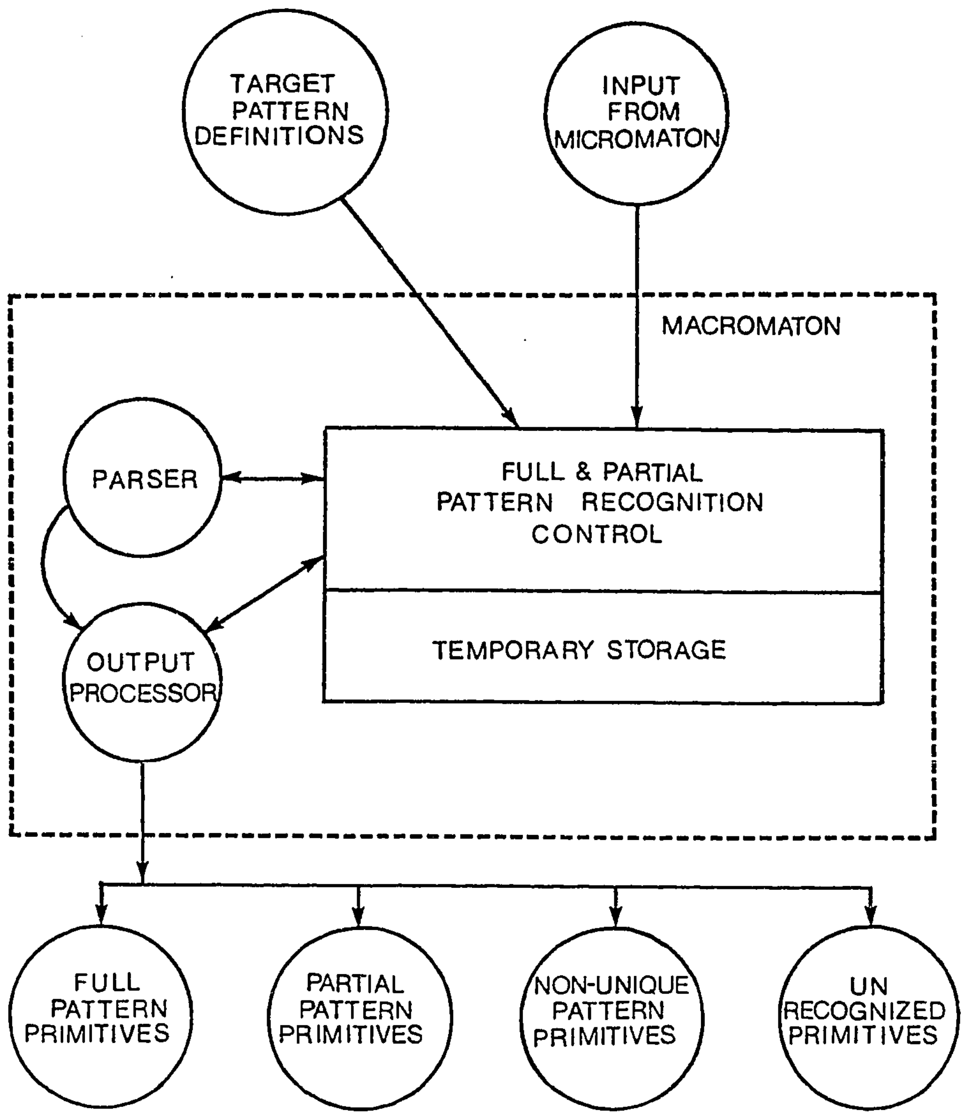


Figure 3.15 Macromaton structure

the discussion on the Macromaton is presented in section 3.16 with a state transition diagram. It is worthwhile to review section 3.16 before proceeding with the rest of this chapter.

The Macromaton has two controlling states. The first one is the state in which the patterns which are fully visible are recognized. The second controlling state is for recognition of partial patterns.

The following symbols and their associated meanings are defined for the Macromaton.

Q = Common set of states

= $\{S_1, S_1', S_2, S_2', S_2'', S_3, S_4, E, Z\}$ where

S_1 = Full pattern recognition state

S_1' = Return state in full pattern recognition

S_2 = Partial pattern recognition state

S_2' = Return state 1 in partial pattern recognition

S_2'' = Return state 2 in partial pattern recognition

S_3 = Parsing function state

S_4 = Output state

E = End state

Z = Termination state

In the above, $\{S_1, S_1', S_2, S_2', S_2'', E, Z\}$ are the controlling states; S_3 and S_4 are component states.

τ = Set of target patterns to be recognized constituting one of the inputs to the Macromaton.

= $\{T_i\}$, $i = 1,2,\ldots,n$.

In this set, T_1 is the most complex pattern comprising the largest number of primitives and T_n

is the simplest with the least number.

$\{T_i\}$ is therefore a set of hierarchical patterns arranged in order of diminishing complexity.

Each T_i is defined as shown below.

$T_i = (G_i, \mu_i, t_{d_i})$ where

G_i = D-L-A grammar that defines pattern T_i by the set $\{t_i\}$, each t_i being a target primitive type corresponding to one of the types output by the Micromaton.

μ_i = Parametrization of G_i and defined for each $t_i \varepsilon T_i$ as shown.

$\{o_j, a_{jk}, v_{jk}, r_{jk}, e_{jk}\}$ in which the symbols have the following meaning.

o_j = jth offset, where $o \varepsilon I$ the index set. It specifies the offset primitive from the current one with which parametrization compliance is required. $j = 1,2,\ldots\ldots,m$.

a_{jk} = Attributes $k = 1,2,\ldots,n$ corresponding to each offset o_j that is to be checked.

v_{jk} = Value of a_{jk}.

r_{jk} = Relation to be used in checking values of attributes between t_i and t_{i+o_j}.

e_{jk} = Error tolerance in the above parameter compliance check.

$t_{d_i} \varepsilon \{t_i\}$ and represents a distinguished target primitive that must be present in the parse if the pattern is fully visible.

λ = Input to the Macromaton. This constitutes the set of primitives output by the Micromaton.

= (P,Ψ) shown as $\lambda' = (P,(\Phi,\Psi))$ in section 3.3.

γ = Next selection function.

For the choice of the next target pattern to be parsed, it is defined as shown.

$\gamma(T_i) = T_{i+1}$ for $1 \leq i \leq n-1$

$\gamma(T_n) = \Phi$ where only n patterns are defined.

Δ = Set of outputs of the Macromaton.

= $\{\rho_i\}$, i = 1,2,3,4 where

ρ_1 = Primitive subset corresponding to fully visible patterns.

ρ_2 = Primitive subset corresponding to partially visible patterns.

ρ_3 = Primitive subset corresponding to patterns that cannot be uniquely identified.

ρ_4 = Primitive subset for which no mapping exists into the chosen target pattern set.

Each ρ is of the form $\{(L,\{p\})\}$ where L corresponds to the index of T the target pattern recognized. In the case of ρ_3 and ρ_4, $L = \Phi$.

3.12 Full Pattern Recognition Function

The structure of the full pattern recognition function is described by a deterministic finite automoton. It is an 8-tuple -

$R_1 = (Q', S', F', \tau, \lambda, \gamma, 0, \delta)$ where

$Q' = \{S_1, S_1', S_2, S_3, S', F'\}$ in which $\{S_1, S_1', S_2, S_3\} \subseteq Q$ as defined in section 3.11.

S' = The start state of full pattern recognition function.

$F' = S_2 \varepsilon Q$ the final state as defined.

τ = The target pattern set as defined in section 3.11.

λ = Input from Micromaton as defined in section 3.11.

γ = Next selection function for full pattern recognition as shown.

γ_T = Next target pattern selection function as defined in section 3.11.

γ_P = The next distinguished source primitive selection function as defined below.

Let p_{d_i} be a source primitive εP, of the same type as t_{d_i} the distinguished target primitive that must be present in the pattern for it to be fully visible. If

p_{d_i} exists, then there is a pointer to it in one of the pointer lists of Ψ.

$\gamma_P((P,\Psi),p_{d_i})$ returns the primitive pointed to by the next pointer in the same list as the pointer to p_{d_i} of Ψ. If all pointers in this list are exhausted, then $\gamma_P((P,\Psi),p_{d_i}) = \Phi$. $\gamma_P((P\Psi),p_{d_i})$ is abbreviated as $\gamma_P(P)$.

O = Output of this state, internal to the Macromaton, going to the parsing function. It is defined as shown.

$= (L,T_i,((P,\Psi),p_{d_i}),S_R)$ where

L is the index of T_i,

$T,((P,\Psi),p_{d_i})$ are as defined and S_R is the state to return to after completion of the state being entered.

δ = Mapping from finite subsets of $Q \times \tau \times \lambda$ to finite subsets of $Q \times \tau \times \lambda \times O^*$ and is defined as shown.

1. $\delta(S',\tau,\lambda)$

$= (S_1,T_1,\lambda,\Phi)$

2. $\delta(S_1,T_i,((P,\Psi),p_{d_i}))$

$= (S_3,(T_i,t_{d_i}),((P,\Psi),p_{d_i}),(L,(T_i,t_{d_i}),((P,\Psi),p_{d_i}),S_1')$

3. $\delta(S_1',T_i,(P,\Psi))$

$= (S_1,T_i,\gamma_P(P),\Phi)$

4. $\delta(S_1, T_i, ((P,\Psi),\Phi))$
$= (S_1, \gamma_T(T_i), (P,\Psi), \Phi)$

5. $\delta(S_1, \Phi, (P,\Psi))$
$= (S_2, \tau, (P,\Psi), \Phi)$

Discussion of Mappings

1. From the start state, enter full pattern recognition state by picking the first target pattern for recognition.
2. If there is a source primitive of the same type as the distinguished target primitive for the pattern chosen, pass the target pattern and the source primitive set to the parsing function; go from full pattern recognition state to parsing function state, requesting return to full pattern recognition return state.
3. Upon return to the full pattern recognition state, get the next source primitive of the same type as the distinguished target primitive. Retain the same target pattern for re-try.
4. If there are no more source primitives of the same type as the distinguished target primitive for the pattern chosen, get the next target pattern for parse.
5. If all target patterns have been tried for full pattern recognition, enter the partial pattern recognition state.

3.13 Partial Pattern Recognition Function

This function is defined by a deterministic finite automaton which is a 12-tuple as shown.

$R_2 = (Q', S', F', \tau, \lambda, K, \gamma, I, \eta, \omega, O, \delta)$ where

$Q' = \{S_2, S_2', S_2'', S_3, S_4, E, Z, S', F'\}$ in which $\{S_2, S_2', S_2'', S_3, S_4, E, Z\} \subseteq Q$ as defined in section 3.11.

$S' = S_2 \varepsilon Q$ the start state as defined.

$F' = Z \varepsilon Q$ the final state as defined.

τ = The target pattern set as defined in section 3.11.

λ = Input from Micromaton as defined in section 3.11.

K = Relational value of good parse primitive count corresponding to a starting source primitive.

= $\{k_i\}$, $i = 1,6$ defined as shown.

k_1 : Old count = New count = 0

k_2 : Highest old count = New count $\neq$ 0

k_3 : Highest old count > New count

k_4 : Highest old count < New count

k_5 : Old count = Φ; New count = 0

k_6 : Undefined (don't care)

γ = Next selection function as shown below.

γ_T = Next target pattern selection function as defined in section 3.11.

γ_s = Next source primitive selection function defined as follows.

The very first source primitive $p_s \varepsilon P$ selected for partial parse is the one pointed to by the first pointer r of the first pointer list in Ψ. The next source primitive p_s selected for partial parse and denoted by the symbol $\gamma_s(P,\Psi)$ is the one pointed to by the next pointer in the list to which r belongs. If there are no more in the same list, selection is made from the next available list in Ψ. $\gamma_s(P,\Psi) = \Phi$ if no more source primitives can be selected using Ψ.

γ_t = Next target primitive selection function defined as follows.

In the grammar defining the target pattern, t_{p_s} corresponds to the same primitive type as the source primitive p_s above, at which reduction can be started. $\gamma_t(T) = t$ if such a target primitive exists in the grammar;

$\gamma_t(T) = \Phi$ if no such target primitive exists in the pattern definition.

I = Input to this state, internal to the Macromaton, received from the parsing function.

$(s, C, (L, \beta), \beta', S_R)$ where

s = Success or failure of recognition.

= $\{0,1\}$ where

0 = failure

1 = success

C = Count of the total number of good parse primitives returned by the parsing function.

L = Index corresponding to the target pattern being recognized.

β = The parse of pattern L.

β' = The primitives to be removed from the primitive set corresponding to this parse.

S_R = The state to which return is to be made.

(For additional details on β and β' refer to symbol O in section 3.14.)

η = Set of partial pattern primitives corresponding to the selected p_s that satisfy the relational good parse primitive value k_2 defined above. This identifies the set of primitives for which a target pattern cannot be uniquely identified.

ω = Primitive set representing the partial pattern recognized. Its elements are the same as shown for I.

O = The output of this state and internal to the Macromaton.

This is specified in one of three forms.

The first form goes to the parsing function and the next two go to the output function.

$O_1 = (L, T_i, ((P,\Psi), p_s), S_R)$ where

L is the index of T_i,

$T_i, ((P,\Psi), p_s)$ are as defined and S_R is the state to return to after completion of the state being entered.

$O_2 = (((P,\psi), p_s), S_R)$ where

P, Ψ, p_s are as defined and S_R is the return state.

$O_3 = (s, C, (L,\beta), \beta', S_R)$ where the symbols have the same meaning as shown for I above.

δ = Mapping from finite subsets of

$Q \times \tau^* \times \lambda^* \times K^* \times I^*$ to finite subsets of

$Q \times \tau \times \lambda^* \times \eta^* \times \omega^* \times O^*$ and is defined as shown.

1. $\delta(S_2, (T_1,\Phi), ((P,\Psi), p_s), \Phi, \Phi)$

$= (S_2,\ \gamma_T(T_1), ((P,\Psi), p_s), \Phi, \Phi, \Phi)$

2. $\delta(S_2, \Phi, ((P,\Psi), p_s), k_1, I)$

$= (S_4, \tau, ((P,\Psi), p_s), \Phi, \Phi, (((P,\Psi), p_s), S_2''))$

3. $\delta(S_2'', \tau, (P,\Psi), \Phi, \Phi)$

$= (S_2, T_1, \gamma_S(P,\Psi), \Phi, \Phi, \Phi)$

4. $\delta(S_2, (T_i, t_{s_i}), ((P,\Psi), p_s), \Phi, \Phi)$

$= (S_3, (T_i, t_{s_i}), ((P,\Psi), p_s), \Phi, \Phi, ((T_i, t_{s_i}), ((P,\Psi), p_s), S_2'))$

5. $\delta(S_2, (T_i, \Phi), ((P,\Psi), p_s), \Phi, \Phi)$

$= (S_2, \gamma_T(T_i), ((P,\Psi), p_s), \Phi, \Phi, \Phi)$

6. $\delta(S_2, \Phi, ((P,\Psi), p_s), \Phi, \Phi)$

$= S_4, \tau, ((P,\Psi), p_s), \Phi, \omega, (2, \omega, S_2''))$

7. $\delta(S_2, \Phi, ((P,\Psi), p_s), \Phi, \Phi)$

$= (S_4, \tau, ((P,\Psi), p_s), \eta, \Phi, (3, \eta, S_2''))$

8. $\delta(S_2', (T_i, t_{s_i}), ((P,\Psi), p_s), \bar{k}_1, I)$

$= (S_2, \gamma_T(T_i), ((P,\Psi), p_s), \Phi, \Phi, (((P,\Psi), p_s), S_2''))$

9. $\delta(S_2', (T_i, t_{s_i}), ((P,\Psi), p_s), k_4, (1, C, (L,\beta), \beta', S_1'))$

$= (S_2, \gamma_T(T_i), ((P,\Psi), p_s), (\eta = \Phi), (\omega = I), \Phi)$

10. $\delta(S_2', (T_i, t_{s_i}), ((P,\Psi), p_s), k_3, (1, C, (L,\beta), \beta', S_1'))$

$= (S_2, \gamma_T(T_i), ((P,\Psi), p_s), \eta, \omega, \Phi)$

11. $\delta(S_2', (T_i, t_{s_i}), ((P,\Psi), p_s), k_2, (1, C, (L,\beta), \beta', S_1'))$

$= (S_2, \gamma_T(T_i), ((P,\Psi), p_s), (\eta = \eta \cup \beta' \cup \beta' \varepsilon \omega), (\omega = \Phi), \Phi)$

12. $\delta(S_2', T_1, (P, \Phi), \Phi, \Phi)$

$= (S_4, \tau, (P, \Phi), \Phi, \Phi, (4, (P, \Phi), E))$

13. $\delta(E, \tau, \Phi, \Phi, \Phi)$

$= (Z, \tau, \Phi, \Phi, \Phi, \Phi)$

Discussion of Mappings

1. Corresponding to the first source primitive selected using the pointer list set Ψ, if the first target pattern has no primitive of the same type that can undergo reduction, get the next target pattern.
2. If none of the target patterns defined have a primitive of the same type that can undergo reduction as the source primitive chosen, output this source primitive to the output function, requesting return to the partial pattern recognition state S_2''.
3. Upon return to partial pattern recognition state from the output function, get the next source primitive available and start again with pattern #1.
4. For any target pattern, if a target primitive of the same type as the source primitive chosen can be reduced, pass the target pattern and the source primitive set to the parser; enter the parsing function state requesting return to the partial pattern recognition state S_2'.
5. This is a repeat of mapping 1 but pertains to any pattern in the target pattern set.
6. If all the target patterns defined have been checked and the partial pattern recognized is

non-null, pass the partial pattern recognized ω to the output function, to be added to the set of partial patterns recognized. Request return to partial pattern recognition state S_2''.

7. If all the target patterns defined have been checked and the set corresponding to the non-unique patterns η is non-null, pass η to the output function, to be added to the set of non-unique patterns. Request return to partial pattern recognition state S_2''.
8. If none of the target patterns defined have a good parse corresponding to the source primitive chosen, output this source primitive to the output function, requesting return to the partial pattern recognition state S_2''.
9. Upon return from the parsing function state, if the new primitive count for the current pattern is greater than the highest old primitive count, set the current partial pattern recognized ω to the input; set the non-unique pattern primitive set η to null. Get the next target pattern and retry.
10. Upon return from the parsing function state, if the new primitive count for the current pattern is less than the highest old primitive count, get the next target pattern and retry.

11. Upon return from the parsing function state, if the new primitive count for the current pattern is equal to the highest old primitive count, add the primitives to be removed (from the input) to the non-unique pattern primitive set. To this add the primitives to be removed from the partial pattern set ω. Set the partial pattern set to null, get the next target pattern and retry.
12. When no more starting source primitives are available, enter the output state; indicate addition of the remaining primitives to the set of unrecognized primitives and request return to the end state.
13. Enter termination state and stop.

3.14 Parsing Function

The structure of the parsing function for a general pattern is a non-deterministic finite automaton. It is a 19-tuple specified as follows.

$R = (Q', S', F', I, Y, F, K, K', C, R', \xi, B, B', W, N, \alpha, \alpha', O, \delta)$

where

$Q = \{S_1', S_2', S_3, S_4, S', F', A_1, A_2, A_3, A_4\}$ in which $\{S_1', S_2', S_3, S_4\} \subseteq Q$ as defined in section 3.11 and

$\{A_1, A_2, A_3, A_4\}$ are states internal to the parsing function.

$S' = S_3 \varepsilon Q$ the start state as defined.

$F' = \{S_1', S_2', S_4\} \subseteq Q$ the final states as defined.

γ = Next selection function, It is defined for the parsing function as follows.

$\gamma(T)$ = Next target primitive selected for parse.

= $t \varepsilon \{t_i\}$ defining the target pattern chosen.

In the grammar defining the target pattern, t corresponds to the next target pattern primitive expected in the parse sequence.

Since the parse can be started from any primitive in the pattern definition, parse proceeds in a forward sequence or a backward sequence from the starting point. When parse proceeds in a forward sequence and all target pattern primitives have been parsed, the parse reverts to the starting point and parse is resumed in the backward sequence.

$\gamma(T) = \Phi$ when all target pattern primitives have been tried.

$\gamma(P,\Psi)$ = Next source primitive available for parse.

This is defined in one of two forms.

$\gamma(P,\Psi)$ = Next p pointed to by a pointer in Ψ for dot primitives and statically chained straight line, curve and area-component primitives.

$\gamma(P,\Psi)$ = Link $p \in P$ for dynamically chained primitives.

$\gamma(P,\Psi) = \Phi$ if no more source primitives are available for parse.

$\gamma(P,\Psi)$ is abbreviated as $\gamma(P)$.

$\gamma(\mu)$ = The next parametrization of p to be tried. (Refer to section 3.11 for symbols.) If subscript $k > n$ then $j = j + 1$

$\gamma(\mu) = \Phi$ if $j = m$ and $k = n$.

I = Input internal to this state of the Macromaton and defined as shown. This is the output from the full or partial pattern recognition states.

= $(L, T_i, ((P,\Psi), p), S_R)$ where

L is the index of T_i,

T_i, $((P,\Psi),p)$ are as defined and S_R is the state to return to after completion of the state being entered. In the mappings this is also shown as $((T,t),((P,\Psi),S_R)$.

F = Outcome of form check where the source primitive type is compared to the target primitive type.

= $\{\Phi, 0, 1\}$ where

Φ = Undefined (don't care)

0 = Failure

1 = Success

K = Parametrization outcome defined as shown.

$= \{\Phi, 0, 1, 2\}$ where

Φ = Undefined (don't care)

0 = Parametrization failed

1 = Parametrization succeeded for all values that had to be checked.

2 = Parametrization succeeded for all the ones checked, but not all of them were checked.

The manner in which the above values are arrived at is shown below.

(For symbols p_f, p_I and β used here, refer to output O later in this section. Symbols a,v,r,o are elements of μ_i as described in section 3.11.)

Let $p_f = p$ where $p_f \varepsilon \beta$.

and $p' \varepsilon \beta$, the offset primitive from p corresponding to offset o_j.

$K(p_{jk}) = 1 \quad \text{if } | r_{jk}(av_{jk}, a'v'_{jk}) | \leq e_{jk}$

$K(p_{jk}) = 0 \quad \text{if } | r_{jk}(av_{jk}, a'v'_{jk})| > e_{jk}$

or p or $p' = p_I$.

The above expressions paraphrased have the following meaning. Get the kth attribute value corresponding to the jth offset for p given by av_{jk} and the kth attribute corresponding to p' given by $a'v'_{jk}$. Get their relational value $V = (r_{jk}(av_{jk}, a'v'_{jk})$. If the absolute value of V is less than or equal to the error tolerance specified, e_{jk}, then the parametrization outcome $K = 1$.

If it is greater than e_{jk} or p or p' is an imaginary primitive p_I, then the parametrization outcome K = 0.

C' = The outcome of final parametrization at the end of the parse. This represents the parameters that could not be verified while parsing was in progress.

= $\{\Phi, (c_1, c_2)\}$ defined as shown.

Φ = Undefined (don't care)

$c_1 \varepsilon \{0,1\}$ where

0 = All remaining parameters did not comply.

1 = All remaining parameters complied

c_2 = Cumulative primitive count corresponding to the remaining parameters.

C = Cumulative good parse primitive count.

R' = Outcome of current primitive reduction.

= $\{0,1\}$ where

0 = Failure

1 = Success

ξ = Synchronization value

= $\{\Phi, 0, 1\}$ where

= Undefined (don't care)

0 = Value of ξ when the source and target primitives are in synchronization.

1 = Value assigned to ξ when an "unusable" or overlapped primitive is encountered in a dynamic chain. This primitive does not participate in

the parse, and makes the source and target primitives get out of synchronization.

B = Backtrack function.

= {Φ,1} where

Φ ≡ Undefined (don't care)

1 = Backtrack

This is a stack function that shows how to recover from a parse that fails. It maintains pointers into the parse lists of α and α'. Associated with each pointer is the type of chain that is being parsed, i.e., whether it is a static chain or dynamic chain. When parse fails at any point, the parse reverts back to the most recent pointer with which the static chain type is associated. If no such pointer exists, or the start of the parse is reverted to, the entire parse fails.

B' = Outcome of Backtrack

= {Φ,0,1} where

Φ = Undefined (don't care)

0 = failure

1 = Success

W = Chaining status of parse

= {Φ,S,D} where

Φ = Undefined (don't care)

S = Static chaining

D = Dynamic chaining

N = Next mapping to be tried

$N \varepsilon \{i\}$ where each i corresponds to a number associated with each mapping shown.

α = Set of primitives participating in the parse. This is the same as β of O shown below.

α' = Set of primitives to be removed from the primi-set. This is the same as β' of O as shown below.

O = Output of the parsing function.

$(s, C, (L, \beta), \beta', S_R)$

This goes to the output function as well as the partial pattern recognition function. s has the following meaning. When return is made to the partial pattern recognition state, s refers to the success (1) or failure (0) of the parse. However, when the output state is entered during full pattern recognition, s refers to the output set ρ to which the successful primitives are to be added.

C is the cumulative good parse primitive count.

L is the index of the target pattern being parsed.

β is the parse of pattern corresponding to L and is defined as follows.

$= \{p_f, \mu_f\}$ where

p_f is the primitive parsed for form and μ_f is its associated parametrization as defined in the target pattern definition. Each p_f is of the form p_i or p_I where $p_i \varepsilon P$ and p_I is primitive imagined to exist in the parse sequence as dictated by G_i. μ_f assumes one of two values - μ_i the parametrization corresponding to p_i as defined by G_i or Φ corresponding to p_I. The form of μ_i is as defined in section 3.11.

β' = $\{p_j\}$ the set of primitives corresponding to pattern T_i to be removed from the primitive set where $p_j \varepsilon$ P. Each p_j is one of the forms p_i, p_o or p_u. Each $p_i \varepsilon \{p_f\} \neq p_I$. p_o are overlapped primitives and p_u are marked as "unusable." In the mappings, p_{ou} refers to a primitive that is either overlapped or unusable; p_{on} refers to a primitive that is either overlapped or non-overlapped.

δ = Mapping from finite subsets of

$Q \times I \times F \times K \times R' \times \xi \times B' \times K' \times W$

to finite subsets of

$Q \times I \times \xi \times C \times \alpha \times \alpha' \times B \times O \times N$ and is defined as shown.

Full Pattern Parse Mappings

1. $\delta(S_3,((t,\mu),p,S_1'),1,\Phi,\Phi,\Phi,\Phi,\Phi,\Phi)$

$= (S_3,(\gamma(T),\gamma(P),S_1'),0,0,\alpha = \{p\}, \alpha' = \{p\},\Phi,\Phi, \{2,3\})$

2. $\delta(S_3,((t,\mu),p,S_1'),\Phi,1,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_3,((t,\gamma(\mu)),p,S_1'),0,C,\alpha,\alpha',\Phi,\Phi,\{2,3,4,5\})$

3. $\delta(S_3,((t,\mu),p,S_1'),\Phi,0,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_1',(T,\lambda,S_1'),\Phi,0,\ \alpha = \Phi,\ \alpha' = \Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

4. $\delta(S_3,((t,\Phi),p,S_1'),\Phi,1,1,0,\Phi,\Phi,\Phi)$

$= (A_1,\gamma(T),\gamma(P),S_1'),0,C = C + 1,(\alpha=\alpha\cup p),(\alpha'=\alpha'\cup p),\Phi,\Phi,\{2,3\})$

5. $\delta(S_3,((t,\Phi),p,S_1'),\Phi,2,1,0,\Phi,\Phi,\Phi)$

$= (A_1,(\gamma(T),\gamma(P),S_1'),0,C,(\alpha=\alpha\cup p),(\alpha'=\alpha'\cup p),\Phi,\Phi,\ \{2,3\})$

6. $\delta(A_1,((t,\mu),p,S_1'),1,\Phi,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_3,((t,\mu),p,S_1'),0,C,\alpha,\alpha',\Phi,\Phi,\{2,3\})$

7. $\delta(A_1,((t,\mu),p,S_1'),0,\Phi,\Phi,0,\Phi,\Phi,\Phi)$

$= (A_2,((t,\mu),\gamma(P),S_1'),0,C,\alpha,\alpha',1,\Phi,8)$

8. $\delta(A_2,((t,\mu),p,S_1'),\Phi,\Phi,\Phi,0,1,\Phi,\Phi)$

$= (A_1,((t,\mu),p,S_1'),0,C,\alpha,\alpha',\Phi,\Phi,\{6,7\})$

9. $\delta(A_2,((t,\mu),\Phi,S_1'),\Phi,\Phi,\Phi,0,1,\Phi,\Phi)$

$= (S_1',(T,\lambda,S_1'),\Phi,0,\alpha = \Phi,\alpha' = \Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

10. $\delta(A_2,((t,\mu),p,S_1'),\Phi,\Phi,\Phi,0,0,\Phi,\Phi)$

$= (S_1',(T,\lambda,S_1'),0,0,\Phi,\Phi,\Phi,\Phi,\Phi)$

11. $\delta(S_3,(\Phi,p,S_1'),\Phi,\Phi,\Phi,0,\Phi,(1,C'),S)$

$= (S_4,(T,\lambda,S_1'),\Phi,C= C+C',\alpha,\alpha',\phi,(1,C,(L,\beta= \alpha),\beta' = \alpha',S'),\Phi)$

12. $\delta(S_3,(\Phi,p,S_1'),\Phi,\Phi,\Phi,0,\Phi,(0,C'),S)$

$= (S_1',(T,\lambda,S_1'),\Phi,0,\alpha = \Phi,\alpha' = \Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

13. $\delta(S_3,(\Phi,p,S_1'),\Phi,\Phi,\Phi,0,\Phi,(0,C),D)$

$= (S_1',(T,\lambda,S_1'),\Phi,0,\ \alpha = \Phi,\alpha' = \Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

14. $\delta(S_3,((t,\mu),\Phi,S_1'),\Phi,\Phi,\Phi,0,\Phi,\Phi,\Phi)$
$= (S_1',(T,\lambda,S_1'),\Phi,0,\alpha=\Phi,\ \alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

Discussion of Full Pattern Parse Mappings

1. Start full pattern recognition with this mapping. When parsing function is entered, one source and target primitive type compliance is ensured. Save the source primitive in the set of good parse primitives and the set of primitives and the set of primitives to be removed. (The parametrization from the target pattern definition is saved in the parse primitive set. This is not shown in the mappings.) Set synchronization value to 0 and the cumulative primitive count to 0. Get the next source and target primitives.
2. Check parametrization. If it is satisfied, get the next parameter to check.
3. If parametrization fails, fail recognition and return to full pattern recognition state.
4. If all parameters for the current primitive are checked and they are satisfied, add 1 to the primitive count. Add the source primitive to the parse primitive set and the set of primitives to be removed. Get the next source and target primitives.
5. If all parameters cannot be checked, but the ones checked are satisfied, add the source primitive to

the parse primitive set and the set of primitives to be removed. Get the next source and target primitives for parse.

6. If the source and target primitive types match, return to check the parametrization as shown in mapping 2.
7. If the check for form fails, backtrack. Get the next source primitive to try for parse at that point in the parse.
8. If backtrack is successful, try for form check again.
9. If there are no more source primitives that can be tried for parse at this point, fail recognition and return to the full pattern recognition state.
10. If backtrack fails, return to the full pattern recognition state signalling failure.
11. If all the target primitives are found and the final parametrization is successful, add the number of primitives from this check to the cumulative primitive count. Move to the output state and pass the cumulative primitive count, the parse primitive set, the set of primitives to be removed and signal successful recognition. Request return to the full pattern recognition state S_1'.
12. If final parametrization fails, return to full pattern recognition state signalling recognition

failure.

13. If target pattern primitives comprising the full pattern are exhausted (which says that the whole pattern has been parsed) at the time of reducing a dynamic chain and there are more source primitives in the dynamic chain, discard the parse. Return to full pattern recognition state with a recognition failure.

14. If there are more target primitives to be parsed, but no more source primitives to be tried, fail parse. Revert to the full pattern recognition state.

<u>Partial Pattern Parse Mappings</u>

1. $\delta(S_3,((t,\mu),p,S_2'),1,\Phi,\Phi,\Phi,\Phi,\Phi,\Phi)$

$= (S_3,(\gamma(T),\gamma(P),S_1'),0,0,\alpha=\{p\},\ \alpha'=\{p\},\Phi,\ \Phi,\{2,3\})$

2. $\delta(S_3,((t,\mu),p,S_2'),\Phi,1,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_3,((t,\gamma(\mu)),p,S_1'),0,C,\alpha,\alpha',\Phi,\Phi,\ \{2,3,4,5\})$

3. $\delta(S_3,((t,\mu),p,S_2'),\Phi,0,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_2',(T,\lambda,S_2'),\Phi,0,\alpha=\Phi,\ \alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

4. $\delta(S_3,((t,\Phi),p,S_2'),\Phi,1,1,0,\Phi,\Phi,\Phi)$

$= (A_3,(\gamma(T),\gamma(P),S_2'),0,C=C+1,(\alpha=\alpha\cup p),(\alpha'=\alpha'\cup p),\Phi,\ \Phi,\{2,3\})$

5. $\delta(S_3,((t,\Phi),p,S_2'),\Phi,2,1,0,\Phi,\Phi,\Phi)$

$= (A_3,(\gamma(T),\gamma(P),S_2'),0,C,(\alpha=\alpha\cup p),(\alpha'=\alpha'\cup p),\Phi,\Phi,\{2,3\})$

6. $\delta(A_3,((t,\mu),p,S_2'),1,\Phi,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_3,((t,\mu),p,S_2'),0,C,\alpha,\alpha',\Phi,\Phi,\ \{2,3\})$

7. $\delta(A_3,((t,\mu),p,S_2'),0,\Phi,\Phi,0,\Phi,\Phi,\Phi)$

$= (A_4,((t,\mu),\gamma(P),S_2'),0,C,\alpha,\alpha',1,\Phi,8)$

8. $\delta(A_4,((t,\mu),p,S_2'),\Phi,\Phi,\Phi,0,1,\Phi,\Phi)$

$= (A_3,((t,\mu),p,S_2'),0,C,\alpha,\alpha',\Phi,\Phi,\{6,7\})$

9. $\delta(A_4,((t,\mu),\Phi,S_2'),\Phi,\Phi,\Phi,0,1,\Phi,\Phi)$

$= S_2',(T,\lambda,S_2'),\Phi,0,\alpha=\Phi,\alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

10. $\delta(A_4,((t,\mu),p,S_2'),\Phi,\Phi,\Phi,0,0,\Phi,\Phi)$

$= S_2',(T,\lambda,S_2'),0,0,\Phi,\Phi,\Phi,\Phi,\Phi)$

11. $\delta(S_3,(\Phi,p,S_2'),\Phi,\Phi,\Phi,0,\Phi,(1,C'),S)$

$= (S_2',(T,\lambda,S_2'),\Phi,C=C+C',\alpha,\alpha',\Phi,(1,C,(L,\beta=\alpha),\beta'=\alpha',S_2'),\Phi)$

12. $\delta(S_3(\Phi,p,S_2'),\Phi,\Phi,\Phi,0,\Phi,(0,C'),S)$

$= (S_2',(T,\lambda,S_2'),\Phi,0,\alpha=\Phi,\alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

13. $\delta(S_3,(\Phi,p,S_2'),\Phi,\Phi,\Phi,0,\Phi,(0,C),D)$

$= (S_2',(T,\lambda,S_2'),\Phi,0,\alpha=\Phi,\alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

14. $\delta(S_3,((t,\mu),\Phi,S_2'),\Phi,\Phi,\Phi,0,\Phi,\Phi,\Phi)$

$= (S_2',(T,\lambda,S_2'),\Phi,0,\alpha=\Phi,\alpha'=\Phi,\Phi,(0,0,\Phi,\Phi,\Phi),\Phi)$

15. $\delta(A_3,((t,\mu),p_{ou},S_2'),0,\Phi,\Phi,0,\Phi,\Phi,D)$

$= (A_4,((t,\mu),\gamma(P),S_2'),1,C,\alpha,\alpha'=\alpha'\cup p_{ou},\Phi,\Phi,16)$

16. $\delta(A_4,((t,\mu),p_{ou},S_2'),0,\Phi,\Phi,1,\Phi,\Phi,D)$

$= (A_4,((t,\mu),\gamma(P),S_2'),1,C,\alpha,\alpha'=\alpha'\cup p_{ou},\Phi,\Phi,\{16,17\})$

17. $\delta(A_4,((t,\mu),p,S_2'),0,\Phi,\Phi,1,\Phi,\Phi,D)$

$= (A_4,(\gamma(T),p,S_2'),1,C,\alpha=\alpha\cup p_I,\alpha',\Phi,\Phi,\{17,18\})$

18. $\delta(A_4,((t,\mu),p_{on},S_2'),1,\Phi,\Phi,1,\Phi,\Phi,D)$

$= (S_3,((t,\mu),p,S_2'),0,C,\alpha,\alpha',\Phi,\Phi,\{2,3\})$

19. $\delta(A_4,(\Phi,p,S_2'),0,\Phi,\Phi,1,\Phi,\Phi,D)$

$= (A_3,((t,\mu),\gamma(P),S_2'),0,C,\alpha,\alpha',1,\Phi,8)$

Discussion of Partial Pattern Parse Mappings

Mappings 1 through 14 are a repetition of the mappings shown for the full pattern parse but pertain to the partial pattern recognition state.

15. If the source and target primitive types do not match and the source primitive is an overlapped or unusable one in a dynamic chain, do the following. Add the current source primitive to the set of primitives to be removed, set the synchronization value to 1, implying that the source and target primitive sequences are out of synchronization. Get the next source primitive for parse.

16. As long as source primitives in a dynamic chain are overlapped or unusable and the type does not match the target primitive type expected, add the source primitive to the set of primitives to be removed. Get the next source primitive.

17. If the synchronization value is 1, a source primitive in a dynamic chain is not overlapped or unusable and the source and target primitive types to not match, do the following. Add an imaginary primitive corresponding to the target primitive type expected (along with the parametrization values) to the parse set β, but not to

the set β', the primitives to be removed. Get the next target pattern primitive.

18. If the source primitive is overlapped or non-overlapped (but not unusable) and the source and target primitive types match when the synchronization value is 1, reset this value to 0 and revert to normal parsing as specified in mapping 2.

19. If the synchronization value is 1 and all the target primitives have been checked, backtrack and try again.

3.15 Output Function

This function of the Macromaton is described by a deterministic finite automaton. It is a 7-tuple and is specified as follows:

$R_4 = (Q', \lambda, I, \Delta, S', F', \delta)$ where

$Q' = \{S_1', S_2', S_2'', S_4, S', F'\}$ in which

$\{S_1', S_2', S_2''\} \subseteq Q$ as defined in section 3.11.

$S' = S_4 \varepsilon Q$ the start state as defined.

$F' = \{S_1', S_2', S_2''\} \varepsilon Q$ the final states as defined.

λ = The primitive set

$= (P, \Psi)$ as defined

I = Input to this state and internal to the Macromaton. It has one of two forms.

$I_1 = ((P, \Psi), p), S_R)$ as defined by O in section

3.13 for partial pattern recognition.

I_2 = $(s, C, (L, \beta), \beta', S_R)$ as defined by O_3 in section 3.13 for partial pattern recognition and O in section 3.14 for parsing function. In the mappings, only $\{p_i\} \subseteq \beta = \{p_f\}$ is shown. (These are the non-imaginary primitives.) β' is shown as $\{p_j\}$.

Δ = The output of the Macromaton as defined in section 3.11.

= $\{\rho_i\}, i = 1,4.$

δ = Mapping from finite subsets of $Q \times \lambda \times I$ to finite subsets of $Q \times \lambda \times \Delta$ and defined as shown.

1. $\delta(S_4, (P, \Psi), (((P, \Psi), p_s), S_2''))$
   $= (S_2'', (P, \Psi \underset{M}{<=} r_{p_s}), \Phi)$

2. $\delta(S_4, (P, \Psi), (1, C, (L, \{p_i\}), \{p_j\}, S_1'))$
   $= (S_1', (P-\{p_j\}; P \underset{U}{<=} \{p_o\} \subseteq \{p_i\}, \Psi => \{r_{p_j}\}), \rho_1 = \rho_1 \cup (L, \{p_j\}))$

3. $\delta(S_4, (P, \Psi), (2, C, (L, \{p_i\}), \{p_j\}, S_2'))$
   $= (S_2', (P-\{p_j\}; P \underset{U}{<=} \{p_o\} \subseteq \{p_i\}, \Psi => \{r_{p_j}\}), \rho_2 = \rho_2 \cup (L, \{p_j\}))$

4. $\delta(S_4, (P, \Psi), (3, (\Phi, \{p_i\}), \{p_j\}, S_2')$
   $= (S_2', (P-\{p_j\}; \Psi => \{r_{p_j}\}), \rho_3 = \rho_3 \cup \{p_j\})$

5. $\delta(S_4, (P, \Psi), (4, (\Phi, P), \Phi, E))$
   $= (E, (P, \Psi = \Phi), \rho_4 = P)$

Discussion of Mappings

1. If a type 1 input is received, mark the pointer corresponding to the primitive for which parse was unsuccessful in the appropriate pointer list. Return to the partial pattern recognition state.
2. From the input, add the index and the set of primitives to be removed, to the set of patterns fully recognized. Remove these primitives from the primitive set and their pointers from the pointer list set. The primitives left over are marked unusable corresponding to the overlapped primitives removed. Return to the full pattern recognition state.
3. This is a repeat of 3, but for partial patterns. At completion, return to partial pattern recognition.
4. Add the primitives to be removed to the set where recognition cannot be uniquely determined. Remove these primitives from the primitive set and their pointers from the pointer list set. Revert to partial pattern recognition.
5. When return to end state is requested, make all the remaining primitives the set for which no mapping into the chosen target pattern set exists. Return to the end state.

3.16 Imaginary Parsing Scheme

This section concludes the discussion on the Macromaton function. Figure 3.16 shows the state transition diagram of the Macromaton.

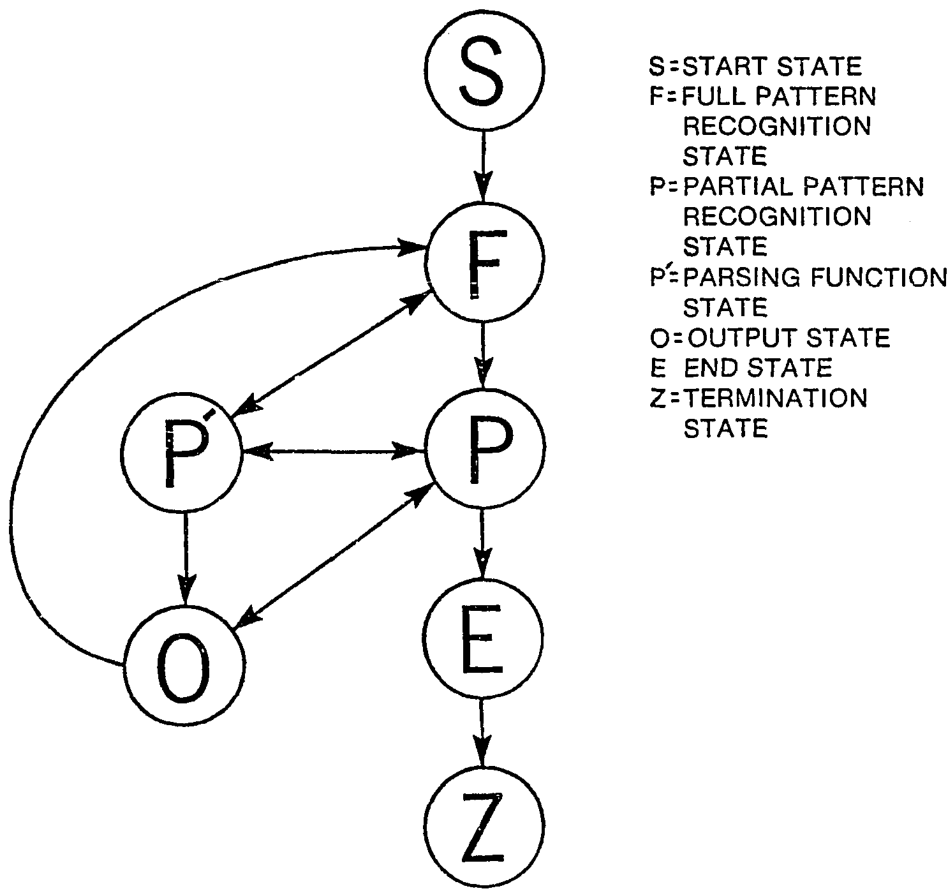


Figure 3.16 Macromaton State Transitions

The following discussion is aimed at providing an overall understanding of the Macromaton function. The parsing scheme outlined is referred to as the "imaginary" parsing scheme. In a pattern parsing scheme wherein patterns overlap each other obscuring some of the primitives, it is not possible to get a complete parse for the pattern. Any attempt to deduce a pattern from only a part of it implies that the missing parts are "imagined" to be present. Hence the name. This scheme is general in scope and works equally well for class A and class B patterns. The following technique describes the imaginary parsing scheme.

The patterns of interest are defined individually using the D-L-A grammar. The order in which the patterns are defined has a hierarchy; the most complex pattern being the first and the simplest the last. The complexity of a pattern is determined by the number of primitives that make up the pattern.

To begin with, all patterns that parse fully are found and removed from the primitive set, starting with the first pattern defined (the most complex) down to the last (the simplest). As the source primitives comprising each target pattern is removed from the source primitive set, the primitives that are left behind and overlapped with the primitives removed, are marked "unusable." Unusable primitives are not eligible to participate in any parse. Consequently they cannot be picked as the starting primitive of a parse.

After all the patterns fully visible are found and removed, recognition of partial patterns is attempted. For any given starting source primitive, parse of each pattern is attempted starting from the most complex, proceeding down to the simplest. Corresponding to this starting source primitive, every possible starting point in each pattern is tried for a parse. Out of all these tries, the parse yielding the greatest number of primitives identifies the partial pattern recognized. This is done as described below.

Starting from the first pointer in the first pointer list, source primitives are selected from the primitive set one at a time as the starting point of a parse. Corresponding to the chosen starting source primitive, the target pattern is searched to see if such a primitive type exists where reduction can be started. If such a primitive exists, parse is tried; if not the next pattern is selected. Once parsing is started, it proceeds by looking for a match between the target primitive and source primitive types and parameter compliance between the primitives in the parse. In dynamic chains, primitives that are marked unusable or those that are overlapped and do not conform to the expected form do not participate in the parse. These are added to the set of primitives to be removed, but not to the parse set. Because of these intervening primitives, if an expected primitive is not found in the parse sequence, an imaginary primitive is filled in and the parse continued until the whole pattern is parsed or the parse fails. The imaginary primitives are not eligible to participate in the parametrization and therefore do not contribute to the count of good primitives in the parse. This is repeated for every possible starting point in the current pattern and the count of the greatest number of good parse primitives is obtained.

The above process is repeated for each pattern defined. The pattern yielding the highest good parse primitive count is identified as the partial pattern. As in the case of full pattern recognition, the source primitives participating in the partial pattern parse are removed from the primitive set and the corresponding overlapped primitives left behind are marked unusable.

If two or more patterns have the same good parse primitive count, then it is not possible to uniquely determine which partial pattern is represented by the parse. In this case, these primitives are added to the set of primitives for which unique recognition is not possible.

If a starting primitive does not yield a good parse for any of the patterns defined, the pointer to that starting primitive is marked. Marked pointers in the pointer list are ineligible to be used to pick a starting source primitive for parse.

The above process is repeated for every possible starting source primitive. Parsing terminates when there are no pointers in any of the pointer lists, using which starting primitive can be obtained. The primitives left over are identified as the set for which no target pattern definitions exist.

CHAPTER IV

VERIFICATION OF FORMALISM

4.0 Introductory Remarks

Computer implementation of concepts discussed was carried out to test the validity of the formalism. Two sets of scenes were defined - one with non-overlapped and the other with overlapped patterns. Scanning and recognition were performed using the principles outlined in the first three chapters. The recognized patterns were displayed on an IBM 3279 color console using "GDDM" software. The scenes defined, data structures and algorithms used in the recognition and the results obtained are presented in the following sections of this chapter.

4.1 Definition of Patterns for Recognition

A set of geometric patterns consisting of circles, squares, rectangles, equilateral triangles and right angle triangles of different colors were used as the basic components of the scenes defined. Patterns from this set were arbitrarily selected and each assigned an arbitrary color. These were then arbitrarily positioned and rotated within the pattern space. The resulting scenes were drawn to scale on paper.

A computer program was written to convert the above scenes to data that could be used by the scanner simulation program. The program was designed to handle up to seven patterns in each scene definition. Of the two sets of scenes defined, the first set consisted of three scenes comprising class A patterns in which none of the shapes overlapped each other. The second set consisted of five class B patterns in which overlapping occurred. The following values obtained from the drawings formed the input to the scene definition program.

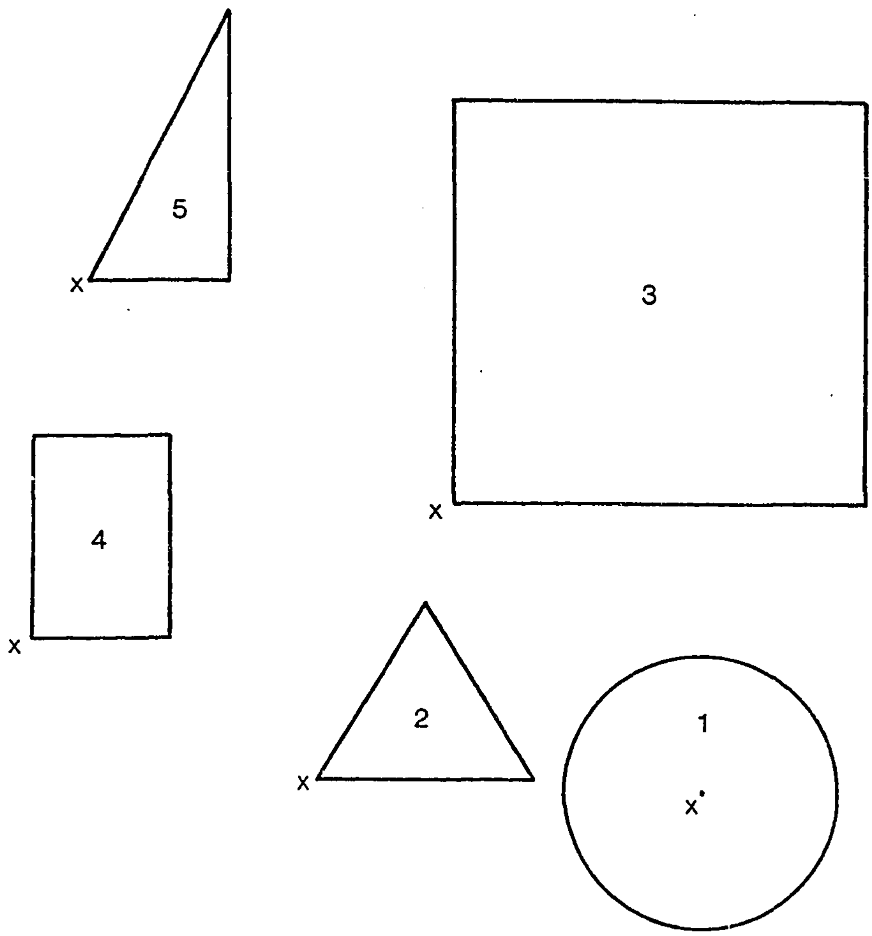
1. Vectorial distance (v_0) to the starting point from the origin - a corner in the case of a straight-sided figure and the center in case of a circle.
2. Angle (Θ_0°) made by the vector v_0 with the +x-axis.
3. Length (L1) of first side in case of a straight-sided figure; radius (R) in case of a circle.
4. Angle (Θ_H°) made by the first side L1 with the +x-axis in the case of straight-sided figures.
5. Length (L2) of the second side in the case of straight-sided figures.
6. Rotation of remaining sides with respect to the first side in the case of straight-sided figures. (0 = clockwise; 1 = counter-clockwise.)
7. Color # of figure.

The smallest side (or radius was limited to 1" for all patterns defined. The program converted the angles from degrees to radians and output the information to a dataset. This then formed the input to the scanner simulation program. The set of patterns defined is shown in Figures 4.1 through 4.8. The symbols used for table headings in these figures is the same as shown in parentheses in the above description. The starting point for the definition of each of these shapes is marked by the symbol "x" in these figures. Samples of output from the scene definition program is included in Appendix A.

4.2 Simulation of Pattern Scanning

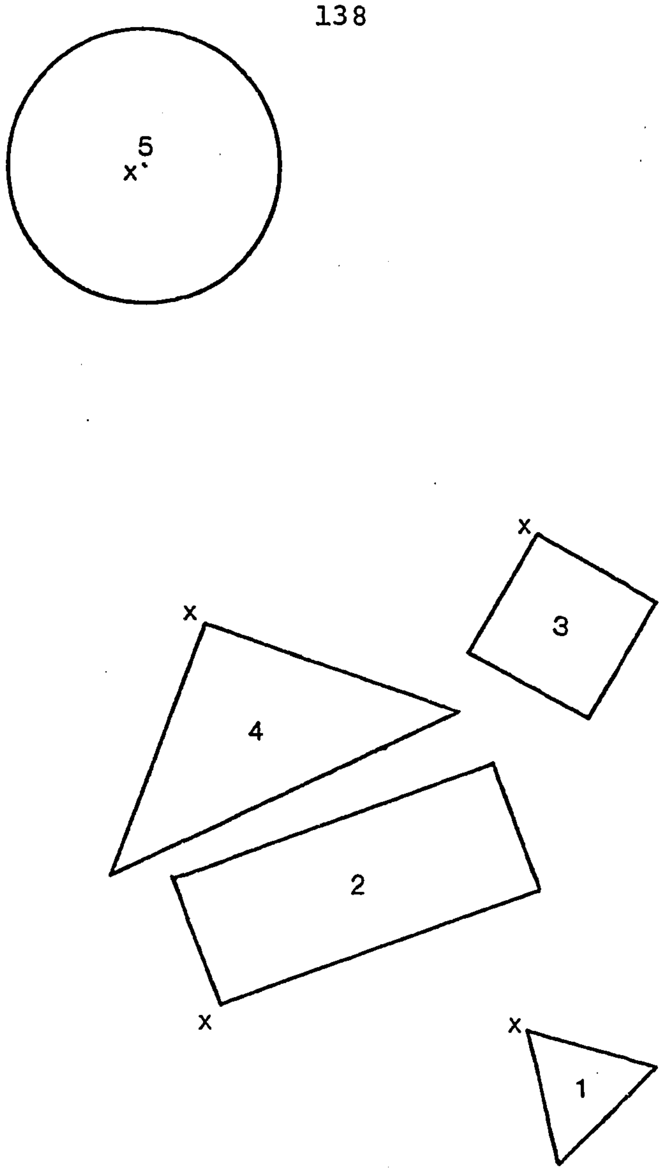
A scanner simulation program was written to convert the defined scenes to a set of values (as outlined in the formalism), which formed the input to the recognition program. Based on the smallest dimension chosen for the pattern definitions (1"), the connectivity distance was arbitrarily selected as 0.1". The sampling distance along the probe was set at 0.025", which amounted to a redundancy factor of 4 in relation to the connectivity distance. The incremental probe angle $d\Theta$ was arrived at as follows. As a first approximation, the expression $r_{max}\,d\Theta$ = connectivity distance was used, where r_{max} is the maximum probe length of the pattern. Based on an 8-1/2" x 11" pattern space, $r_{max} = \sqrt{(8.5^2 + 11^2)} = 13.9"$. Since the connectivity distance was chosen as 0.1", $d\Theta = .007$ radians or 0.4°. With a redundancy factor of 10, the incremental probe angle was set at 0.04.

The scanner simulation program performed the following function. For a given point along the probe, the program



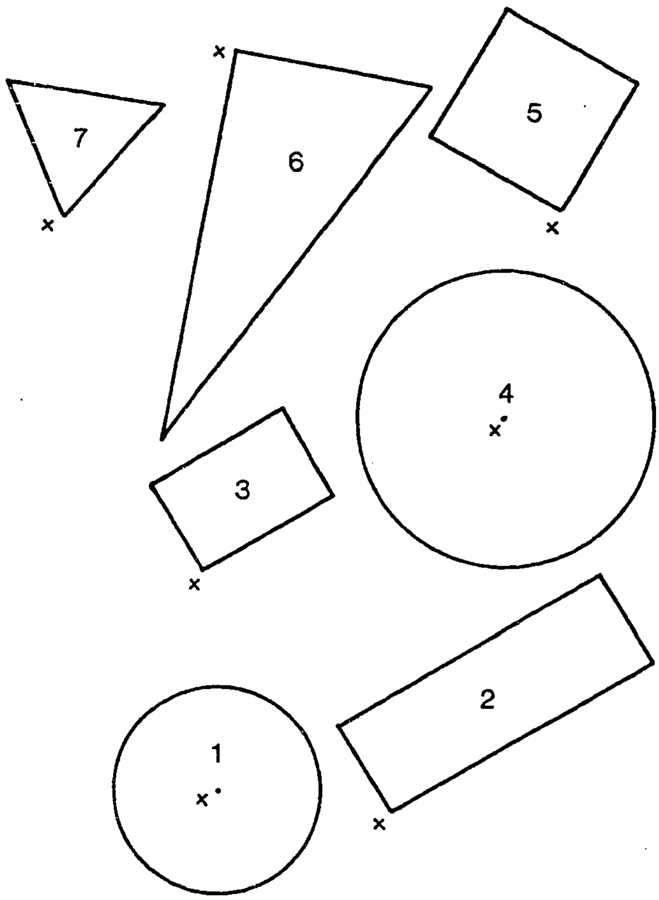
No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Circle	5.5	15.0	1.0				1
2.	Eq.Tri.	3.0	30.0	1.5	0	1.5	1	3
3.	Square	5.0	55.0	3.0	0	3.0	1	2
4.	Rectangle	3.0	60.0	1.0	0	1.5	1	4
5.	Rt.Tri.	5.5	70.0	1.0	0	2.0	1	5

Fig. 4.1 Scene #1 - Non-Overlapped Patterns



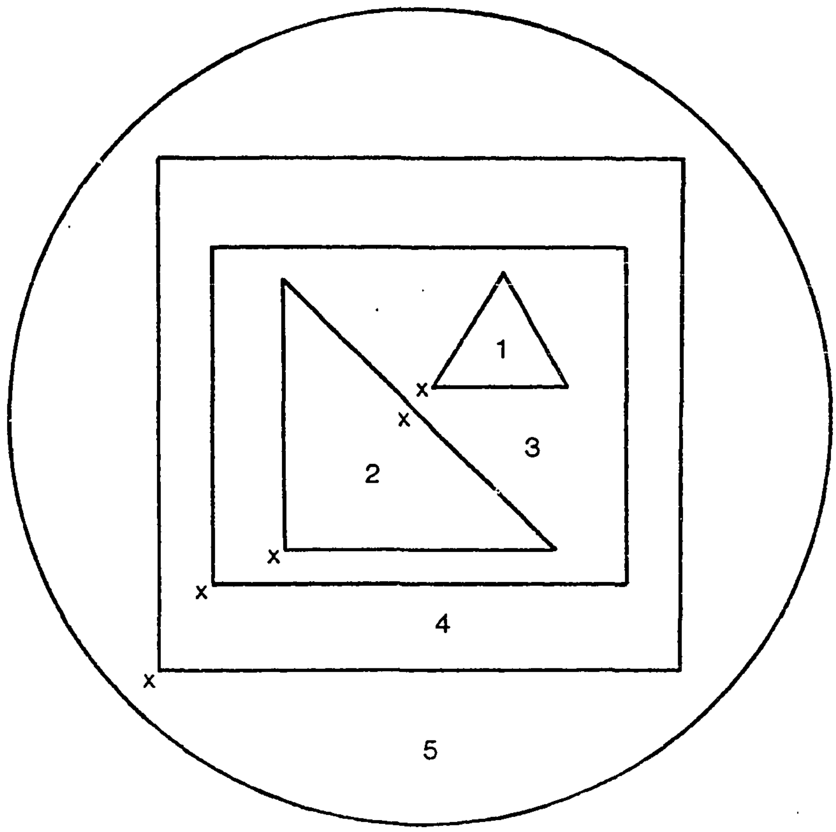
No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Eq.Tri.	5.0	15.0	1.0	15.0	1.0	0	1
2.	Rectangle	3.0	30.0	2.5	20.0	1.0	1	2
3.	Square	7.0	45.0	1.0	30.0	1.0	0	3
4.	Rt.Tri.	5.0	60.0	2.0	20.0	2.0	0	4
5.	Circle	8.0	75.0	1.0				5

Fig. 4.2 Scene #2 - Non-Overlapped Patterns



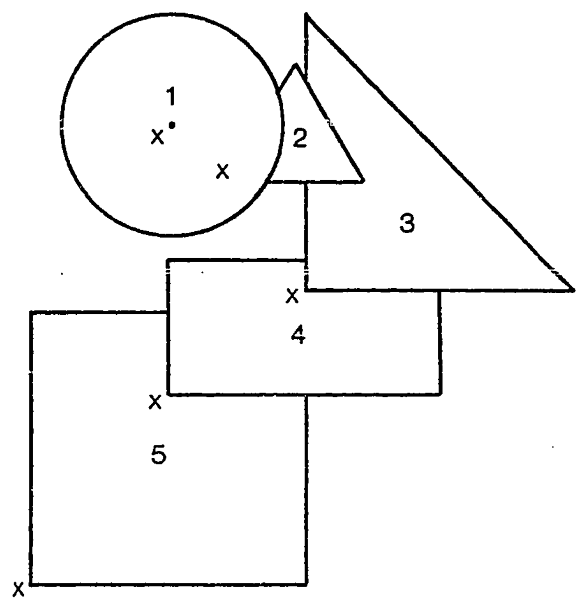
No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Circle	2.5	30.0	1.0				2
2.	Rectangle	4.0	15.0	3.0	30.0	1.0	1	1
3.	Rectangle	4.0	60.0	1.5	30.0	1.0	1	5
4.	Circle	7.0	45.0	1.5				3
5.	Square	9.0	52.0	1.5	60.0	1.5	1	4
6.	Rt.Tri.	9.0	75.0	2.0	10.0	4.0	0	1
7.	Eq.Tri.	7.0	85.0	1.5	50.0	1.5	1	2

Fig. 4.3 Scene #3 - Non-Overlapped Patterns



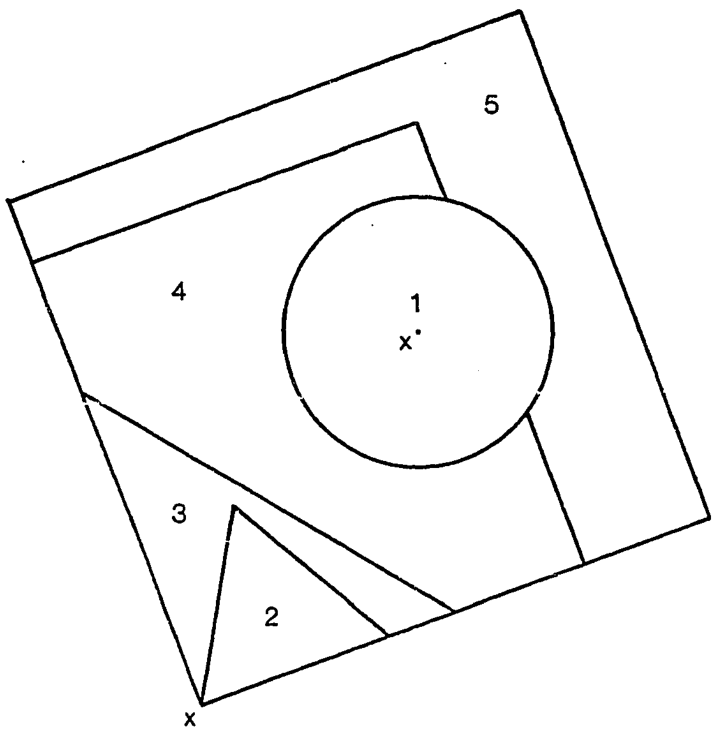
No.	Type	v_o	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Eq.Tri.	6.3	55.5	1.0	0	1.0	1	5
2.	Rt.Tri.	4.7	58.0	2.0	0	2.0	1	4
3.	Rectangle	4.2	61.5	3.0	0	2.5	1	3
4.	Square	3.5	62.5	3.8	0	3.8	1	2
5.	Circle	6.1	55.0	3.0				1

Fig. 4.4 Scene #4 - Overlapped Patterns



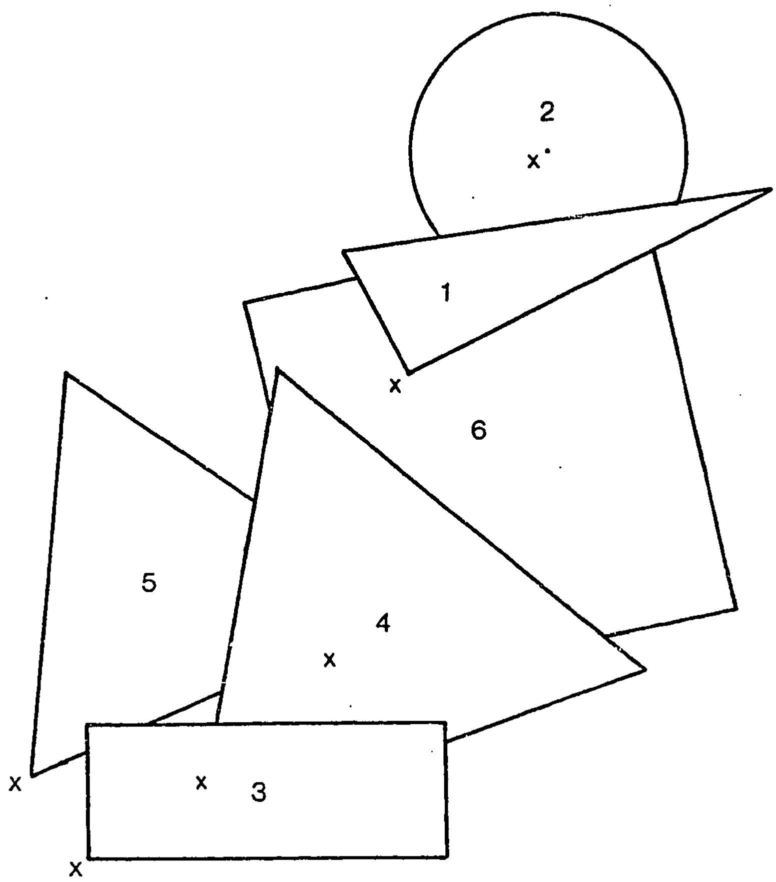
No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Circle	5.8	72.0	1.0				1
2.	Eq.Tri.	5.5	64.0	1.0	0	1.0	1	2
3.	Rt.Tri.	5.1	54.0	2.0	0	2.0	1	3
4.	Rectangle	3.9	59.0	2.0	0	1.0	1	4
5.	Square	2.2	63.0	2.0	0	2.0	1	5

Fig. 4.5 Scene #5 - Overlapped Patterns



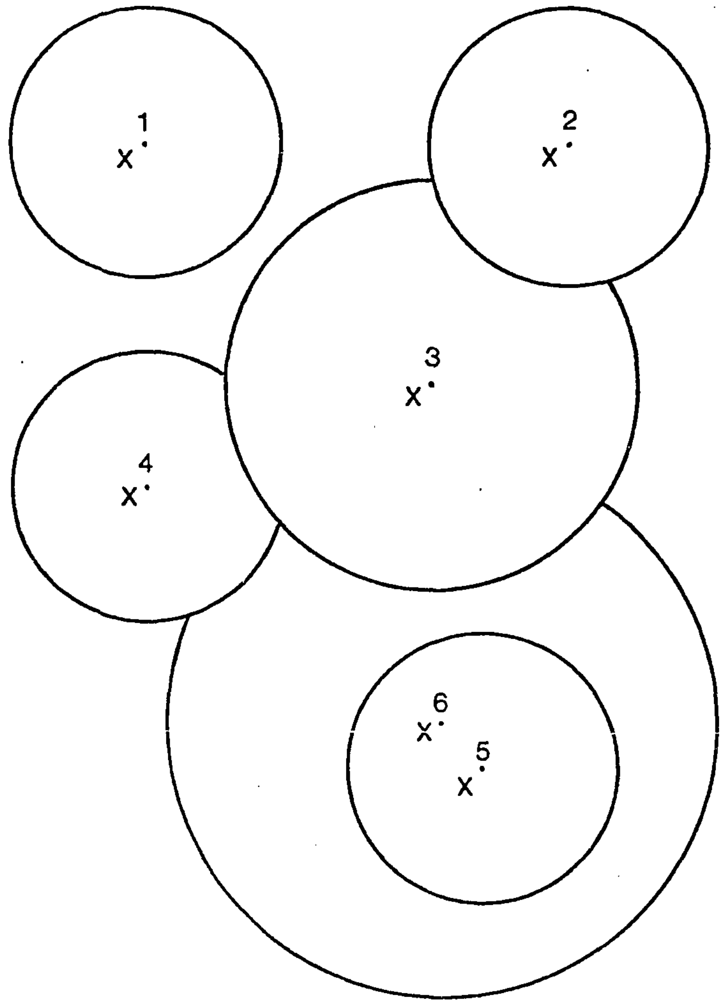
No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Circle	5.8	40.0	1.0				1
2.	Eq.Tri.	3.0	20.0	1.5	20.0	1.5	1	2
3.	Rt.Tri.	3.0	20.0	2.0	20.0	2.5	1	3
4.	Rectangle	3.0	20.0	3.0	20.0	3.5	1	4
5.	Square	3.0	20.0	4.0	20.0	4.0	1	5

Fig. 4.6 Scene #6 - Overlapped Patterns



No.	Type	v_o	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Rt.Tri.	7.1	58.0	3.0	26.5	1.0	1	5
2.	Circle	9.0	58.0	1.0				6
3.	Rectangle	2.8	60.0	2.6	0	1.0	1	1
4.	Eq.Tri.	3.4	50.0	3.5	20.0	3.5	1	2
5.	Eq.Tri.	3.2	72.0	3.0	25.0	3.0	1	3
6.	Square	4.8	48.0	3.0	12.0	3.0	1	4

Fig. 4.7 Scene #7 - Overlapped Patterns



No.	Type	v_0	θ_0^o	R/L1	θ_H^o	L2	Rotation	Color
1.	Circle	8.1	80.0	1.0				1
2.	Circle	9.0	60.0	1.0				2
3.	Circle	7.0	60.0	1.5				3
4.	Circle	5.5	75.0	1.0				4
5.	Circle	5.0	40.0	1.0				5
6.	Circle	5.0	45.0	2.0				6

Fig. 4.8 Scene #8 - Overlapped Patterns

determined whether the point lay within each of the patterns comprising the scene. The color chosen depended on the color of the pattern enclosing the point. In the case of overlapped patterns, the color chosen was that of the first pattern in the pattern definition sequence. Therefore, for overlapped patterns, the first pattern defined was the top-most, while the last pattern defined was the bottommost as would be seen visually. The sampling point was incremented by the sampling distance and the above process was repeated until the end of probe was reached. No output was made until there was a change from a color of interest to the background color or to another color of interest. When this occurred, the following values were output for the color of interest.

1. Distance along probe for start of color.
2. Distance along probe for end of color.
3. Angle made by probe with the +x-axis.
4. Color identification number.
5. Previous scanner color state.
   (0 = Transition from background color.
   1 = Transition from another color.)
6. Next scanner color state.
   (0 = Transition to background color.
   1 = Transition to another color.)
7. Current probe number.

The probe angle was next incremented by $d\Theta$ as defined earlier and the process repeated for a new probe until the probe angle was $\Pi/2$. For this probe angle, when the probe length was 11", scanning was terminated. Samples of scanner output is included in Appendix B.

4.3 Data Structures for Primitive Set Representation

Conforming to the requirements of the formalism, a two-level data structure was used for each primitive in the set of primitives constituting the pattern. One level defined the primitive set P as described in the formalism. It linked together all primitives that constituted any given pattern (such as circle, rectangle, etc., overlapped or not) in a doubly-linked list as shown in Figure 4.9.

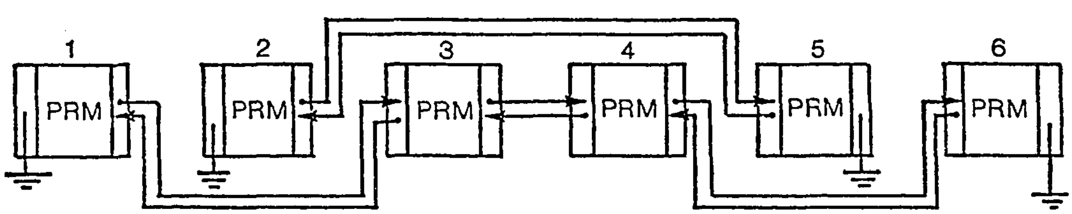


Figure 4.9 Doubly-linked list of pattern primitives

The second level of data structure corresponded to the pointer sets Ω and Ψ. Pointers to all primitives in an "active" state of reduction were linked together in a doubly-linked list, forming the pointer list Ω. Once reduction was completed for a given primitive, the pointer to it was removed from the list Ω, its type determined and added to the appropriate "inactive" primitive pointer list set Ψ. The lists in Ψ were also doubly-linked. This is shown in Figure 4.10.

Samples of output of the primitive set at the end of the primitive formation phase are included in Appendix C.

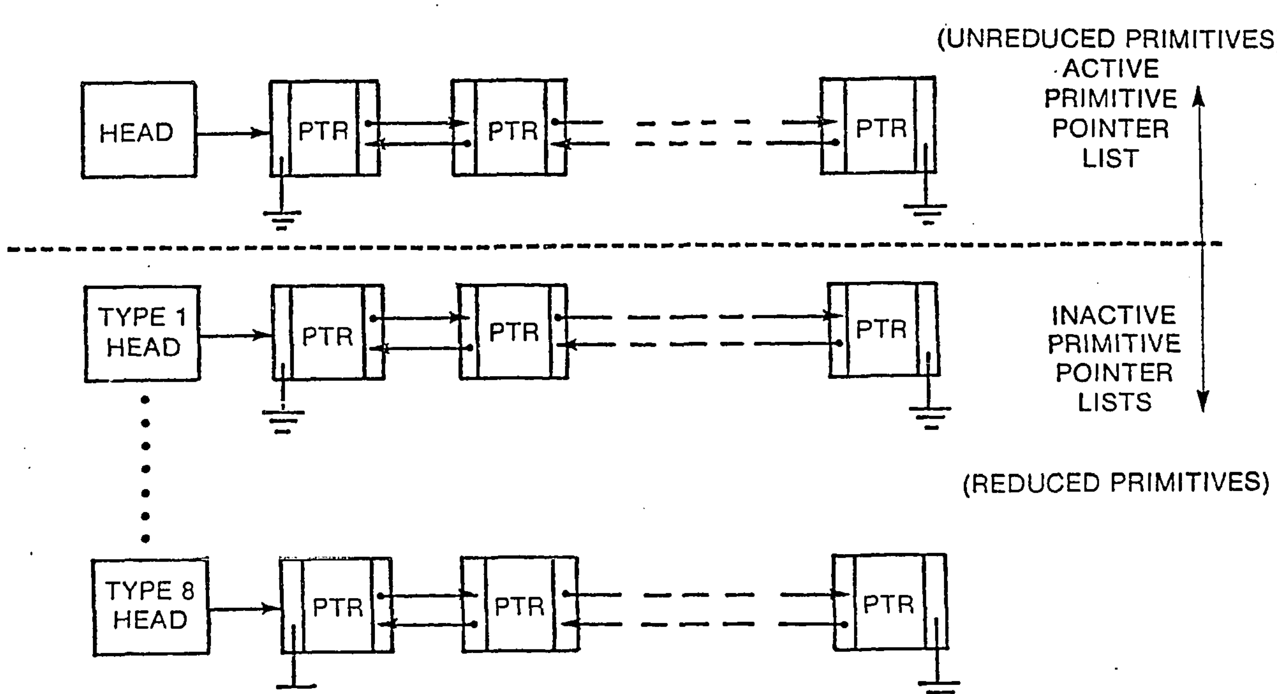


Figure 4.10 Active and inactive primitive pointer lists.

4.4 Data Structure for Target Pattern Representation

The target pattern definitions included the primitive types that made up the form of each pattern and the associated parameters that needed to be satisfied. In the pattern definition sequence, the patterns were defined in the order by the decreasing number of primitives comprising the pattern. The following sequence was used - circle, square, rectangle, equilateral triangle, right angle triangle. Table 4.1 shows the type of parametrization used for the patterns chosen.

Table 4.1 Parametrization Table

Entity	Attribute within entity	Relation	Offset	Tolerance
(A)	(B)	(C)	(D)	(E)
1 = Primitive Attribute	1 = Length 2 = Angle	1 = equal 2 = not equal	+/- integer showing the primitive with which this relation must be satisfied	difference acceptable
2 = Computed value	1 = Radius 2 = Center	3 < $\Pi/2$ 4 = $\Pi/2$ 5 = $\Pi/3$		

The data structure used for definition of these target patterns whose recognition was desired is shown in Figure 4.11. It shows not only the form of the pattern, but its parametrization as well. Details for the rectangle pattern are presented in Figure 4.11.

Pattern id	Form Definition Begin#	Form Definition End#	# of Attr.	Rotate & Reparse	# of Primitives in pattern
3	9	12	3	0	4

#	Prim. Type	Ptr.to Parm. List	Parameter List #	(A)	(B)	(C)	(D)	(E)
						• • • • •		
9	5	21 →	21	1	1	2	-1	5
			22	1	2	4	-1	5
			23	1	1	1	-2	5
10	6	24 →	24	1	1	2	-1	5
			25	1	2	4	-1	5
			26	1	1	1	-2	5
11	7	27 →	27	1	1	2	-1	5
			28	1	2	4	-1	5
			29	1	1	1	-2	5
12	8	30 →	30	1	1	2	-1	5
			31	1	2	4	-1	5
			32	1	1	1	-2	5
	• • •					• • • •		

Figure 4.11 Data structure for rectangle target pattern

4.5 Algorithms

Algorithms used in the recognition scheme are presented in this section. The set of algorithms are presented as a series of "procedures." Each procedure has a set of input and output shown, if applicable. The input are the values that must be available to the procedure upon entry. The output are the values returned or passed by the procedure.

4.5.1 Procedure: Scan

Input: 1. Pattern to be scanned
2. Sampling-distance along probe
3. Incremental-probe-angle

Output: 1. Start-distance of color (QI)
2. End-distance of color (QJ)
3. Probe-angle with +x-axis (Θ)
4. Color-id. (Scolor)
5. Previous-scanner-color-state (PSCS)
6. Next-scanner-color-state (NSCS)
7. Probe-number (PN)

```
Begin
Set  Probe-angle = 0
     Probe-distance = 0
     Probe-number = 0
Do Until Probe-angle = Π/2 and
         Probe-distance = Ymax
     Probe-distance = 0
```

```
Probe-angle = Probe-angle
            + Incremental-probe-angle
Probe-number = Probe-number + 1
Current-color = Background-color
Compute Probe-length
Do Until Probe-end
   Probe-distance = probe-distance
                  + Sampling-distance
   New-color = Background-color
   Do for each pattern defined I,
      If point at Probe-distance is contained by
         pattern (I)
      Then point(I) = 1
      Else point(I) = 0
   End
   Do for each pattern defined I,
      If point(I) = 1
      Then Do
           New-color = color(I)
           stop further checks
           End
   End
   If Current-color ≠ New-color
   Then Do
        If Current-color = Background-color
        Then Do
```

```
            Current-color = New-color
            Start-distance = Probe-distance
            End-Distance = 0
            End
       Else Do
            If New-color = Background-color
            Then Next-scanner-color-state = 0
            Else Next-scanner-color-state = 1
            End-distance = Probe-distance
                         - Sampling-distance
            Output for Current-color
                   Start-distance
                   End-distance
                   Probe-angle
                   Color-id.
                   Previous-scanner-color-state
                   Next-scanner-color-state
                   Probe-number
            If New-color = Background-color
            Then Previous-scanner-color-state = 0
            Else Previous-scanner-color-state = 1
            Set Current-color = New-color
            If Current-color ≠ Background-color
            Then Do
                 Start-distance = Probe-distance
                 End-distance = 0
                 End
```

```
End Do Until
End Do Until
End Scan
```

4.5.2 Procedure: Recognize

```
Output:  1.  Output-all-flag
Begin
   Initialize
   Call Form-Primitives
   Do While primitive set is not null or
            Inactive-primitive-pointer-lists is not null
      Do Until No-more-full-patterns
         Call Find-full-pattern
      End Do Until
      Do Until No-more-partial-patterns
         Call Find-partial-pattern
      End Do Until
      Set Output-all-flag = 1
      Call Output
   End Do While
End  Recognize
```

4.5.3 Procedure: Form-Primitives

Input: 1. Input set from scanner, each input consisting of the following elements.

a. Start-distance of color (QI)

b. End-distance of color (QJ)

c. Probe-angle with +x-axis (θ)

d. Color-id. (Scolor)

e. Previous-scanner-color-state (PSCS)

f. Next-scanner-color-state (NSCS)

g. Probe-number (PN)

2. Active-primitive-pointer-list
3. QI-number from Connectivity-Check Procedure
4. QJ-number - Do -
5. QI-twin from Connectivity-Check Procedure
6. QJ-twin - Do -
7. Reduction primitive set (RPS) from Connectivity-Check Procedure for current scanner input.

Output:

1. One scanner input consisting of the elements shown above.
2. QI-number showing the number of primitives to be reduced with QI of current scanner input
3. QJ-number showing the number of primitives to be reduced with QJ of current scanner input
4. Reduction primitive set (RPS)
5. Primitive-set
6. Final-output-flag

Begin

Initialize

```
Do Until No-more-scanner-input
   Get scanner input
   Using Active-primitive-pointer-list
   If active primitive set is empty
   Then Do
        Set QI-number = 0
            QJ-number = 0
        Call Create-new-primitive
        End
   Else Do
        Call Connectivity-check
        If   QI-number = 0 or
             QJ-number = 0 and QJ ≠ 0
        Then Call Create-new-primitive
        If   QI-number ≠ 0 or
             QJ-number ≠ 0
        Then Call Reduce
        If Previous-probe # ≠ Probe-number
        Then Do
             Set Previous-probe # = Probe-number
             Call Output-Primitives
             End
End Do Until
Set Final-output-flag = 1
Call Output-Primitives
End  Form-Primitives
```

4.5.4 <u>Procedure: Connectivity-Check</u>

<u>Input</u>:
1. Current input from scanner as shown in section 4.5.3
2. Active-primitive-pointer-list
3. Primitive-set
4. Connectivity-distance

<u>Output</u>:
1. Number of primitives to be reduced with QI of current scanner input (QI-number)
2. Number of primitives to be reduced with QJ of current scanner input (QJ-number)
3. Reduction primitive set (RPS) comprising primitives that satisfy connectivity check with current scanner input
4. QI-twin
5. QJ-twin

<u>Begin</u>

<u>Set</u> QI-number = 0

QJ-number = 0

QI-save = QI-twin

QJ-save = QJ-twin

(QI-twin and QJ-twin are from previous scanner input)

QI-twin = 0

QJ-twin = 0

<u>Do While</u> Active-primitive-pointer not null

<u>Using</u> Active-primitive-pointer-list

```
  Get next Active-primitive-pointer
Using Active-primitive-pointer
  Get Primitive
If Primitive-color = Scolor
Then Do
     Set QI-flag = 0
         QJ-flag = 0
     Check distance between QI and New-vector of
       primitive
     If distance ≤ Connectivity-distance
     Then QI-flag = 1
     If QJ ≠ 0
     Then Do
          Check distance between QJ and New-vector
            of primitive
          If distance ≤ Connectivity-distance
          Then QJ-flag = 1
          End
     If QI-flag = 1 and
        QJ-flag = 1 and
        primitive Reduction-id = 0
        Then Do
             QI-number = QI-number + 1
             QJ-number = QJ-number + 1
             Set primitive Reduction-id = 1
             Get next available primitive cell
```

```
        Create new primitive for QJ and set
          its Reduction-id = 2
        (For details on creating a new primi-
        tive for QJ refer to Create-new-primi-
        tive Procedure)
        Link primitive and new primitive to
          each other in the Link1 fields
        Add pointer to the Active-primitive-
          pointer-list for the new primitive;
          mark it ineligible for connectivity-
          check on current probe
        End
If QI-flag = 1 and
   primitive Reduction-id = 1
Then Do
     RPS (I) = primitive #
     I = I + 1
     QI-number = QI-number + 1
     QI-twin = primitive #
     End
If QJ-flag = 1 and
   primitive reduction-id = 2
Then Do
     RPS (I) = primitive #
     I = I + 1
     QJ-number = QJ-number + 1
     QJ-twin = primitive #
```

End

End Do While

If QI-twin $\neq$ 0 and Previous-scanner-color-state = 1

and

QJ-Save $\neq$ 0

Then Do

Save QJ-save as overlapped primitive in QI-twin

Save QI-twin as overlapped primitive in QJ-save

End

End Connectivity-check

4.5.5 Procedure: Create-New-Primitive

Input:

1. Current input from scanner consisting of the elements shown in section 4.5.3
2. Number of primitives to be reduced with QI of current scanner input (QI-number)
3. Number of primitives to be reduced with QJ of current scanner input (QJ-number)
4. Active-primitive-pointer-list
5. Inactive-primitive-pointer-lists
6. Primitive-set
7. Connectivity-distance

Output: 1. New primitive (s)

Begin

If QI-number = 0

Then Do

Get next available primitive cell

```
    Set the following values for new primitive -
      QI # = New primitive #
      Tag # = Probe-number
      Color = Scolor
      Color-state = Previous-scanner-color-state
      Start-vector = QI
      Start-angle = Probe-angle
      End-vector = QI
      End-angle = Probe-angle
      New-vector = QI
      New-angle = Probe-angle
      If QJ ≠ 0
      Then Reduction-id = 1
      Else Reduction-id = 0
      Add pointer to Active-primitive-pointer-list
        for new primitive
    End
If QJ-number = 0 and
   QJ ≠ 0
Then Do
    Get next available primitive cell
    Set the following values for new primitive -
    QJ # = New primitive #
    Tag # = Probe-number
    Color = Scolor
    Color-state = Next-scanner-color-state
```

```
        Start-vector = QJ
        Start-angle = Probe-angle
        End-vector = QJ
        End-angle = Probe-angle
        New-vector = QJ
        New-angle = Probe-angle
        Reduction-id = 2
        Add pointer to Active-primitive-pointer-list for
          new primitive
      End
  If QJ ≠ 0
     If (QJ - QI) ≤ Connectivity-distance
        Then Do
             Set Link1(QI #) = QJ #
                 Link1(QJ #) = QI #
             End
        Else Do
             Get next available primitive cell
             Set the following values for new primitive -
               Tag # = Probe-number
               Primitive-type = 4
               Color = Scolor
               Start-vector = QI
               Start-angle = Probe-angle
               End-vector = QJ
               End-angle = Probe-angle
               Link1 = QI #
```

```
            Link2 = QJ #
            Link1(QI #) = New primitive #
            Link1(QJ #) = New primitive #
            Add pointer to Inactive-primitive-pointer-
              list type 8 for new primitive
          End
     End Create-new-primitive
```

4.5.6 Procedure: Reduce

Input: 1. Current input from scanner as described in section 4.5.3

2. Reduction primitive set (RPS)

3. Primitive-set

4. QI-twin

5. QJ-twin

Output: 1. New primitive (if warranted)

```
Begin
Set I = 1
Do Until No-more-reduction-primitives
   Current-primitive = RPS (I)
   I = I + 1
   If Current-primitive Reduction-id = 1
      Then Vector = QI
      Else Vector = QJ
  For Current-primitive
  If Old-vector = 0
  Then Do
```

```
    Old-vector = New-vector
    Old-angle  = New-angle
    New-vector = Vector
    New-angle  = Probe-angle
    End
Else Do
    Compute the following values -
    dx1 = Algebraic change between the values of
            Start-vector and End-vector in the x-
            direction
    dy1 =      - Do - in the y-direction
    Angle1 = Angle of line joining Start-vector and
               End-vector (defining the primitive)
               with the x-axis
    dx2 = Algebraic change between the values of
            End-vector and Old-vector in the
            x-direction
    dy2 =      - Do -  in the y-direction
    Angle2 = Angle of line joining End-vector and
               Old-vector (defining the primitive)
               with the x-axis
    Rotation1 = Sense of Rotation between the two
                  vectors for which  Angle1 and
                  Angle2 were computed
    dx3 = Algebraic change between the values of
            Old-vector and New-vector in the
            x-direction
```

dy3 = - Do - in the y-direction

Angle3 = Angle of line joining Old-vector and
New-vector (defining the primitive)
with the x-axis

Rotation2 = Sense of Rotation between the two
vectors for which Angle2 and
Angle3 were computed

If (dx1,dx2,dx3) and (dy1,dy2,dy3)
are sign consistent
And
(Angle1 = Angle2 = Angle3)
Or
If (dx1,dx2,dx3) and (dy1,dy2,dy3)
are sign consistent
And
Sense of (Rotation1 = Rotation 2)
Or
If Reduction-id = 1 and
Color-state = Previous-scanner-color-state
Or
If Reduction-id = 2 and
Color-state = Next-scanner-color-state
Then Do
Set the following values for Current-primitive
Tag # = Probe-number
End-vector = Old-vector

```
        End-angle  = Old-angle
        Old-vector = New-vector
        Old-angle  = New-angle
        New-vector = Vector
        New-angle  = Probe-angle
        Cumulative-angle = Cumulative-angle
          + Angle of Line joining Start and
            End-vectors with the x-axis
        Cumulative-total = Cumulative-total + 1
        If (Angle1 = Angle2 = Angle3)
        Then Rotation = 0
        Else Rotation = Rotation1
        If QI-twin ≠ 0 and
           QJ-twin ≠ 0
           If Reduction-id = 1
           Then Primitive-twin = QJ-twin
           Else Primitive-twin = QI-twin
        End
Else Do
 Set Z = Current-primitive #
        Get next available primitive cell
        Set the following values for the
          new primitive from the current primitive-
          Color = Color(Z)
          If Reduction-id(Z) = 1
          Then Color-state =
```

```
            Previous-scanner-color-state
        Else Color-state = Next-scanner-color-state
        Tag # = Probe-number
        Start-vector = Old-vector(Z)
        Start-angle  = Old-angle(Z)
        End-vector   = New-vector(Z)
        End-angle    = New-angle(Z)
        Reduction-id = Reduction-id(Z)
        Primitive-twin = Primitive-twin(Z)
        Link1        = Z
      Link2(Z) = New primitive #
      Primitive-twin(Z) = 0
      Add pointer to the Active-primitive-
        pointer-list for the new primitive
      End
End Do Until
End Reduce
```

4.5.7 Procedure: Output-primitives

Input: 1. Current input from scanner as shown in section 4.5.3
2. Primitive-set
3. Active-primitive-pointer-list
4. Final-output-flag
5. Inactive-primitive-pointer-lists

Output: 1. Inactive-primitive-pointer-lists

Begin

```
Do While Active-primitive pointer not null
   Using Active-primitive-pointer-list
     Get next Active-primitive-pointer
   Using Active-primitive-pointer
     Get Primitive
   If (Probe-number - primitive tag #) > 0 or
      Final-output-flag = 1
   Then Do
        Compute for current active primitive -
        Chord length between Start and End-vectors
          defining the primitive
        Angle that the chord makes with the +x-axis
        Average-angle = Cumulative-angle/Cumulative-total
        If Average-angle ≠ Chord-angle
        Then set primitive type = curve
        Else set primitive type = straight-line
        If Primitive-type = straight-line
        Then Do
             If Reduction-id = 1
             Then Do
                  Vsave = Start-vector
                  Asave = Start-angle
                  Lsave = Link1
                  Start-vector = End-vector
                  Start-angle  = End-angle
                  Link1 = Link2
                  End-vector = Vsave
```

```
            End-angle  = Asave
            Link2 = Lsave
            Area = - Area
            End
        Compute dx = Algebraic change between
                     End-vector and Start-vector
                     in the x-direction
                dy = - Do - in the y-direction
        If dx < 0 and dy > 0
        Then primitive type = 1
        Else
        If dx < 0 and dy < 0
        Then primitive type = 2
        Else
        If dx > 0 and dy < 0
        Then primitive type = 3
        Else
        If dx > 0 and dy > 0
        Then primitive type = 4
        Remove pointer to primitive from
          Active-primitive-pointer-list
        Add pointer to Inactive-primitive-pointer-
          list for primitive by primitive type
        End
    Else Do
        Compute dx = Algebraic change between
```

```
                End-vector and Start-vector
                in the x-direction
            dy = - Do - in the y-direction
If dx < 0 and dy > 0 And Rotation > 0
Then primitive type = 5
Else
If dx < 0 and dy < 0 And Rotation > 0
Then primitive type = 6
Else
If dx < 0 and dy < 0 And Rotation < 0
Then primitive type = 8
Else
If dx < 0 and dy > 0 And Rotation < 0
Then primitive type = 7
Else
If dx > 0 and dy > 0 And Rotation < 0
Then primitive type = 6
Else
If dx > 0 and dy > 0 And Rotation > 0
Then primitive type = 8
Compute radius of primitive
If Reduction-id = 1
Then Do
    Vsave = Start-vector
    Asave = Start-angle
    Lsave = Link1
```

```
    Start-vector = End vector
    Start-angle  = End-angle
    Link1 = Link2
    End-vector = Vsave
    End-angle  - Asave
    Link2 = Lsave
    Area = - Area
    End
Remove pointer to primitive from
  Active-primitive-pointer-list
Add pointer to Inactive-primitive-pointer-
  list for primitive by primitive type
End
If Final-output-flag = 1
Then Do (for each Primitive I in the
         Primitive-set)
    N1 = Twin-primitive # of primitive
    If N1 ≠ 0
    Then Do
         N2 = Twin-primitive # (N1)
         If N2 = I
         Then Do
              Compute
              Chord-length connecting End-
                vectors of primitives N2
                and I
              If Chord-length ≤
```

```
Connectivity-distance
Then Do
    Link2(I) = N2
    Link2(N2) = I
    End
Else Do
    If Reduction-id(I) = 1
    Then M1 = I
    Else M1 = N2
    If M1 = I
    Then M2 = N2
    Else M2 = I
    Get next available
      primitive cell
    Set the following values
      for new primitive -
    Color = Color(M1)
    Type  = 2
    Start-vector = End-
      vector(M2)
    Start-angle = End-angle
      (M2)
    End-vector = Start-vector
      (M1)
    End-angle = Start-angle
      (M1)
```

Set Links as follows -

Link1(M1) = New prim#

Link2(M2) = New prim#

Link1(New prim#) = M2

Link2(New prim#) = M1

Add pointer to Inactive primitive-pointer-list type6 for new primitive

End

End Output-Primitives

4.5.8 Procedure: Find-Full-Pattern

Input:
1. Primitive-set
2. Inactive-primitive-pointer-list
3. Target pattern definitions
4. Form-found-flag
5. Recognition-flag
6. Output-primitive-set
7. Parse-primitive-set

Output:
1. Primitive-set
2. Form-found-flag
3. Recognition-flag
4. Target pattern definition
5. Output-primitive-set
6. Recognition-type
7. Starting-source-primitive

8. Output-primitive-set
9. Parse-primitive-set
10. Output-set

```
Begin
Set  Recognition-type = Full
Do Until  No-more-target-patterns
     Get  next target pattern
     Set  Form-found-flag = No
          Recognition-flag = Fail
          Rotation-exhausted-flag = No
      Do While  Rotation-exhausted-flag = No
         Do Until  No-more-starting-source-primitives or
                   Form-found-flag = Yes
              Set  Distinguished-primitive-type =
                   First Primitive type in target
                   pattern definition
            Using  Inactive-primitive-pointer-list
              Get  next Inactive-primitive-pointer
            Using  Inactive-primitive-pointer
              Get  Starting-source-primitive
              Call Parse-For-Form
            End  Do until
               If  Form-found-flag = Yes
               Then Do
                    Call Check-Parameters
                      If Recognition-flag = Success
```

```
                  Then  Do
                        Set  Output-set = 1
                        Call Output
                        End
                  Else  Do
                        If  Form-found-flag = No   Or
                            Recognition-flag = Fail
                        Then Do
                             If  Rotate-pattern = No
                             Then  Rotation-exhausted-
                                   flag = Yes
                             Else Do
                                  Rotate target pattern
                                  Set Form-found-flag =
                                      No
                                      Recognition-flag
                                      = Fail
                                  End
                  End  Do while
   End  Do Until
   End  Find-Full-Pattern
```

4.5.9 Procedure: Find-Partial-Pattern

Input: 1. Primitive-set

2. Inactive-primitive-pointer-lists

3. Target pattern definitions

4. Form-found-flag

5. Recognition-flag

6. Good-primitive-count

7. Parse-primitive-set

8. Output-primitive-set

Output: 1. Primitive-set

2. Form-found-flag

3. Recognition-flag

4. Target pattern definition

5. Output-primitive-set

6. Recognition-type

7. Starting-source-primitive

8. Good-primitive-count

9. Output-primitive-set

10. Parse-primitive-set

Begin

Set Recognition-type = Partial

Do Until No-more-starting-source-primitives

    Using Inactive-primitive-pointer-lists

        Get next Inactive-primitive-pointer

    Using Inactive-primitive-pointer

        Get Starting-source-primitive

        Set Target-pattern # = 0

            Non-unique-set = Null

            Partial-set = Null

            Previous-primitive-count = 0

        Do Until No-more-target-patterns

            Get next target pattern

            Set Form-found-flag = No

```
          Recognition-flag = Fail
          Rotation-exhausted-flag = No
    Do While  Rotation-exhausted-flag = No
       Call  Parse-for-form
       If    Form-found-flag = Yes
       Then Do
           Set  good-primitive-count = 0
           Call check-parameters
            If  good-primitive-count >
                previous-primitive-count
           Then Do
                Set  Partial-set = Output-primitive-
                       set
                     Partial-pattern # = Pattern #
                     Partial-parse-set = Parse-
                       Primitive-set
                     Non-Unique-set = Null
                End
            Else If  Good-primitive-count =
                     Previous-primitive-count
                Then Do
                     Set  Non-Unique-set =
                            Partial-set
                     Add  to Non-Unique-set the
                          Output-primitive-set
                     Set  Partial-set = Null
```

```
                        Partial-Parse-set = Null
                   End
         Else If Rotate-pattern = No    Or
                 Rotations-exhausted
              Then Set Rotations-exhausted-flag =
                       Yes
              Else Rotate pattern
         End  Do While
     End Do Until
      If Previous-primitive-count = 0
      Then Mark  pointer to current source primitive
      Else Do
           If  Non-Unique-set ≠ Null
           Then Do
                Set  Output-set = 3
                     Output-primitive-set = non-
                       Unique-set
                End
           Else Do
                Set  Output-set = 2
                     Parse-primitive-set = Partial
                       parse-set
                     Output-primitive-set = Partial
                       set
                End
           Call Output
```

End Do Until

End Find-Partial-Pattern

4.5.10 **Procedure**: **Parse-For-Form**

Input: 1. Primitive-set

2. Target pattern to be parsed

3. Starting-source-primitive

4. Recognition-type

5. Form-found-flag

Output: 1. Output-primitive-set

2. Parse-primitive-set

```
Begin
If  Recognition-type = Partial
Then Do
     Search  target pattern form for same type as
       starting-source-primitive
     If      primitive type not found
     Then    Return to calling procedure
     Else Set TPTR = Pointer to target pattern primitive
                     of same type as starting-source-
                     primitive
     End
Else Set  TPTR = pointer to first target pattern
                 primitive
          TSAVE = TPTR
Save  Starting-source-primitive in
      Output-primitive-set   and
```

```
     parse-primitive-set
Set  N =  Starting-source-primitive #
     NSAVE = N
Do Until  check = complete
   Check = Forward
   Increment = +1
   Sync-flag = Off
   Do While  NSAVE ≠ N    or
             N ≠ 0
      If Check = Forward
      Then  N = Link2(N)
      Else  N = LINK1(N)
      If  Source-primitive is marked "Unusable" and
          Recognition-type = Full
      Then  Return to calling procedure
      If  Source-primitive-type = Target primitive type
            pointed to by TPTR or (TPTR + Increment)
      Then Save  Source-primitive in
                 Output-primitive-set    and
                 Parse-primitive-set
      Else Do
           If  Recognition-type = Full
           Then  Return to calling procedure
           Else If  Source-primitive is "overlapped"
                Then Do
                     Set  Sync-flag = On
```

```
          Save  Source-primitive in
                Output-primitive-set
          If  Check = forward
          Then  N = Link2(N)
          Else  N = Link1(N)
          End
     Else Do
          Set  PTR = Current target primitive
                     pointer
          Do While  PTR ≠ TSAVE or
                    Target primitive type
                    same as Source-primitive
                    type
                If  Target primitive (PTR)
                    not same type as source-
                    primitive type
                Then Do
                     Save  Imaginary primi-
                       tive the same type as
                       target primitive in
                       Parse-primitive-set
                       Set PTR = (PTR +
                       Increment)
                       End
                End  Do while
          If  PTR = TSAVE
```

```
                Then  Return to calling procedure
                Else Do
                     Save  Source-primitive in
                           Output-primitive-set
                             and
                           Parse-primitive-set
                     Set   Sync-flag = Off
                           TPTR = PTR
                     If    Check = Forward
                     Then  N = Link2(N)
                     Else  N = Link1(N)
                     End
End   Do While
If    N = NSAVE or
      TPTR = TSAVE
Then Do
      Set  check = complete
           Form-found-flag = Yes
           Return to calling procedure
      End
Else Do
      If  N = 0
      Then Do
           Set  Check = Backward
                NEND = N
                N = Link1(NSAVE)
                NSAVE = NEND
```

```
                    TPTR = TSAVE

               End

      End  Do until

      End  Parse-For-Form
```

4.5.11 Procedure: Check - Parameters

```
      Input:  1.  Parse-primitive-set
              2.  Recognition-type
              3.  Recognition-flag
      Output: 1.  Good-primitive-count
              2.  Recognition-flag

      Begin
      Set  Good-primitive-count = 0
      If   Recognition-type = Partial
      Then Do
           For each non-Imaginary primitive in the parse prim-
           itive set, extrapolate straight-line Primitives
           End
      Do Until  No-more-Parse-primitives
         Do Until  No-more-parameters-to-check
              Get  offset
               If  Offset primitive not imaginary  and
                   Parse-primitive not imaginary
               Then Do
                    Set  value 1 = value of attribute of
                                   parse-primitive
                         value 2 = value of attribute of
                                   offset-primitive
```

```
                Find  Difference = |Value1 - Value2|
                If    Difference > Error tolerance
                Then Do
                     Set  Recognition-flag = Fail
                     Return to calling procedure
                     End
                End
           End  Do Until
           Set  Good-primitive-count =
                Good-primitive-count +1
                Total = Total +1
           End  Do Until
           Set  Recognition-flag = Success
      End  Check-Parameters
```

4.5.12 <u>Procedure</u>: <u>Output</u>

Input: 1. Primitive-set
2. Inactive-primitive-pointer-lists
3. Output-primitive-set
4. Parse-primitive-set
5. Recognition-type
6. Output-all-flag
7. Output-set

Output: 1. Full pattern primitive set
2. Partial pattern primitive set
3. Non-unique primitive set
4. Unrecognized primitive set

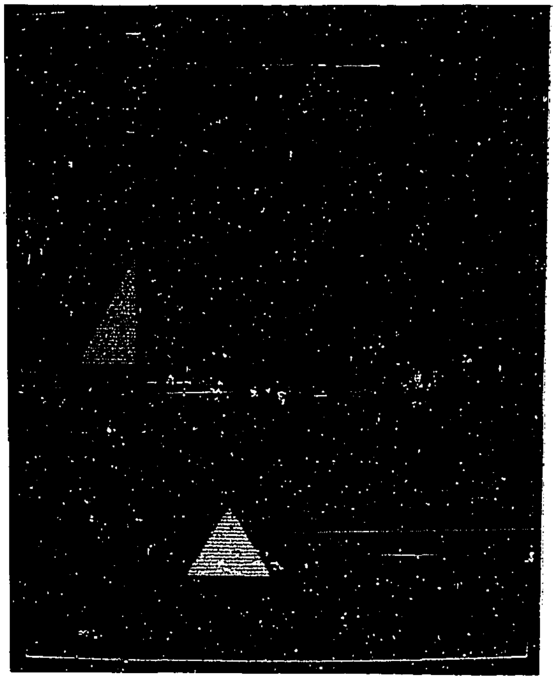
```
Begin
If   Output-all-flag ≠ Yes
Then Do
     If  Output-set = 1 or 2
     Then Do
          Begin
          For  each primitive in the Parse-primitive-
            set that is non-imaginary and overlapped
          Get  corresponding overlapped primitive(s)
               in the Primitive-set
          Mark  overlapped primitive(s) "unusable"
          Remove  pointers to Output-primitive-set
            from  Inactive-primitive-pointer-lists
          End
          If  Output-set = 1
          Then ADD  Output-primitive-set to
                    Full pattern primitive set
          Else ADD  Output-primitive-set to
                    Partial pattern primitive set
          End
     Else  Add Output-primitive-set to
           Non-unique pattern primitive set
           End
Else Add  remaining primitives to
          Unrecognized pattern primitive set
End
End Output
```

4.6 Discussion of Results

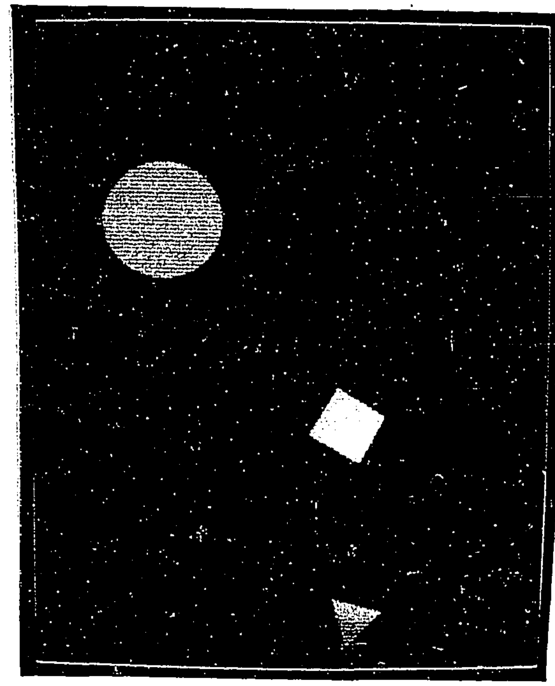
The results obtained from the recognition program were displayed on an IBM 3279 color console, using IBM's "GDDM" software. Color pictures obtained from these displays are shown in color plates 1 and 2. The recognition output from the program showing the primitives of each pattern identified in a given scene is presented in Appendix D.

Out of a total of 44 patterns defined in the 8 scenes, one partial pattern was misrecognized. Two others which were fully visible, though correctly recognized, were identified as partially visible. The misrecognition occurred on the partially visible equilateral triangle (Pattern #2) in Figure 4.5. This was due to an error in identifying the primitive type. In Appendix C, for scene 5, the circled primitive, #23 shows a type 2, but should have been type 3. In the other two instances, the first relates to the square (pattern # 5) in Figure 4.3. The program failed to generate the closing side which coincided with the sweep-vector. The second one relates to one of the circles (pattern #2) in Figure 4.8. In Appendix C for scene 4.8, the circled primitive, #22 shows a radius of 1.8 but should have been close to 1.0.

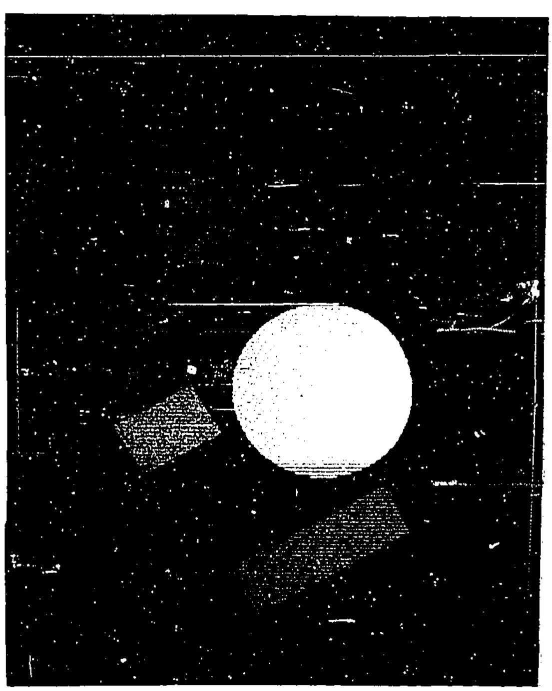
The straight sided figures were drawn from the primitives identified by the recognition program with no smoothing, while circles were drawn using the radius and center



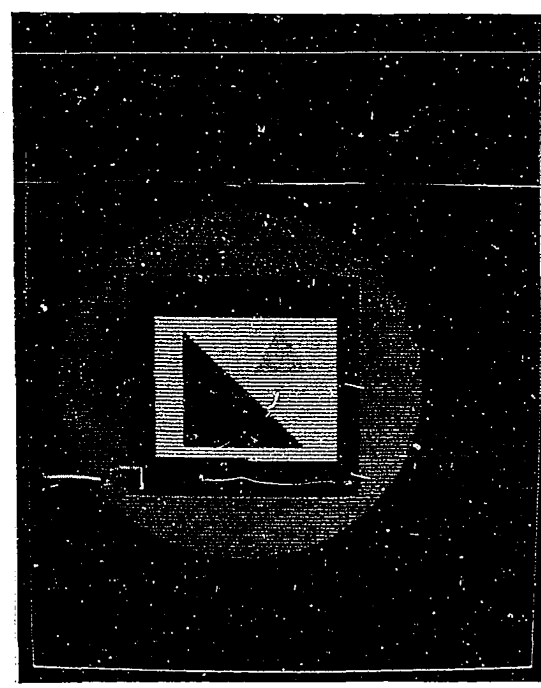
SCENE #1



SCENE #2

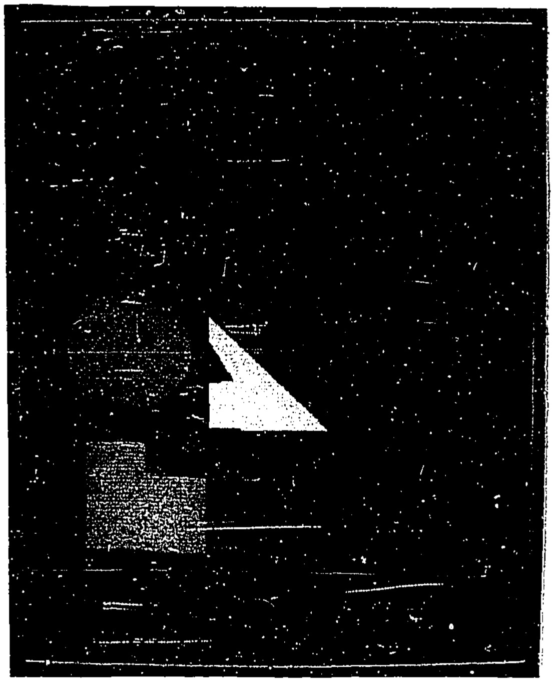


SCENE #3

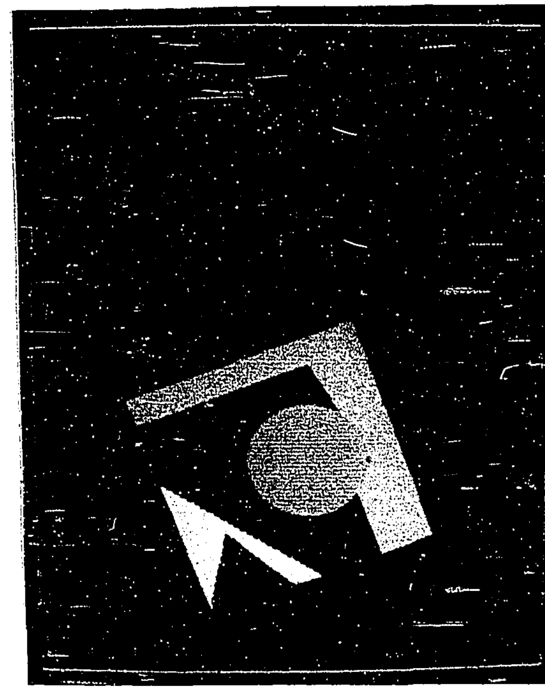


SCENE #4

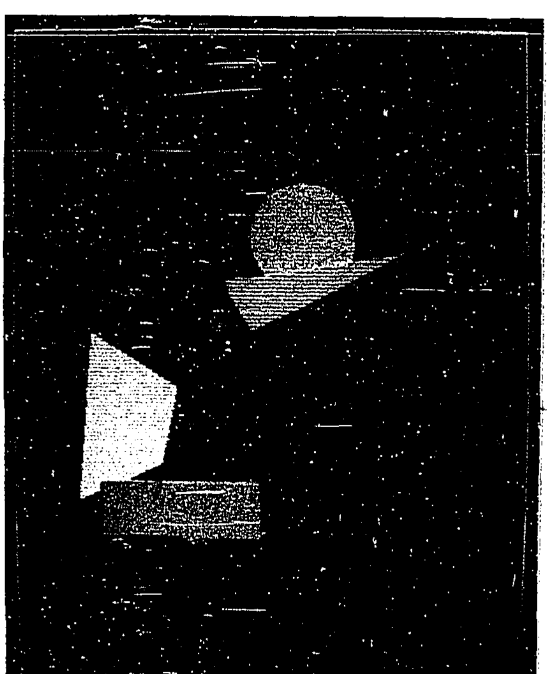
COLOR PLATE 1



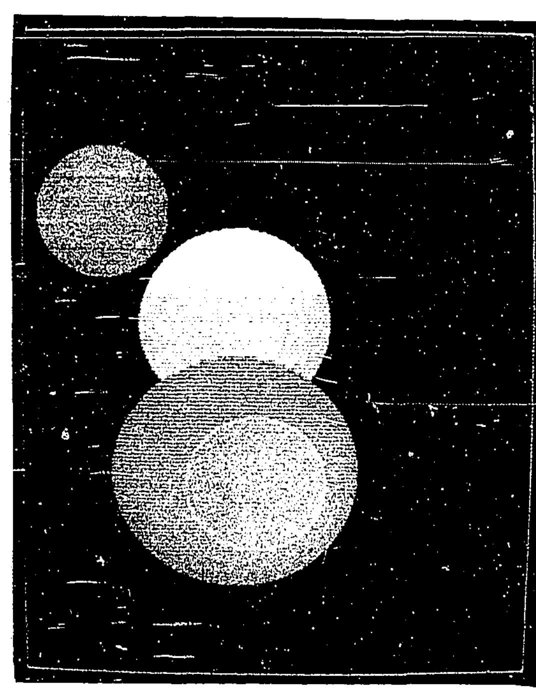
SCENE #5



SCENE #6



SCENE #7



SCENE #8

COLOR PLATE 2

identified by the program. The following observations of the color pictures are worthy of note. In some of the straight sided figures, the horizontal edges have a stair-step appearance. This is especially pronounced in scene #5. In scene #6, a dark area at the right top corner of the green rectangle has been left unfilled. This area belongs to the outer blue square. These are minor problems with the recognition program itself and have no bearing on the validity of the formalism.

One final observation is in order. Referring to Figure 4.8 and its corresponding color picture in color plate 2, the view of the circles in Figure 4.8 differs from the corresponding ones in the color picture. This is due to the "overcoat"/"undercoat" feature of the "GDDM" software and the sequence in which the circles are drawn. Since this does not relate directly to this study, no further discussion is made regarding this.

4.7 Space-Time Complexity of Recognition Algorithm

The space requirements of the recognition algorithms is of the order N where N is the number of primitives comprising the scene. Since the source data from the scanner is not retained, but only its reduced version in terms of the primitives, the memory requirements are small compared to matrix manipulation schemes by an order N. In the worst case, the memory requirements are of the order N^2 for a pattern that consisted of nothing but dots.

The time requirements is addressed in two parts - one for formation of primitives and the other for carrying out the recognition.

During the primitive formation phase, the time requirements are governed by two factors - the number of primitives in the active primitive set and the number of input received from the scanner. For each input from the scanner, the active primitive set has to be searched once for establishing connectivity. If there are N active primitives and N input is received per probe, then the time requirement per probe is N^2. If there are N probes in scanning the pattern, then the time requirement is of the order N^3.

During the recognition phase, the time requirements depend on the number of patterns defined, the number of primitives in the pattern and the number of primitives in the inactive primitive set. The worst case occurs in the recognition of partial patterns. For each starting primitive in the inactive primitive set, a target pattern is searched for a corresponding primitive type for starting the parse. Since recognition is not carried out until each pattern is checked, if there are N primitives in each of the N patterns, the time required for each starting primitive is N^2. With N primitives in the inactive primitive set for starting the parse, the time requirement is of the order of N^3.

CHAPTER V

CONCLUSION

5.0 Review of Current Work

The details presented in the preceding four chapters fulfill the fourfold objectives of this study as stated in section 1.1. The significant contributions of this work may be summarized as follows. Of Primary importance is the approach to the problem of syntactic pattern recognition as presented in Figure 3.1. The conprehensive treatment of the two-dimensional pattern recognition problem starting from the method of scanning the pattern, followed by the syntactic identification of the pattern primitives, all the way to the syntactic recognition of the desired patterns is important as well.

One of the significant outcomes of this work is that the structure of a two-dimensional pattern is nothing more than a static and dynamic combination of the pattern primitives. The choice of primitive types as described, allow a more uniform basis for choosing pattern primitives from one problem area to another. Perhaps one of the more significant contributions of this work is the approach outlined for the recognition of partially obscured patterns. The implementation of these ideas for recognition of geometric patterns gives credibility to the viability of the proposed formalism.

5.1 Suggestions for Further Work

The scope of the two-dimensional pattern recognition problem is too broad indeed for its complete solution in a study such as this. The value of this work may be enhanced by addressing and pursuing several areas of work, some of which is described below.

One of the areas needing further work is the determination of the optimum scanning parameters in terms of the sampling-distance and the incremental probe angle. In the implementation presented in Chapter IV, it appears that the redundancy in sampling is very high in relation to the connectivity-distance chosen. The problem of connectivity not being met presented itself in those instances where an edge was almost coincident with the probe angle, but was slightly off. Since this implementation was not aimed at efficiency, a "brute force" approach was taken to ensure that points sampled in a pattern met the connectivity criterion.

A more basic question to be answered, is the technique for arriving at the connectivity-distance to be used, given the pattern parameters in a scene.

Another area of work involves the study of the organization of data and the structures to be used for improving the efficiency of the algorithms. As an instance, the following may be pointed out. Instead of having a single active primitive pointer list, if one list was maintained for each color function, then only that list needs to be searched corresponding to the color function of the scanner input.

Additional work is required in the formalism developed in two important areas. The first deals with the problem of noise and missing input values from the scanner. This would necessitate the incorporation of smoothing techniques as another module to the formalism outlined. The second involves the extension of the formalism from two to three-dimensional patterns.

In this study, if the scanner is able to distinguish one object from another, then the objects are said to have different colors. What physical condition must prevail to realize this in the real world was of no concern to the present study but warrants further elaboration where required.

This system is not an intelligent system. It is not designed to synthesize patterns from the scanner's input, not already specified in its set of grammars. The possibilities exist for such generalizations, but have not been pursued.

It is hoped that this work has made some innovative contributions to the area of syntactic two-dimensional pattern recognition. The generalizations presented would enable the use of this system to a wide ranging field of applications, all the way from recognition of medical laboratory specimens to vision systems for robots.

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APPENDIX A

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.INPUT.LIST


            <--- C O L U M N S  --->
            000000000111111111122222
            123456789012345678901234

            115.500.261.000.261.0011      SCENE 1 DEFINITION

            235.000.783.000.003.0012

            343.000.521.500.001.5013

            433.001.051.000.001.5014

            555.501.222.001.571.0015


            145.000.261.000.261.0001      SCENE 2 DEFINITION

            233.000.522.500.351.0012

            337.000.791.000.521.0003

            455.001.052.000.352.0004

            518.001.311.000.0 1.0005


            134.000.263.000.521.0011      SCENE 3 DEFINITION

            212.500.521.000.0 1.0012

            317.000.791.500.0 1.5013

            439.000.911.501.051.5014

            534.001.051.500.521.0015

            659.001.312.000.174.0001

            747.001.481.500.871.5012
```

```
<--- C O L U M N S  --->
000000000111111111122222
123456789012345678901234

146.350.971.000.0 1.0015        SCENE 4 DEFINITION
254.701.012.000.0 2.0014
334.251.073.000.0 2.5013
433.501.093.800.0 3.8012
516.100.963.000.0 3.0001

115.801.261.000.0 1.0001        SCENE 5 DEFINITION
245.551.121.000.0 1.0012
355.150.942.000.0 2.0013
433.951.032.000.0 1.0014
532.251.102.000.0 2.0015

115.800.701.000.0 1.0001        SCENE 6 DEFINITION
243.000.351.500.351.5012
353.000.352.000.352.5013
433.000.353.000.353.5014
533.000.354.000.354.0015
```

```
<--- C O L U M N S --->
000000000111111111122222
123456789012345678901234

157.101.013.000.461.0016        SCENE 7 DEFINITION

219.001.011.000.0 1.0015

332.801.052.600.0 1.0011

443.400.873.500.353.5012

543.201.263.000.443.0013

634.800.843.000.213.0014


118.001.401.000.0 1.0001        SCENE 8 DEFINITION

219.001.051.000.0 1.0002

317.001.051.500.0 1.5003

415.501.311.000.0 1.0004

515.000.701.000.0 1.0005

615.000.792.000.0 2.0006
```

COLUMNS	DESCRIPTION	
1	INPUT NUMBER	
2	PATTERN TYPE	1 = CIRCLE
		2 = SQUARE
		3 = RECTANGLE
		4 = EQUILATERAL TRIANGLE
		5 = RIGHT ANGLE TRIANGLE
3 - 6	LENGTH TO STARTING POINT FROM ORIGIN	
7 - 10	ANGLE OF STARTING POINT	
11 - 14	LENGTH OF FIRST SIDE / RADIUS	
15 - 18	ANGLE OF FIRST SIDE / RADIUS WITH +X AXIS	

COLUMNS	DESCRIPTION (CONTD.)
19 - 22	LENGTH OF SECOND SIDE
23	ROTATION OF SUBSEQUENT SIDES WITH FIRST SIDE (0 = CLOCKWISE; 1 = COUNTER-CLOCKWISE)
24	COLOR OF PATTERN

APPENDIX B

**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCAN6.LIST

```
##################################
OUTPUT FROM SCANNER FOR SCENE 6
##################################

0 3.0250 4.47490.35007621      585
0 4.4999 4.97490.35007631      585
0 4.9999 5.99990.35007641      585
0 6.0249 6.99990.35007650      585
0 3.0250 4.47490.35067621      586
0 4.4999 4.97490.35067631      586
0 4.9999 5.99990.35067641      586
0 6.0249 6.99990.35067650      586
0 3.0250 4.47490.35127521      587
0 4.4999 4.97490.35127531      587
0 4.9999 5.99990.35127541      587
0 6.0249 6.99990.35127550      587
0 3.0250 4.47490.35187521      588
0 4.4999 4.97490.35187531      588
0 4.9999 5.99990.35187541      588
0 6.0249 6.99990.35187550      588
0 3.0250 4.47490.35247421      589
0 4.4999 4.97490.35247431      589
0 4.9999 5.99990.35247441      589
0 6.0249 6.99990.35247450      589
0 3.0250 4.47490.35307421      590
0 4.4999 4.97490.35307431      590
0 4.9999 5.99990.35307441      590
0 6.0249 6.99990.35307450      590
0 3.0250 4.47490.35367321      591
0 4.4999 4.97490.35367331      591
0 4.9999 5.99990.35367341      591
0 6.0249 6.99990.35367350      591
0 3.0250 4.47490.35427321      592
0 4.4999 4.97490.35427331      592
0 4.9999 5.99990.35427341      592
0 6.0249 6.99990.35427350      592
0 3.0250 4.47490.35487221      593
0 4.4999 4.97490.35487231      593
0 4.9999 5.99990.35487241      593
0 6.0249 6.99990.35487250      593
0 3.0250 4.47490.35547121      594
0 4.4999 4.97490.35547131      594
0 4.9999 5.99990.35547141      594
0 6.0249 6.99990.35547150      594
0 3.0250 4.47490.35607121      595
0 4.4999 4.97490.35607131      595
0 4.9999 5.99990.35607141      595
```

0	4.9999	0.0	1.27417450	2127
0	4.9999	0.0	1.27477350	2128
0	4.9999	0.0	1.27537250	2129
0	4.9999	0.0	1.27597050	2130
0	4.9999	0.0	1.27656950	2131
0	4.9999	0.0	1.27716850	2132
4	0.0	0.0	1.57078000	2623

COL	DESCRIPTION
1	NEXT STATE
2 - 8	START OF COLOR (QI)
9 - 15	END OF COLOR (QJ)
16 - 23	PROBE ANGLE (RADIANS)
24	COLOR ID.
25	NEXT SCANNER COLOR STATE (0 = TRANSITION TO BACKGROUND COLOR 1 = TRANSITION TO ANOTHER COLOR)
26 - 33	CURRENT PROBE NUMBER

APPENDIX C

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE1.LIST


##################################################################
       ======  OUTPUT FOR SCENE 1  ======
##################################################################

------------------------------------------------------------
   **********   OUTPUT FROM MICROMATON   **********
------------------------------------------------------------
   **********       PRIMITIVE SET       **********
------------------------------------------------------------
PRIM#    1 TYPE 7 ALT.TYPE 3 COLOR 1 TAG# FROM     130 TO  578
START VECTOR => LENGTH  4.55 ANGLE (DEG) 18.44 LINK1     4
END   VECTOR => LENGTH  5.37 ANGLE (DEG)  4.43 LINK2     2
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.7 AREA -2.621 ROTATION -0.0025
AVG.SLOPE     2.67   COMPUTED SLOPE    5.51  CHORD       1.46
RADIUS        1.03   CENTER CO-ORD X=    5.54 Y=    0.26
NON-OVERLAP COUNT=  448 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#    2 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM     130 TO  414
START VECTOR => LENGTH  5.45 ANGLE (DEG)  4.43 LINK1     1
END   VECTOR => LENGTH  6.47 ANGLE (DEG) 12.81 LINK2     3
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.5 AREA  2.767 ROTATION  0.0052
AVG.SLOPE     0.51   COMPUTED SLOPE    0.86  CHORD       1.34
RADIUS        1.02   CENTER CO-ORD X=    5.49 Y=    0.26
NON-OVERLAP COUNT=  284 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#    3 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM     414 TO  739
START VECTOR => LENGTH  6.47 ANGLE (DEG) 12.81 LINK1     2
END   VECTOR => LENGTH  5.80 ANGLE (DEG) 24.56 LINK2     8
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.7 AREA  4.100 ROTATION  0.0006
AVG.SLOPE     2.03   COMPUTED SLOPE    2.39  CHORD       1.42
RADIUS        1.05   CENTER CO-ORD X=    5.44 Y=    0.25
NON-OVERLAP COUNT=  325 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#    4 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM     578 TO  739
START VECTOR => LENGTH  5.35 ANGLE (DEG) 25.35 LINK1     8
END   VECTOR => LENGTH  4.55 ANGLE (DEG) 18.44 LINK2     1
TWIN POINTER #     3 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.0 AREA -1.380 ROTATION -0.0021
AVG.SLOPE     1.24   COMPUTED SLOPE    4.16  CHORD       1.00
RADIUS        1.15   CENTER CO-ORD X=    5.62 Y=    0.24
NON-OVERLAP COUNT=  161 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     6    7    0    0    0    0    0    0
```

```
------------------------------------------------------------
PRIM#   5 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM    585 TO  901
START VECTOR => LENGTH  3.02 ANGLE (DEG) 29.95 LINK1   12
END   VECTOR => LENGTH  4.35 ANGLE (DEG) 20.06 LINK2    6
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.6 AREA -1.100 ROTATION  0.0003
AVG.SLOPE    3.13   COMPUTED SLOPE    6.27  CHORD        1.47
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  316 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   6 TYPE 9 ALT.TYPE 0 COLOR 3 TAG# FROM    589 TO  637
START VECTOR => LENGTH  4.35 ANGLE (DEG) 20.20 LINK1    5
END   VECTOR => LENGTH  4.35 ANGLE (DEG) 20.20 LINK2    7
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.3 AREA  0.0   ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   49 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     4    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   7 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM    637 TO 1153
START VECTOR => LENGTH  4.35 ANGLE (DEG) 20.20 LINK1    6
END   VECTOR => LENGTH  4.35 ANGLE (DEG) 39.57 LINK2   12
TWIN POINTER #    12 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  3.136 ROTATION -0.0007
AVG.SLOPE    2.09   COMPUTED SLOPE    2.09  CHORD        1.46
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  516 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     4    9    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   8 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM    757 TO  757
START VECTOR => LENGTH  5.80 ANGLE (DEG) 24.56 LINK1    3
END   VECTOR => LENGTH  5.47 ANGLE (DEG) 25.35 LINK2    4
TWIN POINTER #     4 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.3 AREA  0.219 ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    3.34  CHORD        0.33
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   9 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    825 TO 1333
START VECTOR => LENGTH  5.02 ANGLE (DEG) 44.79 LINK1   13
END   VECTOR => LENGTH  7.42 ANGLE (DEG) 28.30 LINK2   10
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.1 AREA -5.221 ROTATION -0.0016
AVG.SLOPE    3.14   COMPUTED SLOPE    6.28  CHORD        2.97
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
```

```
NON-OVERLAP COUNT=  508 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     7    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  10 TYPE 9 ALT.TYPE 0 COLOR 2 TAG# FROM    828 TO  876
START VECTOR => LENGTH  7.45 ANGLE (DEG) 28.40 LINK1     9
END   VECTOR => LENGTH  7.45 ANGLE (DEG) 28.40 LINK2    11
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  7.4 AREA  0.0   ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  11 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM    877 TO 1333
START VECTOR => LENGTH  7.45 ANGLE (DEG) 28.40 LINK1    10
END   VECTOR => LENGTH  9.22 ANGLE (DEG) 44.79 LINK2    14
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.1 AREA  9.672 ROTATION -0.0021
AVG.SLOPE    1.58   COMPUTED SLOPE    1.57  CHORD        2.95
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  457 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  12 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM    901 TO 1156
START VECTOR => LENGTH  4.35 ANGLE (DEG) 39.67 LINK1     7
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 29.95 LINK2     5
TWIN POINTER #    7 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -1.114 ROTATION  0.0008
AVG.SLOPE    1.05   COMPUTED SLOPE    4.19  CHORD        1.46
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  255 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  13 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1333 TO 1787
START VECTOR => LENGTH  7.42 ANGLE (DEG) 61.34 LINK1    14
END   VECTOR => LENGTH  5.02 ANGLE (DEG) 44.79 LINK2     9
TWIN POINTER #   14 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.1 AREA -5.306 ROTATION -0.0023
AVG.SLOPE    1.58   COMPUTED SLOPE    4.71  CHORD        2.98
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  454 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    16   17   18    0    0    0    0    0
------------------------------------------------------------
PRIM#  14 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM   1333 TO 1785
START VECTOR => LENGTH  9.22 ANGLE (DEG) 44.79 LINK1    11
END   VECTOR => LENGTH  7.42 ANGLE (DEG) 61.27 LINK2    13
TWIN POINTER #   13 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.2 AREA  9.723 ROTATION  0.0016
```

```
AVG.SLOPE     3.14    COMPUTED SLOPE    3.14  CHORD        2.98
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  452 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#  15 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM    1349 TO 1782
START VECTOR => LENGTH  3.02 ANGLE (DEG) 60.00 LINK1   19
END   VECTOR => LENGTH  3.60 ANGLE (DEG) 46.30 LINK2   16
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.2 AREA -1.275 ROTATION  0.0010
AVG.SLOPE     3.11    COMPUTED SLOPE    6.27  CHORD        0.97
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  433 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#  16 TYPE 9 ALT.TYPE 0 COLOR 4 TAG# FROM    1357 TO 1405
START VECTOR => LENGTH  3.63 ANGLE (DEG) 46.57 LINK1   15
END   VECTOR => LENGTH  3.63 ANGLE (DEG) 46.57 LINK2   17
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.6 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0     COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    13    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#  17 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM    1405 TO 1748
START VECTOR => LENGTH  3.63 ANGLE (DEG) 46.57 LINK1   16
END   VECTOR => LENGTH  4.77 ANGLE (DEG) 58.80 LINK2   18
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  1.836 ROTATION  0.0005
AVG.SLOPE     1.58    COMPUTED SLOPE    1.58  CHORD        1.45
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  343 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    13    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#  18 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM    1748 TO 2033
START VECTOR => LENGTH  4.77 ANGLE (DEG) 58.80 LINK1   17
END   VECTOR => LENGTH  4.35 ANGLE (DEG) 69.78 LINK2   19
TWIN POINTER #    19 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.1 AREA  1.988 ROTATION  0.0034
AVG.SLOPE     3.13    COMPUTED SLOPE    3.14  CHORD        0.97
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  285 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    13    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#  19 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM    1782 TO 2037
START VECTOR => LENGTH  4.35 ANGLE (DEG) 69.92 LINK1   18
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 60.00 LINK2   15
```

```
TWIN POINTER #   18 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.5 AREA -1.126 ROTATION  0.0004
AVG.SLOPE     1.59   COMPUTED SLOPE    4.73  CHORD         1.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  255 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  20 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM   2037 TO 2336
START VECTOR => LENGTH  5.25 ANGLE (DEG) 80.18 LINK1   23
END   VECTOR => LENGTH  5.52 ANGLE (DEG) 70.02 LINK2   22
TWIN POINTER #   23 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.0 AREA -2.517 ROTATION  0.0001
AVG.SLOPE     3.11   COMPUTED SLOPE    6.28  CHORD         0.99
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  299 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  21 TYPE 0 ALT.TYPE 0 COLOR 5 TAG# FROM   2040 TO 2097
START VECTOR => LENGTH  5.52 ANGLE (DEG) 70.02 LINK1   20
END   VECTOR => LENGTH  5.52 ANGLE (DEG) 70.09 LINK2   22
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.0 AREA   0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.79  CHORD         0.01
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   58 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  22 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   2097 TO 2240
START VECTOR => LENGTH  5.52 ANGLE (DEG) 70.09 LINK1   20
END   VECTOR => LENGTH  7.40 ANGLE (DEG) 75.20 LINK2   23
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   2.0 AREA  1.825 ROTATION  0.0007
AVG.SLOPE     1.56   COMPUTED SLOPE    1.57  CHORD         1.96
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  143 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  23 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   2240 TO 2334
START VECTOR => LENGTH  7.40 ANGLE (DEG) 75.20 LINK1   22
END   VECTOR => LENGTH  5.27 ANGLE (DEG) 80.11 LINK2   20
TWIN POINTER #   20 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   2.2 AREA  1.667 ROTATION  0.0033
AVG.SLOPE     2.03   COMPUTED SLOPE    4.25  CHORD         2.19
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   94 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
-------------------------------------------------------------
```

```
------------------------------------------------------------
------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
NPRMHD     0 NPRMLT    23
NL9HD      6 NL9LST    16
NDOUTH    21 NDOUTL    21
NL1HD      7 NL1LST    18 NL2HD     13 NL2LST    23
NL3HD      5 NL3LST    20 NL4HD     11 NL4LST    22
NC1HD      3 NC1LST     3 NC2HD      4 NC2LST     4
NC3HD      1 NC3LST     1 NC4HD      2 NC4LST     2
NXTCEL    24 LSTCEL    23
------------------------------------------------------------
------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     6 %%  PRIMNO    6 LINK1     0 LINK2     10 COLOR  3
% CELL #    10 %%  PRIMNO   10 LINK1     6 LINK2     16 COLOR  2
% CELL #    16 %%  PRIMNO   16 LINK1    10 LINK2      0 COLOR  4
------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    21 %%  PRIMNO   21 LINK1     0 LINK2      0 COLOR  5
------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     7 %%  PRIMNO    7 LINK1     0 LINK2     14 COLOR  3
% CELL #    14 %%  PRIMNO   14 LINK1     7 LINK2     18 COLOR  2
% CELL #    18 %%  PRIMNO   18 LINK1    14 LINK2      0 COLOR  4
------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    13 %%  PRIMNO   13 LINK1     0 LINK2     19 COLOR  2
% CELL #    19 %%  PRIMNO   19 LINK1    13 LINK2      8 COLOR  4
% CELL #     8 %%  PRIMNO    8 LINK1    19 LINK2     12 COLOR  1
% CELL #    12 %%  PRIMNO   12 LINK1     8 LINK2     23 COLOR  3
% CELL #    23 %%  PRIMNO   23 LINK1    12 LINK2      0 COLOR  5
------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     5 %%  PRIMNO    5 LINK1     0 LINK2      9 COLOR  3
% CELL #     9 %%  PRIMNO    9 LINK1     5 LINK2     15 COLOR  2
% CELL #    15 %%  PRIMNO   15 LINK1     9 LINK2     20 COLOR  4
% CELL #    20 %%  PRIMNO   20 LINK1    15 LINK2      0 COLOR  5
------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
```

```
-----------------------------------------------------------
% CELL #    11 %%  PRIMNO    11 LINK1     0 LINK2    17 COLOR  2
% CELL #    17 %%  PRIMNO    17 LINK1    11 LINK2    22 COLOR  4
% CELL #    22 %%  PRIMNO    22 LINK1    17 LINK2     0 COLOR  5
-----------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-----------------------------------------------------------
% CELL #     3 %%  PRIMNO     3 LINK1     0 LINK2     0 COLOR  1
-----------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-----------------------------------------------------------
% CELL #     4 %%  PRIMNO     4 LINK1     0 LINK2     0 COLOR  1
-----------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-----------------------------------------------------------
% CELL #     1 %%  PRIMNO     1 LINK1     0 LINK2     0 COLOR  1
-----------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-----------------------------------------------------------
% CELL #     2 %%  PRIMNO     2 LINK1     0 LINK2     0 COLOR  1
-----------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE2.LIST


            #####################################################
                    ======  OUTPUT FOR SCENE 2  ======
            #####################################################

            -------------------------------------------------------------
               **********   OUTPUT FROM MICROMATON   **********
            -------------------------------------------------------------
               **********       PRIMITIVE SET        **********
            -------------------------------------------------------------
            PRIM#   1 TYPE 3 ALT.TYPE 7 COLOR 1 TAG# FROM    110 TO  429
            START VECTOR => LENGTH  5.02 ANGLE (DEG) 14.70 LINK1     4
            END   VECTOR => LENGTH  5.12 ANGLE (DEG)  3.85 LINK2     3
            TWIN POINTER #    4 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  1.0 AREA -2.383 ROTATION  0.0000
            AVG.SLOPE    1.79   COMPUTED SLOPE    4.95  CHORD        0.97
            RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
            NON-OVERLAP COUNT=  319 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   2 TYPE 0 ALT.TYPE 0 COLOR 1 TAG# FROM    113 TO  162
            START VECTOR => LENGTH  5.12 ANGLE (DEG)  3.85 LINK1     1
            END   VECTOR => LENGTH  5.12 ANGLE (DEG)  3.88 LINK2     3
            TWIN POINTER #    0 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
            AVG.SLOPE    0.0    COMPUTED SLOPE    1.64  CHORD        0.00
            RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
            NON-OVERLAP COUNT=   50 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   3 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM    162 TO  334
            START VECTOR => LENGTH  5.12 ANGLE (DEG)  3.88 LINK1     1
            END   VECTOR => LENGTH  5.87 ANGLE (DEG) 10.06 LINK2     4
            TWIN POINTER #    0 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  1.0 AREA  1.622 ROTATION -0.0004
            AVG.SLOPE    0.79   COMPUTED SLOPE    0.79  CHORD        0.96
            RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
            NON-OVERLAP COUNT=  172 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   4 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM    334 TO  425
            START VECTOR => LENGTH  5.87 ANGLE (DEG) 10.06 LINK1     3
            END   VECTOR => LENGTH  5.05 ANGLE (DEG) 14.56 LINK2     1
            TWIN POINTER #    1 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  0.9 AREA  1.161 ROTATION  0.0028
            AVG.SLOPE    2.89   COMPUTED SLOPE    2.88  CHORD        0.93
            RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
            NON-OVERLAP COUNT=   91 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
```

```
------------------------------------------------------------
PRIM#   5 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM    740 TO  908
START VECTOR => LENGTH  3.02 ANGLE (DEG) 29.78 LINK1    7
END   VECTOR => LENGTH  5.47 ANGLE (DEG) 25.38 LINK2    6
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.5 AREA -0.598 ROTATION -0.0001
AVG.SLOPE     2.79   COMPUTED SLOPE    0.35  CHORD       2.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  168 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   6 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM    741 TO 1073
START VECTOR => LENGTH  5.47 ANGLE (DEG) 25.42 LINK1    5
END   VECTOR => LENGTH  5.65 ANGLE (DEG) 35.45 LINK2   12
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  2.659 ROTATION -0.0003
AVG.SLOPE     1.96   COMPUTED SLOPE    1.92  CHORD       0.99
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  333 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     8   10    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   7 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    908 TO 1369
START VECTOR => LENGTH  3.35 ANGLE (DEG) 46.78 LINK1   12
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 29.78 LINK2    5
TWIN POINTER #   12 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -1.480 ROTATION  0.0001
AVG.SLOPE     1.97   COMPUTED SLOPE    5.08  CHORD       1.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  461 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   8 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM   1001 TO 1052
START VECTOR => LENGTH  6.40 ANGLE (DEG) 34.45 LINK1   10
END   VECTOR => LENGTH  6.42 ANGLE (DEG) 34.35 LINK2    9
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.97  CHORD       0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   51 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     6    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#   9 TYPE 9 ALT.TYPE 0 COLOR 3 TAG# FROM   1004 TO 1052
START VECTOR => LENGTH  6.42 ANGLE (DEG) 34.35 LINK1   10
END   VECTOR => LENGTH  6.45 ANGLE (DEG) 34.45 LINK2   11
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  6.4 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD       0.0
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
```

```
NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  10 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM   1053 TO 1288
START VECTOR => LENGTH  6.05 ANGLE (DEG) 42.83 LINK1   16
END   VECTOR => LENGTH  6.40 ANGLE (DEG) 34.45 LINK2    9
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -2.828 ROTATION  0.0010
AVG.SLOPE     2.60   COMPUTED SLOPE    5.75  CHORD       0.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  236 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     6   12   15    0    0    0    0    0
------------------------------------------------------------
PRIM#  11 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1053 TO 1140
START VECTOR => LENGTH  6.45 ANGLE (DEG) 34.45 LINK1    9
END   VECTOR => LENGTH  7.30 ANGLE (DEG) 37.75 LINK2   13
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.9 AREA  1.358 ROTATION -0.0020
AVG.SLOPE     1.06   COMPUTED SLOPE    1.07  CHORD       0.94
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   88 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  12 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1073 TO 1363
START VECTOR => LENGTH  5.65 ANGLE (DEG) 35.45 LINK1    6
END   VECTOR => LENGTH  3.35 ANGLE (DEG) 46.71 LINK2    7
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.5 AREA  1.855 ROTATION  0.0016
AVG.SLOPE     2.79   COMPUTED SLOPE    3.49  CHORD       2.45
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  290 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    10   14    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  13 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM   1141 TO 1317
START VECTOR => LENGTH  7.30 ANGLE (DEG) 37.75 LINK1   11
END   VECTOR => LENGTH  7.00 ANGLE (DEG) 45.20 LINK2   16
TWIN POINTER #    16 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  3.313 ROTATION -0.0028
AVG.SLOPE     2.61   COMPUTED SLOPE    2.61  CHORD       0.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  177 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  14 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   1165 TO 1601
START VECTOR => LENGTH  3.07 ANGLE (DEG) 53.58 LINK1   18
END   VECTOR => LENGTH  5.67 ANGLE (DEG) 39.98 LINK2   15
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.8 AREA -2.023 ROTATION  0.0005
```

```
AVG.SLOPE     2.71   COMPUTED SLOPE    0.43  CHORD        2.78
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  436 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    12    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  15 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM   1167 TO 1751
START VECTOR => LENGTH  5.67 ANGLE (DEG) 40.05 LINK1   14
END   VECTOR => LENGTH  5.00 ANGLE (DEG) 60.10 LINK2   18
TWIN POINTER #    18 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   2.1 AREA  4.826 ROTATION -0.0002
AVG.SLOPE     2.79   COMPUTED SLOPE    2.79  CHORD        1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  585 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    10   16    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  16 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM   1289 TO 1318
START VECTOR => LENGTH  7.00 ANGLE (DEG) 45.23 LINK1   13
END   VECTOR => LENGTH  6.05 ANGLE (DEG) 42.83 LINK2   10
TWIN POINTER #    13 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.0 AREA -0.887 ROTATION -0.0007
AVG.SLOPE     1.05   COMPUTED SLOPE    4.19  CHORD        0.99
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   30 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    15    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  17 TYPE 0 ALT.TYPE 0 COLOR 2 TAG# FROM   1401 TO 1401
START VECTOR => LENGTH  3.35 ANGLE (DEG) 46.71 LINK1   12
END   VECTOR => LENGTH  3.35 ANGLE (DEG) 46.78 LINK2    7
TWIN POINTER #     7 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.0 AREA  0.007 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.39  CHORD        0.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  18 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1601 TO 1752
START VECTOR => LENGTH  5.00 ANGLE (DEG) 60.14 LINK1   15
END   VECTOR => LENGTH  3.07 ANGLE (DEG) 53.58 LINK2   14
TWIN POINTER #    15 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.9 AREA -0.837 ROTATION -0.0016
AVG.SLOPE     1.24   COMPUTED SLOPE    4.37  CHORD        1.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  151 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  19 TYPE 8 ALT.TYPE 4 COLOR 5 TAG# FROM   1978 TO 2171
START VECTOR => LENGTH  7.05 ANGLE (DEG) 72.83 LINK1   22
END   VECTOR => LENGTH  7.87 ANGLE (DEG) 67.89 LINK2   20
```

```
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -2.198 ROTATION -0.0057
AVG.SLOPE     2.37  COMPUTED SLOPE    0.57  CHORD        1.05
RADIUS        0.98  CENTER CO-ORD X=    7.99 Y=    1.31
NON-OVERLAP COUNT=  193 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  20 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1978 TO 2048
START VECTOR => LENGTH  8.00 ANGLE (DEG) 67.89 LINK1   19
END   VECTOR => LENGTH  8.37 ANGLE (DEG) 68.58 LINK2   21
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.307 ROTATION  0.0040
AVG.SLOPE     1.44  COMPUTED SLOPE    1.45  CHORD        0.39
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   70 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  21 TYPE 5 ALT.TYPE 1 COLOR 5 TAG# FROM   2048 TO 2279
START VECTOR => LENGTH  8.37 ANGLE (DEG) 68.58 LINK1   20
END   VECTOR => LENGTH  8.97 ANGLE (DEG) 76.54 LINK2   23
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  5.425 ROTATION  0.0098
AVG.SLOPE     2.14  COMPUTED SLOPE    2.38  CHORD        1.34
RADIUS        1.00  CENTER CO-ORD X=    8.00 Y=    1.31
NON-OVERLAP COUNT=  231 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  22 TYPE 7 ALT.TYPE 3 COLOR 5 TAG# FROM   2171 TO 2396
START VECTOR => LENGTH  7.92 ANGLE (DEG) 82.24 LINK1   23
END   VECTOR => LENGTH  7.05 ANGLE (DEG) 72.83 LINK2   19
TWIN POINTER #     23 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.6 AREA -4.163 ROTATION -0.0034
AVG.SLOPE     2.76  COMPUTED SLOPE    5.45  CHORD        1.51
RADIUS        0.99  CENTER CO-ORD X=    7.99 Y=    1.31
NON-OVERLAP COUNT=  225 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  23 TYPE 6 ALT.TYPE 2 COLOR 5 TAG# FROM   2279 TO 2396
START VECTOR => LENGTH  8.97 ANGLE (DEG) 76.54 LINK1   21
END   VECTOR => LENGTH  7.95 ANGLE (DEG) 82.24 LINK2   22
TWIN POINTER #     22 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.3 AREA  3.699 ROTATION  0.0077
AVG.SLOPE     2.76  COMPUTED SLOPE    3.84  CHORD        1.32
RADIUS        1.02  CENTER CO-ORD X=    7.99 Y=    1.31
NON-OVERLAP COUNT=  117 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
-------------------------------------------------------------
```

```
------------------------------------------------------------
------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
NPRMHD     0 NPRMLT   23
NL9HD      9 NL9LST    9
NDOUTH     2 NDOUTL   17
NL1HD      4 NL1LST   15 NL2HD     12 NL2LST    18
NL3HD      1 NL3LST   10 NL4HD      3 NL4LST    20
NC1HD     21 NC1LST   21 NC2HD     23 NC2LST    23
NC3HD     22 NC3LST   22 NC4HD     19 NC4LST    19
NXTCEL    24 LSTCEL   23
------------------------------------------------------------
------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     9 %%  PRIMNO     9 LINK1     0 LINK2      0 COLOR  3
------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     2 %%  PRIMNO     2 LINK1     0 LINK2      8 COLOR  1
% CELL #     8 %%  PRIMNO     8 LINK1     2 LINK2     17 COLOR  3
% CELL #    17 %%  PRIMNO    17 LINK1     8 LINK2      0 COLOR  2
------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     4 %%  PRIMNO     4 LINK1     0 LINK2      6 COLOR  1
% CELL #     6 %%  PRIMNO     6 LINK1     4 LINK2     13 COLOR  2
% CELL #    13 %%  PRIMNO    13 LINK1     6 LINK2     15 COLOR  3
% CELL #    15 %%  PRIMNO    15 LINK1    13 LINK2      0 COLOR  4
------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    12 %%  PRIMNO    12 LINK1     0 LINK2     16 COLOR  2
% CELL #    16 %%  PRIMNO    16 LINK1    12 LINK2     18 COLOR  3
% CELL #    18 %%  PRIMNO    18 LINK1    16 LINK2      0 COLOR  4
------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     1 %%  PRIMNO     1 LINK1     0 LINK2      7 COLOR  1
% CELL #     7 %%  PRIMNO     7 LINK1     1 LINK2     10 COLOR  2
% CELL #    10 %%  PRIMNO    10 LINK1     7 LINK2      0 COLOR  3
------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     3 %%  PRIMNO     3 LINK1     0 LINK2      5 COLOR  1
```

```
% CELL #     5 %%  PRIMNO     5 LINK1     3 LINK2     11 COLOR  2
% CELL #    11 %%  PRIMNO    11 LINK1     5 LINK2     14 COLOR  3
% CELL #    14 %%  PRIMNO    14 LINK1    11 LINK2     20 COLOR  4
% CELL #    20 %%  PRIMNO    20 LINK1    14 LINK2      0 COLOR  5
------------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #    21 %%  PRIMNO    21 LINK1     0 LINK2      0 COLOR  5
------------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #    23 %%  PRIMNO    23 LINK1     0 LINK2      0 COLOR  5
------------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #    22 %%  PRIMNO    22 LINK1     0 LINK2      0 COLOR  5
------------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #    19 %%  PRIMNO    19 LINK1     0 LINK2      0 COLOR  5
------------------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE3.LIST


            #####################################################
                    ======  OUTPUT FOR SCENE 3   ======
            #####################################################

            --------------------------------------------------------------
               **********   OUTPUT FROM MICROMATON   **********
            --------------------------------------------------------------
               **********       PRIMITIVE SET        **********
            --------------------------------------------------------------
            PRIM#    1 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM    182 TO  230
            START VECTOR => LENGTH  2.20 ANGLE (DEG)  6.35 LINK1     3
            END   VECTOR => LENGTH  2.30 ANGLE (DEG)  6.22 LINK2     2
            TWIN POINTER #     0 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  0.1 AREA  0.0   ROTATION  0.0
            AVG.SLOPE     0.0    COMPUTED SLOPE    0.06  CHORD        0.10
            RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
            NON-OVERLAP COUNT=   48 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            --------------------------------------------------------------
            PRIM#    2 TYPE 8 ALT.TYPE 4 COLOR 2 TAG# FROM    183 TO  659
            START VECTOR => LENGTH  2.32 ANGLE (DEG)  6.25 LINK1     1
            END   VECTOR => LENGTH  3.40 ANGLE (DEG) 21.23 LINK2     7
            TWIN POINTER #     0 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  1.4 AREA  1.228 ROTATION  0.0021
            AVG.SLOPE     0.49   COMPUTED SLOPE    0.85  CHORD        1.30
            RADIUS        1.01   CENTER CO-ORD X=   2.50 Y=     0.53
            NON-OVERLAP COUNT=  477 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     4    0    0    0    0    0    0    0
            --------------------------------------------------------------
            PRIM#    3 TYPE 7 ALT.TYPE 3 COLOR 2 TAG# FROM    230 TO 1395
            START VECTOR => LENGTH  1.70 ANGLE (DEG) 46.50 LINK1    14
            END   VECTOR => LENGTH  2.20 ANGLE (DEG)  6.35 LINK2     1
            TWIN POINTER #     0 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  1.7 AREA -0.931 ROTATION -0.0016
            AVG.SLOPE     2.69   COMPUTED SLOPE    5.51  CHORD        1.42
            RADIUS        1.03   CENTER CO-ORD X=   2.55 Y=     0.53
            NON-OVERLAP COUNT= 1165 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            --------------------------------------------------------------
            PRIM#    4 TYPE 3 ALT.TYPE 7 COLOR 1 TAG# FROM    435 TO  856
            START VECTOR => LENGTH  3.88 ANGLE (DEG) 29.37 LINK1     0
            END   VECTOR => LENGTH  4.00 ANGLE (DEG) 14.91 LINK2     5
            TWIN POINTER #     0 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  1.1 AREA -1.928 ROTATION  0.0000
            AVG.SLOPE     2.05   COMPUTED SLOPE    5.22  CHORD        1.00
            RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
            NON-OVERLAP COUNT=  421 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     2    7    0    0    0    0    0    0
```

```
---------------------------------------------------------------
PRIM#   5 TYPE 9 ALT.TYPE 0 COLOR 1 TAG# FROM     438 TO  486
START VECTOR => LENGTH  4.02 ANGLE (DEG) 15.01 LINK1     4
END   VECTOR => LENGTH  4.02 ANGLE (DEG) 15.01 LINK2     6
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD         0.0
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   6 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM     487 TO  662
START VECTOR => LENGTH  4.02 ANGLE (DEG) 15.01 LINK1     5
END   VECTOR => LENGTH  6.92 ANGLE (DEG) 21.33 LINK2     8
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.0 AREA  1.541 ROTATION -0.0008
AVG.SLOPE     0.52   COMPUTED SLOPE    0.52  CHORD        2.96
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  176 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   7 TYPE 5 ALT.TYPE 1 COLOR 2 TAG# FROM     659 TO 1375
START VECTOR => LENGTH  3.40 ANGLE (DEG) 21.23 LINK1     2
END   VECTOR => LENGTH  3.13 ANGLE (DEG) 45.82 LINK2    13
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  2.480 ROTATION  0.0010
AVG.SLOPE     1.97   COMPUTED SLOPE    2.35  CHORD        1.42
RADIUS        1.06   CENTER CO-ORD X=    2.42 Y=     0.51
NON-OVERLAP COUNT=  716 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     4    9   11    0    0    0    0    0
---------------------------------------------------------------
PRIM#   8 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM     663 TO  861
START VECTOR => LENGTH  6.92 ANGLE (DEG) 21.33 LINK1     6
END   VECTOR => LENGTH  6.85 ANGLE (DEG) 29.54 LINK2    34
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  3.387 ROTATION -0.0011
AVG.SLOPE     2.09   COMPUTED SLOPE    2.09  CHORD        0.99
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  199 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   9 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM     959 TO 1066
START VECTOR => LENGTH  6.02 ANGLE (DEG) 35.20 LINK1    11
END   VECTOR => LENGTH  6.77 ANGLE (DEG) 32.90 LINK2    10
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -0.753 ROTATION -0.0044
AVG.SLOPE     2.82   COMPUTED SLOPE    0.26  CHORD        0.79
RADIUS        1.51   CENTER CO-ORD X=    7.00 Y=     0.79
```

```
NON-OVERLAP COUNT=  107 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     7    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  10 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM     959 TO 1134
START VECTOR => LENGTH  6.90 ANGLE (DEG) 32.90 LINK1     9
END   VECTOR => LENGTH  8.10 ANGLE (DEG) 37.54 LINK2    12
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.4 AREA  2.355 ROTATION  0.0065
AVG.SLOPE     0.91    COMPUTED SLOPE     1.08  CHORD       1.34
RADIUS        1.56    CENTER CO-ORD X=    6.98 Y=     0.80
NON-OVERLAP COUNT=  175 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  11 TYPE 7 ALT.TYPE 3 COLOR 3 TAG# FROM    1067 TO 1647
START VECTOR => LENGTH  6.00 ANGLE (DEG) 55.16 LINK1    21
END   VECTOR => LENGTH  6.02 ANGLE (DEG) 35.20 LINK2     9
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.4 AREA -5.590 ROTATION -0.0001
AVG.SLOPE     2.72    COMPUTED SLOPE     5.51  CHORD       2.08
RADIUS        1.57    CENTER CO-ORD X=    7.09 Y=     0.79
NON-OVERLAP COUNT=  581 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     7   13   16    0    0    0    0    0
-------------------------------------------------------------
PRIM#  12 TYPE 5 ALT.TYPE 1 COLOR 3 TAG# FROM    1135 TO 1571
START VECTOR => LENGTH  8.10 ANGLE (DEG) 37.54 LINK1    10
END   VECTOR => LENGTH  8.15 ANGLE (DEG) 52.55 LINK2    19
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.4 AREA  9.172 ROTATION  0.0032
AVG.SLOPE     1.99    COMPUTED SLOPE     2.33  CHORD       2.12
RADIUS        1.49    CENTER CO-ORD X=    7.00 Y=     0.79
NON-OVERLAP COUNT=  437 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    17    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  13 TYPE 6 ALT.TYPE 2 COLOR 2 TAG# FROM    1375 TO 1554
START VECTOR => LENGTH  3.13 ANGLE (DEG) 45.82 LINK1     7
END   VECTOR => LENGTH  2.32 ANGLE (DEG) 53.34 LINK2    14
TWIN POINTER #    14 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.9 AREA  0.529 ROTATION  0.0004
AVG.SLOPE     2.88    COMPUTED SLOPE     3.59  CHORD       0.87
RADIUS        0.99    CENTER CO-ORD X=    2.50 Y=     0.52
NON-OVERLAP COUNT=  179 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    11   15    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  14 TYPE 6 ALT.TYPE 2 COLOR 2 TAG# FROM    1395 TO 1554
START VECTOR => LENGTH  2.25 ANGLE (DEG) 53.34 LINK1    13
END   VECTOR => LENGTH  1.70 ANGLE (DEG) 46.50 LINK2     3
TWIN POINTER #    13 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -0.212 ROTATION -0.0007
```

```
AVG.SLOPE     1.38   COMPUTED SLOPE    4.42  CHORD        0.60
RADIUS        1.03   CENTER CO-ORD X=    2.52 Y=    0.51
NON-OVERLAP COUNT=  159 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  15 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1517 TO 1801
START VECTOR => LENGTH  4.02 ANGLE (DEG) 59.97 LINK1    23
END   VECTOR => LENGTH  5.35 ANGLE (DEG) 52.07 LINK2    16
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -1.430 ROTATION  0.0002
AVG.SLOPE     2.62   COMPUTED SLOPE    0.52  CHORD        1.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  284 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    13    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  16 TYPE 1 ALT.TYPE 5 COLOR 5 TAG# FROM   1519 TO 1841
START VECTOR => LENGTH  5.35 ANGLE (DEG) 52.14 LINK1    15
END   VECTOR => LENGTH  5.77 ANGLE (DEG) 61.34 LINK2    26
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.1 AREA  2.439 ROTATION  0.0002
AVG.SLOPE     2.13   COMPUTED SLOPE    2.12  CHORD        0.99
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  323 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    11   21   17   24    0    0    0    0
--------------------------------------------------------------
PRIM#  17 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM   1520 TO 1798
START VECTOR => LENGTH  8.92 ANGLE (DEG) 61.72 LINK1     0
END   VECTOR => LENGTH  9.00 ANGLE (DEG) 52.17 LINK2    18
TWIN POINTER #    22 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -6.596 ROTATION  0.0001
AVG.SLOPE     2.59   COMPUTED SLOPE    5.76  CHORD        1.49
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  279 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    12   19   16   22    0    0    0    0
--------------------------------------------------------------
PRIM#  18 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   1520 TO 1595
START VECTOR => LENGTH  9.02 ANGLE (DEG) 52.17 LINK1    17
END   VECTOR => LENGTH 10.47 ANGLE (DEG) 53.37 LINK2    20
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  0.929 ROTATION  0.0039
AVG.SLOPE     1.05   COMPUTED SLOPE    1.06  CHORD        1.46
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   75 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  19 TYPE 6 ALT.TYPE 2 COLOR 3 TAG# FROM   1572 TO 1679
START VECTOR => LENGTH  8.15 ANGLE (DEG) 52.55 LINK1    12
END   VECTOR => LENGTH  6.87 ANGLE (DEG) 57.63 LINK2    21
```

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TWIN POINTER #   21 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  2.653 ROTATION  0.0037
AVG.SLOPE     2.90   COMPUTED SLOPE    3.62  CHORD        1.44
RADIUS        1.58   CENTER CO-ORD X=    6.97 Y=     0.78
NON-OVERLAP COUNT=  108 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    17    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  20 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM   1596 TO 1792
START VECTOR => LENGTH 10.47 ANGLE (DEG) 53.37 LINK1   18
END   VECTOR => LENGTH 10.40 ANGLE (DEG) 61.48 LINK2    0
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  7.677 ROTATION -0.0004
AVG.SLOPE     2.62   COMPUTED SLOPE    2.62  CHORD        1.48
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  197 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  21 TYPE 6 ALT.TYPE 2 COLOR 3 TAG# FROM   1648 TO 1679
START VECTOR => LENGTH  6.80 ANGLE (DEG) 57.63 LINK1   19
END   VECTOR => LENGTH  6.00 ANGLE (DEG) 55.16 LINK2   11
TWIN POINTER #   19 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.9 AREA -0.848 ROTATION -0.0089
AVG.SLOPE     1.40   COMPUTED SLOPE    4.46  CHORD        0.85
RADIUS        1.66   CENTER CO-ORD X=    7.09 Y=     0.77
NON-OVERLAP COUNT=   32 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    16    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  22 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1797 TO 1797
START VECTOR => LENGTH  9.30 ANGLE (DEG) 61.66 LINK1    0
END   VECTOR => LENGTH  9.20 ANGLE (DEG) 61.68 LINK2    0
TWIN POINTER #   17 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.1 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.19  CHORD        0.10
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    1 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    17    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  23 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM   1801 TO 2064
START VECTOR => LENGTH  4.57 ANGLE (DEG) 70.81 LINK1    0
END   VECTOR => LENGTH  4.02 ANGLE (DEG) 59.97 LINK2   15
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -1.728 ROTATION -0.0013
AVG.SLOPE     2.13   COMPUTED SLOPE    5.26  CHORD        0.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  263 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  24 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM   1831 TO 2112
```

```
START VECTOR => LENGTH  5.07 ANGLE (DEG) 70.78 LINK1   30
END   VECTOR => LENGTH  9.37 ANGLE (DEG) 62.85 LINK2   25
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  4.4 AREA -3.182 ROTATION  0.0013
AVG.SLOPE     2.20   COMPUTED SLOPE    0.94  CHORD        4.40
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  281 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    16   26    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  25 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM   1832 TO 2186
START VECTOR => LENGTH  9.37 ANGLE (DEG) 62.88 LINK1   24
END   VECTOR => LENGTH  9.00 ANGLE (DEG) 75.03 LINK2   30
TWIN POINTER #    30 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.0 AREA  8.800 ROTATION  0.0001
AVG.SLOPE     2.96   COMPUTED SLOPE    2.96  CHORD        1.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  355 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  26 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1841 TO 2063
START VECTOR => LENGTH  5.77 ANGLE (DEG) 61.34 LINK1   16
END   VECTOR => LENGTH  4.60 ANGLE (DEG) 70.64 LINK2    0
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  2.145 ROTATION -0.0002
AVG.SLOPE     2.61   COMPUTED SLOPE    3.67  CHORD        1.44
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  222 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    24    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  27 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM   1846 TO 1846
START VECTOR => LENGTH 10.40 ANGLE (DEG) 61.48 LINK1   20
END   VECTOR => LENGTH 10.35 ANGLE (DEG) 61.51 LINK2    0
TWIN POINTER #    17 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.1 AREA  0.032 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.19  CHORD        0.05
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  28 TYPE 0 ALT.TYPE 0 COLOR 5 TAG# FROM   2107 TO 2107
START VECTOR => LENGTH  4.60 ANGLE (DEG) 70.64 LINK1   26
END   VECTOR => LENGTH  4.60 ANGLE (DEG) 70.81 LINK2    0
TWIN POINTER #    23 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.032 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.81  CHORD        0.01
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
```

```
------------------------------------------------------------
PRIM#  29 TYPE 0 ALT.TYPE 0 COLOR 5 TAG# FROM   2112 TO 2112
START VECTOR => LENGTH  4.60 ANGLE (DEG) 70.84 LINK1    0
END   VECTOR => LENGTH  4.57 ANGLE (DEG) 70.81 LINK2   23
TWIN POINTER #   26 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.006 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    1.35  CHORD       0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  30 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM   2112 TO 2186
START VECTOR => LENGTH  8.97 ANGLE (DEG) 75.03 LINK1   25
END   VECTOR => LENGTH  5.07 ANGLE (DEG) 70.78 LINK2   24
TWIN POINTER #   25 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.9 AREA -1.661 ROTATION -0.0079
AVG.SLOPE     1.41   COMPUTED SLOPE    4.55  CHORD       3.93
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    74 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  31 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM   2300 TO 2516
START VECTOR => LENGTH  7.02 ANGLE (DEG) 84.67 LINK1   33
END   VECTOR => LENGTH  8.25 ANGLE (DEG) 78.94 LINK2   32
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -2.799 ROTATION  0.0017
AVG.SLOPE     2.28   COMPUTED SLOPE    0.87  CHORD       1.44
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   216 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  32 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM   2303 TO 2594
START VECTOR => LENGTH  8.25 ANGLE (DEG) 79.05 LINK1   31
END   VECTOR => LENGTH  8.37 ANGLE (DEG) 89.03 LINK2   33
TWIN POINTER #   33 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  5.952 ROTATION -0.0000
AVG.SLOPE     2.95   COMPUTED SLOPE    2.95  CHORD       1.45
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   292 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  33 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM   2516 TO 2596
START VECTOR => LENGTH  8.37 ANGLE (DEG) 89.10 LINK1   32
END   VECTOR => LENGTH  7.02 ANGLE (DEG) 84.67 LINK2   31
TWIN POINTER #   32 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -2.241 ROTATION -0.0019
AVG.SLOPE     1.94   COMPUTED SLOPE    5.07  CHORD       1.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
```

```
NON-OVERLAP COUNT=   80 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM# 34 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM      0 TO  861
START VECTOR => LENGTH  6.85 ANGLE (DEG) 29.54 LINK1     8
END   VECTOR => LENGTH  3.88 ANGLE (DEG) 29.37 LINK2     0
TWIN POINTER #     0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  3.0 AREA  0.0  ROTATION  0.0
AVG.SLOPE     0.0   COMPUTED SLOPE    3.66  CHORD       2.97
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
NPRMHD     0 NPRMLT   34
NL9HD      5 NL9LST    5
NDOUTH    27 NDOUTL   29
NL1HD      8 NL1LST   32 NL2HD     34 NL2LST   30
NL3HD      4 NL3LST   33 NL4HD      1 NL4LST   31
NC1HD      7 NC1LST   12 NC2HD     13 NC2LST   21
NC3HD      3 NC3LST   11 NC4HD      2 NC4LST   10
NXTCEL    35 LSTCEL   34
------------------------------------------------------------
------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     5 %%  PRIMNO     5 LINK1     0 LINK2     0 COLOR  1
------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    27 %%  PRIMNO    27 LINK1     0 LINK2    28 COLOR  4
% CELL #    28 %%  PRIMNO    28 LINK1    27 LINK2    29 COLOR  5
% CELL #    29 %%  PRIMNO    29 LINK1    28 LINK2     0 COLOR  5
------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #     8 %%  PRIMNO     8 LINK1     0 LINK2    16 COLOR  1
% CELL #    16 %%  PRIMNO    16 LINK1     8 LINK2    20 COLOR  5
% CELL #    20 %%  PRIMNO    20 LINK1    16 LINK2    25 COLOR  4
% CELL #    25 %%  PRIMNO    25 LINK1    20 LINK2    32 COLOR  1
% CELL #    32 %%  PRIMNO    32 LINK1    25 LINK2     0 COLOR  2
------------------------------------------------------------
```

```
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   34 %%  PRIMNO   34 LINK1    0 LINK2   22 COLOR  1
% CELL #   22 %%  PRIMNO   22 LINK1   34 LINK2   26 COLOR  4
% CELL #   26 %%  PRIMNO   26 LINK1   22 LINK2   30 COLOR  5
% CELL #   30 %%  PRIMNO   30 LINK1   26 LINK2    0 COLOR  1
-------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    4 %%  PRIMNO    4 LINK1    0 LINK2   17 COLOR  1
% CELL #   17 %%  PRIMNO   17 LINK1    4 LINK2   23 COLOR  4
% CELL #   23 %%  PRIMNO   23 LINK1   17 LINK2   33 COLOR  5
% CELL #   33 %%  PRIMNO   33 LINK1   23 LINK2    0 COLOR  2
-------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    1 %%  PRIMNO    1 LINK1    0 LINK2    6 COLOR  2
% CELL #    6 %%  PRIMNO    6 LINK1    1 LINK2   15 COLOR  1
% CELL #   15 %%  PRIMNO   15 LINK1    6 LINK2   18 COLOR  5
% CELL #   18 %%  PRIMNO   18 LINK1   15 LINK2   24 COLOR  4
% CELL #   24 %%  PRIMNO   24 LINK1   18 LINK2   31 COLOR  1
% CELL #   31 %%  PRIMNO   31 LINK1   24 LINK2    0 COLOR  2
-------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    7 %%  PRIMNO    7 LINK1    0 LINK2   12 COLOR  2
% CELL #   12 %%  PRIMNO   12 LINK1    7 LINK2    0 COLOR  3
-------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   13 %%  PRIMNO   13 LINK1    0 LINK2   14 COLOR  2
% CELL #   14 %%  PRIMNO   14 LINK1   13 LINK2   19 COLOR  2
% CELL #   19 %%  PRIMNO   19 LINK1   14 LINK2   21 COLOR  3
% CELL #   21 %%  PRIMNO   21 LINK1   19 LINK2    0 COLOR  3
-------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    3 %%  PRIMNO    3 LINK1    0 LINK2   11 COLOR  2
% CELL #   11 %%  PRIMNO   11 LINK1    3 LINK2    0 COLOR  3
-------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    2 %%  PRIMNO    2 LINK1    0 LINK2    9 COLOR  2
% CELL #    9 %%  PRIMNO    9 LINK1    2 LINK2   10 COLOR  3
% CELL #   10 %%  PRIMNO   10 LINK1    9 LINK2    0 COLOR  3
-------------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE4.LIST



      ##################################################
             ======  OUTPUT FOR SCENE 4  ======
      ##################################################

      ------------------------------------------------------------
         **********   OUTPUT FROM MICROMATON   **********
      ------------------------------------------------------------
         **********       PRIMITIVE SET        **********
      ------------------------------------------------------------
      PRIM#    1 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM    745 TO  920
      START VECTOR => LENGTH  3.98 ANGLE (DEG) 30.19 LINK1     7
      END   VECTOR => LENGTH  5.25 ANGLE (DEG) 25.55 LINK2     2
      TWIN POINTER #     0 REDUCTION ID. 1.0
      PRIMITIVE VALUES => LENGTH   1.3 AREA -0.750 ROTATION -0.0034
      AVG.SLOPE     2.87   COMPUTED SLOPE     0.20  CHORD        1.33
      RADIUS        3.35   CENTER CO-ORD X=     6.36 Y=     1.00
      NON-OVERLAP COUNT=  175 OVERLAP COUNT=      0
      OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
      ------------------------------------------------------------
      PRIM#    2 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM    745 TO 1129
      START VECTOR => LENGTH  5.37 ANGLE (DEG) 25.55 LINK1     1
      END   VECTOR => LENGTH  8.17 ANGLE (DEG) 37.37 LINK2    12
      TWIN POINTER #     0 REDUCTION ID. 2.0
      PRIMITIVE VALUES => LENGTH   3.3 AREA  5.369 ROTATION  0.0066
      AVG.SLOPE     0.78   COMPUTED SLOPE     1.01  CHORD        3.11
      RADIUS        3.00   CENTER CO-ORD X=     6.10 Y=     0.96
      NON-OVERLAP COUNT=  384 OVERLAP COUNT=      0
      OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
      ------------------------------------------------------------
      PRIM#    3 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM    872 TO 1860
      START VECTOR => LENGTH  6.20 ANGLE (DEG) 29.92 LINK1     6
      END   VECTOR => LENGTH  3.50 ANGLE (DEG) 62.64 LINK2    37
      TWIN POINTER #     0 REDUCTION ID. 2.0
      PRIMITIVE VALUES => LENGTH   4.3 AREA  5.798 ROTATION  0.0017
      AVG.SLOPE     3.14   COMPUTED SLOPE     3.14  CHORD        3.77
      RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
      NON-OVERLAP COUNT=    0 OVERLAP COUNT=    988
      OVERLAP PRIMITIVES     4   36    0    0    0    0    0    0
      ------------------------------------------------------------
      PRIM#    4 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    872 TO 1849
      START VECTOR => LENGTH  3.52 ANGLE (DEG) 62.26 LINK1    36
      END   VECTOR => LENGTH  6.22 ANGLE (DEG) 29.92 LINK2     5
      TWIN POINTER #     0 REDUCTION ID. 1.0
      PRIMITIVE VALUES => LENGTH   4.2 AREA -5.834 ROTATION  0.0013
      AVG.SLOPE     3.14   COMPUTED SLOPE     6.28  CHORD        3.76
      RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
      NON-OVERLAP COUNT=    0 OVERLAP COUNT=    977
      OVERLAP PRIMITIVES     3    0    0    0    0    0    0    0
```

```
--------------------------------------------------------------
PRIM#   5 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM     872 TO 1537
START VECTOR => LENGTH  6.25 ANGLE (DEG) 29.92 LINK1     4
END   VECTOR => LENGTH  8.75 ANGLE (DEG) 51.79 LINK2    26
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.0 AREA 10.136 ROTATION -0.0016
AVG.SLOPE     1.58   COMPUTED SLOPE     1.57  CHORD        3.76
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   665
OVERLAP PRIMITIVES     6    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#   6 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM     872 TO 1537
START VECTOR => LENGTH  8.77 ANGLE (DEG) 51.79 LINK1    27
END   VECTOR => LENGTH  6.27 ANGLE (DEG) 29.92 LINK2     3
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  4.0 AREA ****** ROTATION -0.0016
AVG.SLOPE     1.58   COMPUTED SLOPE     4.72  CHORD        3.77
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   665
OVERLAP PRIMITIVES     5    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#   7 TYPE 7 ALT.TYPE 3 COLOR 1 TAG# FROM     920 TO 2460
START VECTOR => LENGTH  5.20 ANGLE (DEG) 84.43 LINK1     0
END   VECTOR => LENGTH  3.98 ANGLE (DEG) 30.19 LINK2     1
TWIN POINTER #    39 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  5.0 AREA -5.662 ROTATION -0.0011
AVG.SLOPE     2.76   COMPUTED SLOPE     5.46  CHORD        4.32
RADIUS        3.04   CENTER CO-ORD X=     6.16 Y=     0.96
NON-OVERLAP COUNT= 1540 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#   8 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM    1066 TO 1824
START VECTOR => LENGTH  6.25 ANGLE (DEG) 36.58 LINK1    10
END   VECTOR => LENGTH  4.25 ANGLE (DEG) 61.41 LINK2    34
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.4 AREA  5.514 ROTATION -0.0002
AVG.SLOPE     3.14   COMPUTED SLOPE     3.14  CHORD        2.98
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   758
OVERLAP PRIMITIVES     9    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#   9 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM    1066 TO 1824
START VECTOR => LENGTH  4.27 ANGLE (DEG) 61.41 LINK1    35
END   VECTOR => LENGTH  6.27 ANGLE (DEG) 36.58 LINK2    11
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.4 AREA -5.568 ROTATION -0.0002
AVG.SLOPE     3.14   COMPUTED SLOPE     6.28  CHORD        2.99
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
```

```
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   758
OVERLAP PRIMITIVES      8     0     0     0     0     0     0     0
-----------------------------------------------------------------------
PRIM#  10 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1066 TO 1513
START VECTOR => LENGTH  8.02 ANGLE (DEG) 50.97 LINK1   24
END   VECTOR => LENGTH  6.30 ANGLE (DEG) 36.58 LINK2    8
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.6 AREA -6.231 ROTATION -0.0036
AVG.SLOPE     1.58   COMPUTED SLOPE    4.71  CHORD        2.48
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   447
OVERLAP PRIMITIVES     11     0     0     0     0     0     0     0
-----------------------------------------------------------------------
PRIM#  11 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1068 TO 1517
START VECTOR => LENGTH  6.27 ANGLE (DEG) 36.65 LINK1    9
END   VECTOR => LENGTH  8.00 ANGLE (DEG) 51.11 LINK2   25
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.6 AREA  6.264 ROTATION -0.0029
AVG.SLOPE     1.57   COMPUTED SLOPE    1.58  CHORD        2.48
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   450
OVERLAP PRIMITIVES     10    24     0     0     0     0     0     0
-----------------------------------------------------------------------
PRIM#  12 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM   1130 TO 1973
START VECTOR => LENGTH  8.17 ANGLE (DEG) 37.37 LINK1    2
END   VECTOR => LENGTH  8.75 ANGLE (DEG) 66.01 LINK2   39
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.8 AREA 19.620 ROTATION  0.0004
AVG.SLOPE     1.98   COMPUTED SLOPE    2.34  CHORD        4.22
RADIUS        3.04   CENTER CO-ORD X=    6.05  Y=    0.96
NON-OVERLAP COUNT=  844 OVERLAP COUNT=     0
OVERLAP PRIMITIVES      0     0     0     0     0     0     0     0
-----------------------------------------------------------------------
PRIM#  13 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM   1211 TO 1719
START VECTOR => LENGTH  5.97 ANGLE (DEG) 41.56 LINK1   15
END   VECTOR => LENGTH  4.70 ANGLE (DEG) 57.80 LINK2   32
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.2 AREA  3.898 ROTATION  0.0002
AVG.SLOPE     3.13   COMPUTED SLOPE    3.13  CHORD        1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   508
OVERLAP PRIMITIVES     14     0     0     0     0     0     0     0
-----------------------------------------------------------------------
PRIM#  14 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM   1211 TO 1719
START VECTOR => LENGTH  4.72 ANGLE (DEG) 57.80 LINK1   33
END   VECTOR => LENGTH  6.00 ANGLE (DEG) 41.56 LINK2   16
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.2 AREA -3.936 ROTATION  0.0002
```

```
AVG.SLOPE     3.13   COMPUTED SLOPE    6.27  CHORD        1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   508
OVERLAP PRIMITIVES    13    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  15 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM   1211 TO 1960
START VECTOR => LENGTH  6.50 ANGLE (DEG) 67.27 LINK1   32
END   VECTOR => LENGTH  6.02 ANGLE (DEG) 41.56 LINK2   13
TWIN POINTER #   25 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.0 AREA -8.443 ROTATION -0.0000
AVG.SLOPE     2.37   COMPUTED SLOPE    5.50  CHORD        2.83
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   749
OVERLAP PRIMITIVES    16   17    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  16 TYPE 9 ALT.TYPE 0 COLOR 4 TAG# FROM   1218 TO 1266
START VECTOR => LENGTH  6.00 ANGLE (DEG) 41.80 LINK1   14
END   VECTOR => LENGTH  6.00 ANGLE (DEG) 41.80 LINK2   17
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  6.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    49
OVERLAP PRIMITIVES    15    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  17 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM   1267 TO 1957
START VECTOR => LENGTH  6.00 ANGLE (DEG) 41.80 LINK1   16
END   VECTOR => LENGTH  6.47 ANGLE (DEG) 67.17 LINK2   33
TWIN POINTER #   33 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.9 AREA  8.293 ROTATION -0.0012
AVG.SLOPE     2.37   COMPUTED SLOPE    2.35  CHORD        2.78
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   690
OVERLAP PRIMITIVES    15    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  18 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM   1426 TO 1636
START VECTOR => LENGTH  6.97 ANGLE (DEG) 48.94 LINK1   22
END   VECTOR => LENGTH  6.35 ANGLE (DEG) 55.50 LINK2   22
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  2.471 ROTATION -0.0007
AVG.SLOPE     3.12   COMPUTED SLOPE    3.13  CHORD        0.95
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   210
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  19 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM   1426 TO 1636
START VECTOR => LENGTH  6.37 ANGLE (DEG) 55.50 LINK1   31
END   VECTOR => LENGTH  6.95 ANGLE (DEG) 48.94 LINK2   21
```

```
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -2.490 ROTATION -0.0007
AVG.SLOPE     3.12   COMPUTED SLOPE     6.27  CHORD        0.95
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   210
OVERLAP PRIMITIVES    18     0     0     0     0     0     0     0
-------------------------------------------------------------------
PRIM#  20 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM    1426 TO 1477
START VECTOR => LENGTH  7.00 ANGLE (DEG) 49.05 LINK1    22
END   VECTOR => LENGTH  6.97 ANGLE (DEG) 48.94 LINK2    18
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     1.32  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    51
OVERLAP PRIMITIVES    21     0     0     0     0     0     0     0
-------------------------------------------------------------------
PRIM#  21 TYPE 9 ALT.TYPE 0 COLOR 5 TAG# FROM    1429 TO 1477
START VECTOR => LENGTH  6.97 ANGLE (DEG) 49.05 LINK1    19
END   VECTOR => LENGTH  6.97 ANGLE (DEG) 49.05 LINK2    23
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  7.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     0.0   CHORD        0.0
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    49
OVERLAP PRIMITIVES    20     0     0     0     0     0     0     0
-------------------------------------------------------------------
PRIM#  22 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM    1478 TO 1636
START VECTOR => LENGTH  7.35 ANGLE (DEG) 56.16 LINK1    18
END   VECTOR => LENGTH  7.00 ANGLE (DEG) 49.05 LINK2    18
TWIN POINTER #    25 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -3.180 ROTATION -0.0018
AVG.SLOPE     2.12   COMPUTED SLOPE     5.26  CHORD        0.96
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   159
OVERLAP PRIMITIVES    23     0     0     0     0     0     0     0
-------------------------------------------------------------------
PRIM#  23 TYPE 1 ALT.TYPE 5 COLOR 5 TAG# FROM    1478 TO 1635
START VECTOR => LENGTH  6.97 ANGLE (DEG) 49.05 LINK1    21
END   VECTOR => LENGTH  7.32 ANGLE (DEG) 56.12 LINK2    31
TWIN POINTER #    19 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  3.142 ROTATION -0.0018
AVG.SLOPE     2.12   COMPUTED SLOPE     2.11  CHORD        0.95
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   158
OVERLAP PRIMITIVES    22     0     0     0     0     0     0     0
-------------------------------------------------------------------
PRIM#  24 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    1514 TO 2093
```

```
START VECTOR => LENGTH  6.57 ANGLE (DEG) 71.84 LINK1   34
END   VECTOR => LENGTH  8.02 ANGLE (DEG) 50.97 LINK2   10
TWIN POINTER #   28 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.2 AREA -9.396 ROTATION  0.0016
AVG.SLOPE     3.14   COMPUTED SLOPE    6.28  CHORD       3.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   580
OVERLAP PRIMITIVES    11   25    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  25 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM    1518 TO 2091
START VECTOR => LENGTH  8.00 ANGLE (DEG) 51.11 LINK1   11
END   VECTOR => LENGTH  6.55 ANGLE (DEG) 71.77 LINK2   35
TWIN POINTER #   35 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.2 AREA  9.222 ROTATION -0.0048
AVG.SLOPE     3.14   COMPUTED SLOPE    3.14  CHORD       2.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   574
OVERLAP PRIMITIVES    24    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  26 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM    1538 TO 1629
START VECTOR => LENGTH  8.75 ANGLE (DEG) 51.79 LINK1    5
END   VECTOR => LENGTH  8.47 ANGLE (DEG) 54.54 LINK2   28
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.5 AREA  1.779 ROTATION -0.0001
AVG.SLOPE     3.07   COMPUTED SLOPE    3.09  CHORD       0.50
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    92
OVERLAP PRIMITIVES    27    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  27 TYPE 3 ALT.TYPE 7 COLOR 1 TAG# FROM    1538 TO 1629
START VECTOR => LENGTH  8.50 ANGLE (DEG) 54.54 LINK1   29
END   VECTOR => LENGTH  8.77 ANGLE (DEG) 51.79 LINK2    6
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -1.789 ROTATION -0.0001
AVG.SLOPE     3.07   COMPUTED SLOPE    6.23  CHORD       0.50
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    92
OVERLAP PRIMITIVES    26    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  28 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM    1630 TO 2235
START VECTOR => LENGTH  8.47 ANGLE (DEG) 54.54 LINK1   26
END   VECTOR => LENGTH  7.07 ANGLE (DEG) 76.71 LINK2   38
TWIN POINTER #   38 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.4 AREA 11.304 ROTATION -0.0065
AVG.SLOPE     3.14   COMPUTED SLOPE    3.15  CHORD       3.29
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   606
OVERLAP PRIMITIVES    29    0    0    0    0    0    0    0
```

```
------------------------------------------------------------
PRIM#  29 TYPE 3 ALT.TYPE 7 COLOR 1 TAG# FROM   1630 TO 2236
START VECTOR => LENGTH  7.10 ANGLE (DEG) 76.75 LINK1   37
END   VECTOR => LENGTH  8.50 ANGLE (DEG) 54.54 LINK2   27
TWIN POINTER #   39 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.5 AREA ****** ROTATION -0.0065
AVG.SLOPE     3.14   COMPUTED SLOPE    0.00  CHORD       3.30
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   607
OVERLAP PRIMITIVES    28    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  30 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1646 TO 1646
START VECTOR => LENGTH  6.35 ANGLE (DEG) 55.50 LINK1   18
END   VECTOR => LENGTH  7.30 ANGLE (DEG) 56.16 LINK2    0
TWIN POINTER #   15 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  0.264 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    1.06  CHORD       0.95
RADIUS       41.85   CENTER CO-ORD X= -41.85 Y=   -0.68
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  31 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1646 TO 1646
START VECTOR => LENGTH  7.32 ANGLE (DEG) 56.16 LINK1   23
END   VECTOR => LENGTH  6.37 ANGLE (DEG) 55.50 LINK2   19
TWIN POINTER #   23 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -0.266 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.20  CHORD       0.95
RADIUS       41.85   CENTER CO-ORD X= -41.85 Y=   -0.68
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  32 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1720 TO 1960
START VECTOR => LENGTH  4.70 ANGLE (DEG) 57.80 LINK1   13
END   VECTOR => LENGTH  6.45 ANGLE (DEG) 67.27 LINK2   15
TWIN POINTER #   35 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.0 AREA  2.488 ROTATION -0.0001
AVG.SLOPE     1.58   COMPUTED SLOPE    1.58  CHORD       1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   241
OVERLAP PRIMITIVES    33    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  33 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1720 TO 1960
START VECTOR => LENGTH  6.47 ANGLE (DEG) 67.27 LINK1   17
END   VECTOR => LENGTH  4.72 ANGLE (DEG) 57.80 LINK2   14
TWIN POINTER #   17 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.0 AREA -2.511 ROTATION -0.0001
AVG.SLOPE     1.58   COMPUTED SLOPE    4.72  CHORD       1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    -0.0
```

```
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   241
OVERLAP PRIMITIVES    32    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  34 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM    1825 TO 2093
START VECTOR => LENGTH  4.25 ANGLE (DEG) 61.41 LINK1    8
END   VECTOR => LENGTH  6.52 ANGLE (DEG) 71.84 LINK2   24
TWIN POINTER #   38 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.5 AREA  2.518 ROTATION  0.0015
AVG.SLOPE     1.57   COMPUTED SLOPE    1.57  CHORD         2.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   269
OVERLAP PRIMITIVES    35    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  35 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM    1825 TO 2093
START VECTOR => LENGTH  6.55 ANGLE (DEG) 71.84 LINK1   25
END   VECTOR => LENGTH  4.27 ANGLE (DEG) 61.41 LINK2    9
TWIN POINTER #   25 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.5 AREA -2.541 ROTATION  0.0030
AVG.SLOPE     1.57   COMPUTED SLOPE    4.71  CHORD         2.47
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   269
OVERLAP PRIMITIVES    34    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  36 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    1850 TO 1909
START VECTOR => LENGTH  3.63 ANGLE (DEG) 63.47 LINK1   38
END   VECTOR => LENGTH  3.52 ANGLE (DEG) 62.26 LINK2    4
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.1 AREA -0.134 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.88  CHORD         0.12
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    60
OVERLAP PRIMITIVES     3   37    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  37 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM    1860 TO 2236
START VECTOR => LENGTH  3.50 ANGLE (DEG) 62.64 LINK1    3
END   VECTOR => LENGTH  7.05 ANGLE (DEG) 76.75 LINK2   29
TWIN POINTER #    7 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.8 AREA  3.015 ROTATION  0.0021
AVG.SLOPE     1.57   COMPUTED SLOPE    1.57  CHORD         3.75
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   376
OVERLAP PRIMITIVES    36   38    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  38 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM    1910 TO 2236
START VECTOR => LENGTH  7.07 ANGLE (DEG) 76.75 LINK1   28
END   VECTOR => LENGTH  3.63 ANGLE (DEG) 63.47 LINK2   36
TWIN POINTER #   28 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.6 AREA -2.953 ROTATION -0.0004
```

```
AVG.SLOPE      1.57   COMPUTED SLOPE     4.71  CHORD        3.64
RADIUS         0.0    CENTER CO-ORD X=     0.0  Y=      0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    327
OVERLAP PRIMITIVES    37    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM# 39 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM    1974 TO 2460
START VECTOR => LENGTH  8.75 ANGLE (DEG) 66.01 LINK1    12
END   VECTOR => LENGTH  5.42 ANGLE (DEG) 84.43 LINK2     0
TWIN POINTER #     7 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   4.2 AREA  9.532 ROTATION  0.0073
AVG.SLOPE      2.81   COMPUTED SLOPE     3.85  CHORD        3.99
RADIUS         3.02   CENTER CO-ORD X=     6.09 Y=      0.96
NON-OVERLAP COUNT=   486 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
NPRMHD     0 NPRMLT    39
NL9HD     16 NL9LST    21
NDOUTH    20 NDOUTL    20
NL1HD      3 NL1LST    28 NL2HD      6 NL2LST    31
NL3HD      4 NL3LST    36 NL4HD      5 NL4LST    30
NC1HD     12 NC1LST    12 NC2HD     39 NC2LST    39
NC3HD      7 NC3LST     7 NC4HD      1 NC4LST     2
NXTCEL    40 LSTCEL    39
--------------------------------------------------------------
--------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #    16 %%  PRIMNO    16 LINK1     0 LINK2     21 COLOR  4
% CELL #    21 %%  PRIMNO    21 LINK1    16 LINK2      0 COLOR  5
--------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #    20 %%  PRIMNO    20 LINK1     0 LINK2      0 COLOR  3
--------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #     3 %%  PRIMNO     3 LINK1     0 LINK2      8 COLOR  1
% CELL #     8 %%  PRIMNO     8 LINK1     3 LINK2     13 COLOR  2
% CELL #    13 %%  PRIMNO    13 LINK1     8 LINK2     17 COLOR  3
% CELL #    17 %%  PRIMNO    17 LINK1    13 LINK2     18 COLOR  4
% CELL #    18 %%  PRIMNO    18 LINK1    17 LINK2     23 COLOR  3
```

```
% CELL #   23 %%  PRIMNO   23 LINK1   18 LINK2   25 COLOR  5
% CELL #   25 %%  PRIMNO   25 LINK1   23 LINK2   26 COLOR  3
% CELL #   26 %%  PRIMNO   26 LINK1   25 LINK2   28 COLOR  2
% CELL #   28 %%  PRIMNO   28 LINK1   26 LINK2    0 COLOR  2
-------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    6 %%  PRIMNO    6 LINK1    0 LINK2   10 COLOR  1
% CELL #   10 %%  PRIMNO   10 LINK1    6 LINK2   33 COLOR  2
% CELL #   33 %%  PRIMNO   33 LINK1   10 LINK2   35 COLOR  4
% CELL #   35 %%  PRIMNO   35 LINK1   33 LINK2   38 COLOR  3
% CELL #   38 %%  PRIMNO   38 LINK1   35 LINK2   31 COLOR  2
% CELL #   31 %%  PRIMNO   31 LINK1   38 LINK2    0 COLOR  5
-------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    4 %%  PRIMNO    4 LINK1    0 LINK2    9 COLOR  2
% CELL #    9 %%  PRIMNO    9 LINK1    4 LINK2   14 COLOR  3
% CELL #   14 %%  PRIMNO   14 LINK1    9 LINK2   15 COLOR  4
% CELL #   15 %%  PRIMNO   15 LINK1   14 LINK2   19 COLOR  3
% CELL #   19 %%  PRIMNO   19 LINK1   15 LINK2   22 COLOR  5
% CELL #   22 %%  PRIMNO   22 LINK1   19 LINK2   24 COLOR  3
% CELL #   24 %%  PRIMNO   24 LINK1   22 LINK2   27 COLOR  2
% CELL #   27 %%  PRIMNO   27 LINK1   24 LINK2   29 COLOR  1
% CELL #   29 %%  PRIMNO   29 LINK1   27 LINK2   36 COLOR  1
% CELL #   36 %%  PRIMNO   36 LINK1   29 LINK2    0 COLOR  2
-------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    5 %%  PRIMNO    5 LINK1    0 LINK2   11 COLOR  2
% CELL #   11 %%  PRIMNO   11 LINK1    5 LINK2   32 COLOR  3
% CELL #   32 %%  PRIMNO   32 LINK1   11 LINK2   34 COLOR  3
% CELL #   34 %%  PRIMNO   34 LINK1   32 LINK2   37 COLOR  2
% CELL #   37 %%  PRIMNO   37 LINK1   34 LINK2   30 COLOR  1
% CELL #   30 %%  PRIMNO   30 LINK1   37 LINK2    0 COLOR  3
-------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   12 %%  PRIMNO   12 LINK1    0 LINK2    0 COLOR  1
-------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   39 %%  PRIMNO   39 LINK1    0 LINK2    0 COLOR  1
-------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    7 %%  PRIMNO    7 LINK1    0 LINK2    0 COLOR  1
-------------------------------------------------------------
```

CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :

% CELL #	1	%%	PRIMNO	1	LINK1	0	LINK2	2	COLOR	1
% CELL #	2	%%	PRIMNO	2	LINK1	1	LINK2	0	COLOR	1

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE5.LIST


          #####################################################
                  ======  OUTPUT FOR SCENE 5  ======
          #####################################################

          -------------------------------------------------------------
             **********   OUTPUT FROM MICROMATON   **********
          -------------------------------------------------------------
             **********       PRIMITIVE SET        **********
          -------------------------------------------------------------
          PRIM#    1 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM    979 TO 1865
          START VECTOR => LENGTH  2.27 ANGLE (DEG) 62.81 LINK1    33
          END   VECTOR => LENGTH  3.63 ANGLE (DEG) 33.59 LINK2     2
          TWIN POINTER #     0 REDUCTION ID. 1.0
          PRIMITIVE VALUES => LENGTH  2.4 AREA -1.997 ROTATION  0.0007
          AVG.SLOPE     3.13    COMPUTED SLOPE     6.27  CHORD        1.98
          RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
          NON-OVERLAP COUNT=  886 OVERLAP COUNT=      0
          OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
          -------------------------------------------------------------
          PRIM#    2 TYPE 9 ALT.TYPE 0 COLOR 5 TAG# FROM    987 TO 1035
          START VECTOR => LENGTH  3.63 ANGLE (DEG) 33.87 LINK1     1
          END   VECTOR => LENGTH  3.63 ANGLE (DEG) 33.87 LINK2     3
          TWIN POINTER #     0 REDUCTION ID. 2.0
          PRIMITIVE VALUES => LENGTH  3.6 AREA  0.0   ROTATION  0.0
          AVG.SLOPE     0.0     COMPUTED SLOPE     0.0   CHORD        0.0
          RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
          NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
          OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
          -------------------------------------------------------------
          PRIM#    3 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1035 TO 1406
          START VECTOR => LENGTH  3.63 ANGLE (DEG) 33.87 LINK1     2
          END   VECTOR => LENGTH  4.50 ANGLE (DEG) 48.12 LINK2    14
          TWIN POINTER #     0 REDUCTION ID. 2.0
          PRIMITIVE VALUES => LENGTH  1.5 AREA  2.016 ROTATION -0.0001
          AVG.SLOPE     1.57    COMPUTED SLOPE     1.58  CHORD        1.33
          RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
          NON-OVERLAP COUNT=  367 OVERLAP COUNT=      0
          OVERLAP PRIMITIVES     4    6   12    0    0    0    0    0
          -------------------------------------------------------------
          PRIM#    4 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM   1154 TO 1337
          START VECTOR => LENGTH  5.82 ANGLE (DEG) 45.75 LINK1    10
          END   VECTOR => LENGTH  6.52 ANGLE (DEG) 39.60 LINK2     5
          TWIN POINTER #     0 REDUCTION ID. 1.0
          PRIMITIVE VALUES => LENGTH  1.0 AREA -2.001 ROTATION  0.0024
          AVG.SLOPE     3.12    COMPUTED SLOPE     6.27  CHORD        0.96
          RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
          NON-OVERLAP COUNT=  179 OVERLAP COUNT=      0
          OVERLAP PRIMITIVES     3    7    0    0    0    0    0    0
```

```
----------------------------------------------------------------
PRIM#   5 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM    1160 TO 1852
START VECTOR => LENGTH  6.52 ANGLE (DEG) 39.81 LINK1    4
END   VECTOR => LENGTH  6.85 ANGLE (DEG) 63.57 LINK2   30
TWIN POINTER #    30 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.9 AREA  8.979 ROTATION  0.0008
AVG.SLOPE     2.37   COMPUTED SLOPE    2.36  CHORD        2.77
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  693 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#   6 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM    1170 TO 1405
START VECTOR => LENGTH  4.57 ANGLE (DEG) 48.08 LINK1   12
END   VECTOR => LENGTH  5.27 ANGLE (DEG) 40.15 LINK2    7
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -1.631 ROTATION -0.0032
AVG.SLOPE     3.13   COMPUTED SLOPE    6.28  CHORD        0.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  231 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    3    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#   7 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM    1171 TO 1337
START VECTOR => LENGTH  5.27 ANGLE (DEG) 40.18 LINK1    6
END   VECTOR => LENGTH  5.77 ANGLE (DEG) 45.75 LINK2    9
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  1.455 ROTATION -0.0032
AVG.SLOPE     1.59   COMPUTED SLOPE    1.57  CHORD        0.73
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  163 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    4    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#   8 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM    1338 TO 1385
START VECTOR => LENGTH  5.80 ANGLE (DEG) 45.89 LINK1   10
END   VECTOR => LENGTH  5.82 ANGLE (DEG) 45.75 LINK2    4
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.041 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.85  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    48
OVERLAP PRIMITIVES    9    0    0    0    0    0    0    0
----------------------------------------------------------------
PRIM#   9 TYPE 5 ALT.TYPE 1 COLOR 4 TAG# FROM    1338 TO 1421
START VECTOR => LENGTH  5.77 ANGLE (DEG) 45.75 LINK1    7
END   VECTOR => LENGTH  5.65 ANGLE (DEG) 47.40 LINK2   13
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.471 ROTATION  0.0007
AVG.SLOPE     2.95   COMPUTED SLOPE    3.03  CHORD        0.21
RADIUS        0.90   CENTER CO-ORD X=    6.44 Y=    0.90
```

```
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     84
OVERLAP PRIMITIVES     8   10    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  10 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM    1386 TO 1597
START VECTOR => LENGTH  5.17 ANGLE (DEG) 53.85 LINK1    15
END   VECTOR => LENGTH  5.80 ANGLE (DEG) 45.89 LINK2     4
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -2.078 ROTATION  0.0015
AVG.SLOPE     3.13   COMPUTED SLOPE     6.27  CHORD        0.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   212
OVERLAP PRIMITIVES     9   13    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  11 TYPE 0 ALT.TYPE 0 COLOR 5 TAG# FROM    1406 TO 1454
START VECTOR => LENGTH  4.50 ANGLE (DEG) 48.12 LINK1     3
END   VECTOR => LENGTH  4.52 ANGLE (DEG) 48.26 LINK2    14
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.024 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     1.25  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    48
OVERLAP PRIMITIVES    12    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  12 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM    1406 TO 1759
START VECTOR => LENGTH  3.98 ANGLE (DEG) 59.18 LINK1    24
END   VECTOR => LENGTH  4.57 ANGLE (DEG) 48.08 LINK2     6
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.2 AREA -1.736 ROTATION -0.0023
AVG.SLOPE     3.13   COMPUTED SLOPE     6.27  CHORD        1.02
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   354
OVERLAP PRIMITIVES     3   11   14    0    0    0    0    0
------------------------------------------------------------
PRIM#  13 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM    1422 TO 1601
START VECTOR => LENGTH  5.65 ANGLE (DEG) 47.40 LINK1     9
END   VECTOR => LENGTH  5.15 ANGLE (DEG) 53.99 LINK2    16
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  1.659 ROTATION -0.0003
AVG.SLOPE     3.12   COMPUTED SLOPE     3.13  CHORD        0.80
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   180
OVERLAP PRIMITIVES    10   15    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  14 TYPE 1 ALT.TYPE 5 COLOR 5 TAG# FROM    1454 TO 1760
START VECTOR => LENGTH  4.52 ANGLE (DEG) 48.26 LINK1     3
END   VECTOR => LENGTH  3.95 ANGLE (DEG) 59.21 LINK2    25
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.1 AREA  1.692 ROTATION -0.0002
```

```
AVG.SLOPE      3.13   COMPUTED SLOPE    3.12  CHORD        0.99
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   306
OVERLAP PRIMITIVES    12   24    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 15 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM   1598 TO 1708
START VECTOR => LENGTH  5.85 ANGLE (DEG) 58.63 LINK1   17
END   VECTOR => LENGTH  5.17 ANGLE (DEG) 53.85 LINK2   10
TWIN POINTER #    17 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -1.253 ROTATION -0.0045
AVG.SLOPE      1.59   COMPUTED SLOPE    4.72  CHORD        0.82
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    94 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    13   16   21    0    0    0    0    0
-------------------------------------------------------------
PRIM# 16 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   1602 TO 1649
START VECTOR => LENGTH  5.15 ANGLE (DEG) 53.99 LINK1   13
END   VECTOR => LENGTH  5.27 ANGLE (DEG) 54.95 LINK2   21
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.228 ROTATION  0.0
AVG.SLOPE      0.0    COMPUTED SLOPE    1.56  CHORD        0.15
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    35 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    15    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 17 TYPE 5 ALT.TYPE 1 COLOR 3 TAG# FROM   1622 TO 1706
START VECTOR => LENGTH  6.02 ANGLE (DEG) 55.67 LINK1   19
END   VECTOR => LENGTH  5.85 ANGLE (DEG) 58.56 LINK2   15
TWIN POINTER #    15 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.857 ROTATION  0.0018
AVG.SLOPE      3.01   COMPUTED SLOPE    3.10  CHORD        0.35
RADIUS         0.47   CENTER CO-ORD X=    6.38 Y=     1.02
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    84
OVERLAP PRIMITIVES    18    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 18 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM   1622 TO 1729
START VECTOR => LENGTH  5.82 ANGLE (DEG) 59.18 LINK1   23
END   VECTOR => LENGTH  6.05 ANGLE (DEG) 56.02 LINK2   22
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.4 AREA -1.048 ROTATION  0.0034
AVG.SLOPE      3.01   COMPUTED SLOPE    6.27  CHORD        0.43
RADIUS       207.33   CENTER CO-ORD X=  212.39 Y=     1.54
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    86
OVERLAP PRIMITIVES    17   21    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 19 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM   1622 TO 1839
START VECTOR => LENGTH  6.42 ANGLE (DEG) 61.75 LINK1   30
END   VECTOR => LENGTH  6.07 ANGLE (DEG) 55:67 LINK2   17
```

```
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -2.032 ROTATION  0.0002
AVG.SLOPE     2.12   COMPUTED SLOPE     5.25  CHORD        0.75
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   177
OVERLAP PRIMITIVES    20   22   27    0    0    0    0    0
-------------------------------------------------------------
PRIM#  20 TYPE 0 ALT.TYPE 0 COLOR 2 TAG# FROM   1632 TO 1684
START VECTOR => LENGTH  6.05 ANGLE (DEG) 56.02 LINK1   18
END   VECTOR => LENGTH  6.07 ANGLE (DEG) 56.05 LINK2   22
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     1.12  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    53
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  21 TYPE 5 ALT.TYPE 1 COLOR 4 TAG# FROM   1650 TO 1764
START VECTOR => LENGTH  5.27 ANGLE (DEG) 54.95 LINK1   16
END   VECTOR => LENGTH  5.12 ANGLE (DEG) 58.83 LINK2   26
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.922 ROTATION  0.0058
AVG.SLOPE     2.92   COMPUTED SLOPE     2.97  CHORD        0.38
RADIUS        1.73   CENTER CO-ORD X=     3.68 Y=     0.81
NON-OVERLAP COUNT=   115 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    15   18   23    0    0    0    0    0
-------------------------------------------------------------
PRIM#  22 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM   1685 TO 1809
START VECTOR => LENGTH  6.07 ANGLE (DEG) 56.05 LINK1   18
END   VECTOR => LENGTH  6.42 ANGLE (DEG) 61.92 LINK2   27
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  1.989 ROTATION -0.0012
AVG.SLOPE     2.12   COMPUTED SLOPE     2.10  CHORD        0.73
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   118
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  23 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1730 TO 1849
START VECTOR => LENGTH  5.65 ANGLE (DEG) 62.26 LINK1   32
END   VECTOR => LENGTH  5.82 ANGLE (DEG) 59.18 LINK2   18
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.4 AREA -0.890 ROTATION  0.0043
AVG.SLOPE     3.09   COMPUTED SLOPE     0.00  CHORD        0.36
RADIUS       66.48   CENTER CO-ORD X=   61.55 Y=    -1.52
NON-OVERLAP COUNT=    85 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    21   26   29   27    0    0    0    0
-------------------------------------------------------------
PRIM#  24 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1760 TO 1844
```

```
START VECTOR => LENGTH  4.50 ANGLE (DEG) 63.12 LINK1   37
END   VECTOR => LENGTH  3.98 ANGLE (DEG) 59.18 LINK2   12
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -0.618 ROTATION -0.0001
AVG.SLOPE    1.56   COMPUTED SLOPE    4.72  CHORD        0.60
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    80
OVERLAP PRIMITIVES    14   25    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  25 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1760 TO 1875
START VECTOR => LENGTH  3.95 ANGLE (DEG) 59.21 LINK1   14
END   VECTOR => LENGTH  4.42 ANGLE (DEG) 62.64 LINK2   34
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.5 AREA  0.523 ROTATION -0.0004
AVG.SLOPE    1.54   COMPUTED SLOPE    1.55  CHORD        0.54
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    65
OVERLAP PRIMITIVES    24   31    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  26 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM   1765 TO 1891
START VECTOR => LENGTH  5.12 ANGLE (DEG) 58.83 LINK1   21
END   VECTOR => LENGTH  4.82 ANGLE (DEG) 64.91 LINK2   37
TWIN POINTER #    31 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.6 AREA  1.304 ROTATION -0.0008
AVG.SLOPE    6.21   COMPUTED SLOPE    3.17  CHORD        0.61
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  127 OVERLAP COUNT=    0
OVERLAP PRIMITIVES    23   28    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  27 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM   1810 TO 1855
START VECTOR => LENGTH  6.42 ANGLE (DEG) 61.92 LINK1   22
END   VECTOR => LENGTH  6.52 ANGLE (DEG) 63.47 LINK2   35
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.565 ROTATION  0.0000
AVG.SLOPE    2.12   COMPUTED SLOPE    2.14  CHORD        0.20
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   46 OVERLAP COUNT=    0
OVERLAP PRIMITIVES    19   23   30    0    0    0    0    0
-------------------------------------------------------------
PRIM#  28 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM   1815 TO 2057
START VECTOR => LENGTH  4.85 ANGLE (DEG) 68.92 LINK1   39
END   VECTOR => LENGTH  5.65 ANGLE (DEG) 62.30 LINK2   29
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -1.454 ROTATION -0.0032
AVG.SLOPE    2.43   COMPUTED SLOPE    0.50  CHORD        1.00
RADIUS       1.01   CENTER CO-ORD X=    5.81 Y=    1.26
NON-OVERLAP COUNT=  242 OVERLAP COUNT=    0
OVERLAP PRIMITIVES    26   34   38    0    0    0    0    0
```

```
-------------------------------------------------------------
PRIM#  29 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM   1815 TO 1899
START VECTOR => LENGTH  5.77 ANGLE (DEG) 62.30 LINK1   28
END   VECTOR => LENGTH  6.20 ANGLE (DEG) 63.47 LINK2   36
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.331 ROTATION  0.0038
AVG.SLOPE     1.33   COMPUTED SLOPE    1.38  CHORD        0.44
RADIUS       11.29   CENTER CO-ORD X=  -11.23 Y=   -0.73
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     34
OVERLAP PRIMITIVES    23   32    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  30 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM   1840 TO 1855
START VECTOR => LENGTH  6.85 ANGLE (DEG) 63.67 LINK1    5
END   VECTOR => LENGTH  6.42 ANGLE (DEG) 61.75 LINK2   19
TWIN POINTER #     5 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -0.738 ROTATION  0.0006
AVG.SLOPE     1.58   COMPUTED SLOPE    4.72  CHORD        0.48
RADIUS        3.43   CENTER CO-ORD X=    8.71 Y=    0.73
NON-OVERLAP COUNT=    16 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    27    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  31 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM   1845 TO 1895
START VECTOR => LENGTH  4.52 ANGLE (DEG) 63.29 LINK1   37
END   VECTOR => LENGTH  4.50 ANGLE (DEG) 63.12 LINK2   24
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.030 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    1.60  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    51 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    25   34    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  32 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1850 TO 1855
START VECTOR => LENGTH  6.25 ANGLE (DEG) 63.67 LINK1   35
END   VECTOR => LENGTH  5.65 ANGLE (DEG) 62.26 LINK2   23
TWIN POINTER #    27 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -0.369 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.48  CHORD        0.62
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=      6
OVERLAP PRIMITIVES    29    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  33 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1865 TO 2204
START VECTOR => LENGTH  4.13 ANGLE (DEG) 75.65 LINK1   40
END   VECTOR => LENGTH  2.27 ANGLE (DEG) 62.81 LINK2    1
TWIN POINTER #    40 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.0 AREA -1.030 ROTATION -0.0005
AVG.SLOPE     1.59   COMPUTED SLOPE    4.72  CHORD        1.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
```

```
NON-OVERLAP COUNT=  339 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  34 TYPE 5 ALT.TYPE 1 COLOR 5 TAG# FROM   1875 TO 1979
START VECTOR => LENGTH  4.42 ANGLE (DEG) 62.64 LINK1   25
END   VECTOR => LENGTH  4.37 ANGLE (DEG) 66.21 LINK2   38
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.3 AREA  0.606 ROTATION  0.0035
AVG.SLOPE     2.83   COMPUTED SLOPE    2.88  CHORD        0.28
RADIUS        0.44   CENTER CO-ORD X=    3.99 Y=     1.11
NON-OVERLAP COUNT=  104 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    31   28    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  35 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1900 TO 1900
START VECTOR => LENGTH  6.52 ANGLE (DEG) 63.47 LINK1   27
END   VECTOR => LENGTH  6.30 ANGLE (DEG) 63.67 LINK2   32
TWIN POINTER #   32 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.074 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.15  CHORD        0.23
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  36 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM   1900 TO 2235
START VECTOR => LENGTH  6.20 ANGLE (DEG) 63.47 LINK1   29
END   VECTOR => LENGTH  6.75 ANGLE (DEG) 75.00 LINK2   41
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  4.452 ROTATION  0.0064
AVG.SLOPE     2.08   COMPUTED SLOPE    2.38  CHORD        1.41
RADIUS        1.01   CENTER CO-ORD X=    5.78 Y=     1.26
NON-OVERLAP COUNT=  336 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  37 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1905 TO 1905
START VECTOR => LENGTH  4.82 ANGLE (DEG) 65.04 LINK1   26
END   VECTOR => LENGTH  4.52 ANGLE (DEG) 63.29 LINK2   24
TWIN POINTER #   26 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.333 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.71  CHORD        0.33
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  38 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1979 TO 2102
START VECTOR => LENGTH  4.37 ANGLE (DEG) 66.21 LINK1   34
END   VECTOR => LENGTH  4.22 ANGLE (DEG) 70.47 LINK2   40
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.684 ROTATION -0.0021
```

```
AVG.SLOPE      3.08   COMPUTED SLOPE     3.20  CHORD        0.35
RADIUS         0.0    CENTER CO-ORD X=     0.0  Y=      0.0
NON-OVERLAP COUNT=  123 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    28   39    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  39 TYPE 7 ALT.TYPE 3 COLOR 1 TAG# FROM    2058 TO 2392
START VECTOR => LENGTH  5.65 ANGLE (DEG) 82.10 LINK1   41
END   VECTOR => LENGTH  4.85 ANGLE (DEG) 68.92 LINK2   28
TWIN POINTER #   41 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.6 AREA -2.792 ROTATION -0.0020
AVG.SLOPE      2.73   COMPUTED SLOPE     5.45  CHORD        1.44
RADIUS         1.03   CENTER CO-ORD X=     5.84 Y=     1.26
NON-OVERLAP COUNT=  335 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    38   40    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  40 TYPE 1 ALT.TYPE 5 COLOR 5 TAG# FROM    2102 TO 2202
START VECTOR => LENGTH  4.22 ANGLE (DEG) 70.47 LINK1   38
END   VECTOR => LENGTH  4.13 ANGLE (DEG) 75.58 LINK2   33
TWIN POINTER #   33 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.4 AREA   0.779 ROTATION  0.0010
AVG.SLOPE      3.09   COMPUTED SLOPE     3.11  CHORD        0.39
RADIUS         0.0    CENTER CO-ORD X=     0.0  Y=      0.0
NON-OVERLAP COUNT=  100 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    39    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  41 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM    2235 TO 2392
START VECTOR => LENGTH  6.75 ANGLE (DEG) 75.00 LINK1   36
END   VECTOR => LENGTH  5.77 ANGLE (DEG) 82.10 LINK2   39
TWIN POINTER #   39 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.2 AREA   2.543 ROTATION  0.0013
AVG.SLOPE      2.74   COMPUTED SLOPE     3.84  CHORD        1.24
RADIUS         1.05   CENTER CO-ORD X=     5.76 Y=     1.25
NON-OVERLAP COUNT=  157 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------

NPRMHD     0 NPRMLT   41
NL9HD      2 NL9LST    2
NDOUTH     8 NDOUTL   31
NL1HD      5 NL1LST   40 NL2HD     15 NL2LST   38
NL3HD      1 NL3LST   30 NL4HD      3 NL4LST   16
NC1HD      9 NC1LST   36 NC2HD     41 NC2LST   41
```

```
NC3HD    39 NC3LST   39 NC4HD    28 NC4LST   28
NXTCEL   42 LSTCEL   41
-------------------------------------------------------------
-------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     2 %%  PRIMNO     2 LINK1     0 LINK2     0 COLOR  5
-------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     8 %%  PRIMNO     8 LINK1     0 LINK2    11 COLOR  3
% CELL #    11 %%  PRIMNO    11 LINK1     8 LINK2    20 COLOR  5
% CELL #    20 %%  PRIMNO    20 LINK1    11 LINK2    31 COLOR  2
% CELL #    31 %%  PRIMNO    31 LINK1    20 LINK2     0 COLOR  4
-------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     5 %%  PRIMNO     5 LINK1     0 LINK2    13 COLOR  3
% CELL #    13 %%  PRIMNO    13 LINK1     5 LINK2    14 COLOR  4
% CELL #    14 %%  PRIMNO    14 LINK1    13 LINK2    22 COLOR  5
% CELL #    22 %%  PRIMNO    22 LINK1    14 LINK2    26 COLOR  2
% CELL #    26 %%  PRIMNO    26 LINK1    22 LINK2    27 COLOR  4
% CELL #    27 %%  PRIMNO    27 LINK1    26 LINK2    40 COLOR  2
% CELL #    40 %%  PRIMNO    40 LINK1    27 LINK2     0 COLOR  5
-------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    15 %%  PRIMNO    15 LINK1     0 LINK2    23 COLOR  3
% CELL #    23 %%  PRIMNO    23 LINK1    15 LINK2    24 COLOR  2
% CELL #    24 %%  PRIMNO    24 LINK1    23 LINK2    33 COLOR  4
% CELL #    33 %%  PRIMNO    33 LINK1    24 LINK2    32 COLOR  5
% CELL #    32 %%  PRIMNO    32 LINK1    33 LINK2    35 COLOR  2
% CELL #    35 %%  PRIMNO    35 LINK1    32 LINK2    37 COLOR  2
% CELL #    37 %%  PRIMNO    37 LINK1    35 LINK2    38 COLOR  4
% CELL #    38 %%  PRIMNO    38 LINK1    37 LINK2     0 COLOR  5
-------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     1 %%  PRIMNO     1 LINK1     0 LINK2     4 COLOR  5
% CELL #     4 %%  PRIMNO     4 LINK1     1 LINK2     6 COLOR  3
% CELL #     6 %%  PRIMNO     6 LINK1     4 LINK2    10 COLOR  4
% CELL #    10 %%  PRIMNO    10 LINK1     6 LINK2    12 COLOR  3
% CELL #    12 %%  PRIMNO    12 LINK1    10 LINK2    18 COLOR  4
% CELL #    18 %%  PRIMNO    18 LINK1    12 LINK2    19 COLOR  2
% CELL #    19 %%  PRIMNO    19 LINK1    18 LINK2    30 COLOR  3
% CELL #    30 %%  PRIMNO    30 LINK1    19 LINK2     0 COLOR  3
-------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
```

```
------------------------------------------------------------
% CELL #    3 %%  PRIMNO    3 LINK1    0 LINK2    7 COLOR  5
% CELL #    7 %%  PRIMNO    7 LINK1    3 LINK2   25 COLOR  4
% CELL #   25 %%  PRIMNO   25 LINK1    7 LINK2   29 COLOR  5
% CELL #   29 %%  PRIMNO   29 LINK1   25 LINK2   16 COLOR  1
% CELL #   16 %%  PRIMNO   16 LINK1   29 LINK2    0 COLOR  4
------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    9 %%  PRIMNO    9 LINK1    0 LINK2   17 COLOR  4
% CELL #   17 %%  PRIMNO   17 LINK1    9 LINK2   21 COLOR  3
% CELL #   21 %%  PRIMNO   21 LINK1   17 LINK2   34 COLOR  4
% CELL #   34 %%  PRIMNO   34 LINK1   21 LINK2   36 COLOR  5
% CELL #   36 %%  PRIMNO   36 LINK1   34 LINK2    0 COLOR  1
------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   41 %%  PRIMNO   41 LINK1    0 LINK2    0 COLOR  1
------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   39 %%  PRIMNO   39 LINK1    0 LINK2    0 COLOR  1
------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   28 %%  PRIMNO   28 LINK1    0 LINK2    0 COLOR  1
------------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE6.LIST


########################################################
        ======  OUTPUT FOR SCENE 6  ======
########################################################

-------------------------------------------------------------
   **********   OUTPUT FROM MICROMATON    **********
-------------------------------------------------------------
   **********       PRIMITIVE SET         **********
-------------------------------------------------------------
PRIM#    1 TYPE 2 ALT.TYPE 0 COLOR 2 TAG# FROM     585 TO  648
START VECTOR => LENGTH  3.02 ANGLE (DEG) 20.75 LINK1    15
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 20.06 LINK2     3
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.044 ROTATION  0.0000
AVG.SLOPE    1.93   COMPUTED SLOPE    1.93  CHORD        0.04
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   20 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    14    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#    2 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM     585 TO 1127
START VECTOR => LENGTH  4.47 ANGLE (DEG) 20.06 LINK1     3
END   VECTOR => LENGTH  3.95 ANGLE (DEG) 38.91 LINK2    15
TWIN POINTER #    15 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  2.816 ROTATION -0.0001
AVG.SLOPE    2.41   COMPUTED SLOPE    2.43  CHORD        1.45
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   542
OVERLAP PRIMITIVES     4    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#    3 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM       0 TO  583
START VECTOR => LENGTH  3.02 ANGLE (DEG) 20.06 LINK1     1
END   VECTOR => LENGTH  4.47 ANGLE (DEG) 20.06 LINK2     2
TWIN POINTER #     0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  4.5 AREA  0.0  ROTATION  0.0
AVG.SLOPE     0.0   COMPUTED SLOPE    0.35  CHORD        1.45
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#    4 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM     585 TO 1134
START VECTOR => LENGTH  4.00 ANGLE (DEG) 38.67 LINK1    16
END   VECTOR => LENGTH  4.50 ANGLE (DEG) 20.06 LINK2     6
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.6 AREA -2.856 ROTATION  0.0003
AVG.SLOPE    2.41   COMPUTED SLOPE    5.57  CHORD        1.46
RADIUS        0.0   CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   549
OVERLAP PRIMITIVES     2    0    0    0    0    0    0    0
```

```
---------------------------------------------------------------
PRIM#   5 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM    585 TO 1728
START VECTOR => LENGTH  4.97 ANGLE (DEG) 20.06 LINK1    6
END   VECTOR => LENGTH  3.90 ANGLE (DEG) 59.31 LINK2   13
TWIN POINTER #   13 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.4 AREA  6.124 ROTATION  0.0001
AVG.SLOPE     2.58   COMPUTED SLOPE    2.59  CHORD       3.15
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=  1143
OVERLAP PRIMITIVES     7    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   6 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM      0 TO  583
START VECTOR => LENGTH  4.50 ANGLE (DEG) 20.06 LINK1    4
END   VECTOR => LENGTH  4.97 ANGLE (DEG) 20.06 LINK2    5
TWIN POINTER #    0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  5.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.35  CHORD       0.48
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   7 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM    585 TO 1748
START VECTOR => LENGTH  3.93 ANGLE (DEG) 59.83 LINK1   40
END   VECTOR => LENGTH  5.00 ANGLE (DEG) 20.06 LINK2    9
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.4 AREA -6.266 ROTATION  0.0001
AVG.SLOPE     2.58   COMPUTED SLOPE    5.73  CHORD       3.20
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=  1156
OVERLAP PRIMITIVES     5    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   8 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM    585 TO  898
START VECTOR => LENGTH  6.00 ANGLE (DEG) 20.06 LINK1    9
END   VECTOR => LENGTH  6.07 ANGLE (DEG) 30.43 LINK2    0
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.1 AREA  3.250 ROTATION  0.0001
AVG.SLOPE     1.94   COMPUTED SLOPE    1.94  CHORD       1.09
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   313
OVERLAP PRIMITIVES    10    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#   9 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM      0 TO  583
START VECTOR => LENGTH  5.00 ANGLE (DEG) 20.06 LINK1    7
END   VECTOR => LENGTH  6.00 ANGLE (DEG) 20.06 LINK2    8
TWIN POINTER #    0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  6.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.35  CHORD       1.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
```

```
NON-OVERLAP COUNT=     0 OVERLAP COUNT=      0                .
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM#  10 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM     585 TO  943
START VECTOR => LENGTH  6.12 ANGLE (DEG) 30.98 LINK1   23
END   VECTOR => LENGTH  6.02 ANGLE (DEG) 20.06 LINK2   12
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.2 AREA -3.456 ROTATION  0.0001
AVG.SLOPE     1.94   COMPUTED SLOPE    5.07  CHORD        1.16
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   358
OVERLAP PRIMITIVES     8   19    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM#  11 TYPE 1 ALT.TYPE 5 COLOR 5 TAG# FROM     585 TO 1492
START VECTOR => LENGTH  7.00 ANGLE (DEG) 20.06 LINK1   12
END   VECTOR => LENGTH  8.05 ANGLE (DEG) 49.84 LINK2   37
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.1 AREA 13.919 ROTATION  0.0003
AVG.SLOPE     1.93   COMPUTED SLOPE    1.92  CHORD        4.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   907 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM#  12 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM       0 TO  583
START VECTOR => LENGTH  6.02 ANGLE (DEG) 20.06 LINK1   10
END   VECTOR => LENGTH  7.00 ANGLE (DEG) 20.06 LINK2   11
TWIN POINTER #     0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  7.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.35  CHORD        0.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM#  13 TYPE 3 ALT.TYPE 7 COLOR 3 TAG# FROM     609 TO 1741
START VECTOR => LENGTH  3.90 ANGLE (DEG) 59.76 LINK1    5
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 20.88 LINK2   14
TWIN POINTER #     5 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.6 AREA -3.682 ROTATION -0.0001
AVG.SLOPE     1.94   COMPUTED SLOPE    5.07  CHORD        2.45
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT= 1132 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM#  14 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM     632 TO  741
START VECTOR => LENGTH  3.05 ANGLE (DEG) 21.67 LINK1   13
END   VECTOR => LENGTH  3.13 ANGLE (DEG) 24.45 LINK2   16
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.228 ROTATION  0.0000
```

```
AVG.SLOPE     1.61   COMPUTED SLOPE     1.51  CHORD        0.17
RADIUS        1.51   CENTER CO-ORD X=    4.49 Y=     0.25
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   110
OVERLAP PRIMITIVES     1   15    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  15 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM    649 TO 1134
START VECTOR => LENGTH  3.95 ANGLE (DEG) 38.67 LINK1    2
END   VECTOR => LENGTH  3.02 ANGLE (DEG) 20.75 LINK2    1
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.4 AREA -1.850 ROTATION -0.0005
AVG.SLOPE     1.37   COMPUTED SLOPE     4.53  CHORD        1.42
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   486
OVERLAP PRIMITIVES    14   16    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  16 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM    741 TO 1134
START VECTOR => LENGTH  3.13 ANGLE (DEG) 24.45 LINK1   14
END   VECTOR => LENGTH  3.93 ANGLE (DEG) 38.71 LINK2    4
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.2 AREA  1.520 ROTATION  0.0003
AVG.SLOPE     1.36   COMPUTED SLOPE     1.38  CHORD        1.18
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   393
OVERLAP PRIMITIVES    15    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  17 TYPE 8 ALT.TYPE 4 COLOR 4 TAG# FROM    880 TO  971
START VECTOR => LENGTH  5.65 ANGLE (DEG) 30.19 LINK1   20
END   VECTOR => LENGTH  5.15 ANGLE (DEG) 31.94 LINK2   24
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.5 AREA  0.407 ROTATION -0.0026
AVG.SLOPE     2.87   COMPUTED SLOPE     3.36  CHORD        0.53
RADIUS        1.01   CENTER CO-ORD X=    5.78 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    91
OVERLAP PRIMITIVES    18    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  18 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM    880 TO  971
START VECTOR => LENGTH  5.17 ANGLE (DEG) 31.94 LINK1   25
END   VECTOR => LENGTH  5.67 ANGLE (DEG) 30.19 LINK2   19
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -0.411 ROTATION -0.0026
AVG.SLOPE     2.87   COMPUTED SLOPE     0.22  CHORD        0.53
RADIUS        1.01   CENTER CO-ORD X=    5.80 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    91
OVERLAP PRIMITIVES    17    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  19 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM    880 TO 1047
START VECTOR => LENGTH  5.75 ANGLE (DEG) 30.19 LINK1   18
END   VECTOR => LENGTH  6.60 ANGLE (DEG) 34.55 LINK2   26
```

```
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  1.491 ROTATION  0.0038
AVG.SLOPE     0.89   COMPUTED SLOPE    1.07  CHORD        0.97
RADIUS        1.13   CENTER CO-ORD X=    5.75 Y=     0.72
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   167
OVERLAP PRIMITIVES    20   10   23    0    0    0    0    0
--------------------------------------------------------------
PRIM#  20 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM     880 TO  900
START VECTOR => LENGTH  6.10 ANGLE (DEG) 30.84 LINK1     0
END   VECTOR => LENGTH  5.77 ANGLE (DEG) 30.19 LINK2    17
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.172 ROTATION  0.0030
AVG.SLOPE     0.73   COMPUTED SLOPE    3.88  CHORD        0.33
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    20
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  21 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM     928 TO  928
START VECTOR => LENGTH  6.07 ANGLE (DEG) 30.43 LINK1     8
END   VECTOR => LENGTH  6.10 ANGLE (DEG) 30.81 LINK2     0
TWIN POINTER #    20 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.122 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.05
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  22 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM     940 TO  940
START VECTOR => LENGTH  6.10 ANGLE (DEG) 30.88 LINK1     0
END   VECTOR => LENGTH  6.10 ANGLE (DEG) 30.84 LINK2    20
TWIN POINTER #     8 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.011 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  23 TYPE 8 ALT.TYPE 4 COLOR 5 TAG# FROM     944 TO 1047
START VECTOR => LENGTH  6.62 ANGLE (DEG) 34.55 LINK1    27
END   VECTOR => LENGTH  6.12 ANGLE (DEG) 30.98 LINK2    10
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -1.282 ROTATION  0.0044
AVG.SLOPE     1.18   COMPUTED SLOPE    4.39  CHORD        0.64
RADIUS        0.98   CENTER CO-ORD X=    5.84 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   104
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM# -24 TYPE 5 ALT.TYPE 1 COLOR 4 TAG# FROM     972 TO 1420
```

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START VECTOR => LENGTH  5.15 ANGLE (DEG) 31.94 LINK1   17
END   VECTOR => LENGTH  5.05 ANGLE (DEG) 47.36 LINK2   35
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  3.213 ROTATION  0.0007
AVG.SLOPE     2.67   COMPUTED SLOPE    2.34  CHORD       1.37
RADIUS        0.99   CENTER CO-ORD X=     5.76 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   449
OVERLAP PRIMITIVES    25    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  25 TYPE 7 ALT.TYPE 3 COLOR 1 TAG# FROM    972 TO 1420
START VECTOR => LENGTH  5.07 ANGLE (DEG) 47.36 LINK1   36
END   VECTOR => LENGTH  5.17 ANGLE (DEG) 31.94 LINK2   18
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.6 AREA -3.246 ROTATION  0.0007
AVG.SLOPE     2.67   COMPUTED SLOPE    5.48  CHORD       1.38
RADIUS        1.00   CENTER CO-ORD X=     5.80 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   449
OVERLAP PRIMITIVES    24    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  26 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM   1048 TO 1416
START VECTOR => LENGTH  6.60 ANGLE (DEG) 34.55 LINK1   19
END   VECTOR => LENGTH  6.45 ANGLE (DEG) 47.23 LINK2   33
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.7 AREA  4.961 ROTATION  0.0016
AVG.SLOPE     2.03   COMPUTED SLOPE    2.39  CHORD       1.45
RADIUS        1.06   CENTER CO-ORD X=     5.71 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   369
OVERLAP PRIMITIVES    27   31    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  27 TYPE 7 ALT.TYPE 3 COLOR 5 TAG# FROM   1048 TO 1508
START VECTOR => LENGTH  6.95 ANGLE (DEG) 50.39 LINK1   38
END   VECTOR => LENGTH  6.62 ANGLE (DEG) 34.55 LINK2   23
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.1 AREA -6.323 ROTATION  0.0012
AVG.SLOPE     2.05   COMPUTED SLOPE    5.28  CHORD       1.90
RADIUS        3.58   CENTER CO-ORD X=     3.37 Y=     0.92
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   461
OVERLAP PRIMITIVES    26   32    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  28 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM   1168 TO 1168
START VECTOR => LENGTH  3.98 ANGLE (DEG) 38.91 LINK1    0
END   VECTOR => LENGTH  4.00 ANGLE (DEG) 38.67 LINK2    4
TWIN POINTER #     5 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.033 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD       0.03
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
```

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------------------------------------------------------------
PRIM#  29 TYPE 0 ALT.TYPE 0 COLOR 2 TAG# FROM   1168 TO 1168
START VECTOR => LENGTH  3.95 ANGLE (DEG) 38.91 LINK1    2
END   VECTOR => LENGTH  3.95 ANGLE (DEG) 38.67 LINK2   15
TWIN POINTER #     2 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.033 ROTATION  0.0
AVG.SLOPE      0.0    COMPUTED SLOPE    0.0   CHORD        0.02
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  30 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM   1168 TO 1168
START VECTOR => LENGTH  3.93 ANGLE (DEG) 38.71 LINK1   16
END   VECTOR => LENGTH  3.93 ANGLE (DEG) 38.91 LINK2    0
TWIN POINTER #    13 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.028 ROTATION  0.0
AVG.SLOPE      0.0    COMPUTED SLOPE    0.0   CHORD        0.01
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  31 TYPE 7 ALT.TYPE 3 COLOR 4 TAG# FROM   1321 TO 1416
START VECTOR => LENGTH  6.47 ANGLE (DEG) 47.23 LINK1   34
END   VECTOR => LENGTH  6.62 ANGLE (DEG) 45.34 LINK2   32
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.670 ROTATION  0.0008
AVG.SLOPE      2.91   COMPUTED SLOPE    6.13  CHORD        0.26
RADIUS         0.75   CENTER CO-ORD X=    5.96 Y=     0.74
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    95
OVERLAP PRIMITIVES    26    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  32 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM   1329 TO 1508
START VECTOR => LENGTH  6.65 ANGLE (DEG) 45.61 LINK1   31
END   VECTOR => LENGTH  6.92 ANGLE (DEG) 50.39 LINK2   39
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.7 AREA  1.875 ROTATION -0.0003
AVG.SLOPE      1.99   COMPUTED SLOPE    1.96  CHORD        0.63
RADIUS         0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   180
OVERLAP PRIMITIVES    27    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  33 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM   1417 TO 1457
START VECTOR => LENGTH  6.45 ANGLE (DEG) 47.23 LINK1   26
END   VECTOR => LENGTH  5.77 ANGLE (DEG) 50.01 LINK2   36
TWIN POINTER #    36 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  0.936 ROTATION  0.0076
AVG.SLOPE      2.81   COMPUTED SLOPE    3.58  CHORD        0.74
RADIUS         1.09   CENTER CO-ORD X=    5.77 Y=     0.68
```

```
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     41
OVERLAP PRIMITIVES    34    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  34 TYPE 6 ALT.TYPE 2 COLOR 4 TAG# FROM   1417 TO 1457
START VECTOR => LENGTH  5.80 ANGLE (DEG) 50.01 LINK1   35
END   VECTOR => LENGTH  6.47 ANGLE (DEG) 47.23 LINK2   31
TWIN POINTER #   32 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -0.944 ROTATION  0.0076
AVG.SLOPE     2.82   COMPUTED SLOPE    0.43  CHORD        0.74
RADIUS        1.09   CENTER CO-ORD X=    5.79 Y=     0.68
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     41
OVERLAP PRIMITIVES    33    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  35 TYPE 6 ALT.TYPE 2 COLOR 4 TAG# FROM   1421 TO 1457
START VECTOR => LENGTH  5.05 ANGLE (DEG) 47.36 LINK1   24
END   VECTOR => LENGTH  5.62 ANGLE (DEG) 50.01 LINK2   34
TWIN POINTER #    7 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.6 AREA  0.636 ROTATION -0.0032
AVG.SLOPE     1.34   COMPUTED SLOPE    1.25  CHORD        0.63
RADIUS        0.99   CENTER CO-ORD X=    5.77 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     37
OVERLAP PRIMITIVES    36    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  36 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM   1421 TO 1457
START VECTOR => LENGTH  5.65 ANGLE (DEG) 50.01 LINK1   33
END   VECTOR => LENGTH  5.07 ANGLE (DEG) 47.36 LINK2   25
TWIN POINTER #   33 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -0.643 ROTATION -0.0033
AVG.SLOPE     1.34   COMPUTED SLOPE    4.40  CHORD        0.63
RADIUS        0.99   CENTER CO-ORD X=    5.79 Y=     0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     37
OVERLAP PRIMITIVES    35    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  37 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1493 TO 2125
START VECTOR => LENGTH  8.05 ANGLE (DEG) 49.84 LINK1   11
END   VECTOR => LENGTH  5.00 ANGLE (DEG) 72.94 LINK2   42
TWIN POINTER #   42 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  4.0 AREA  7.866 ROTATION  0.0014
AVG.SLOPE     2.79   COMPUTED SLOPE    3.49  CHORD        3.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   633 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  38 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1509 TO 2068
START VECTOR => LENGTH  4.62 ANGLE (DEG) 69.27 LINK1   42
END   VECTOR => LENGTH  6.95 ANGLE (DEG) 50.39 LINK2   27
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.0 AREA -5.201 ROTATION -0.0004
```

```
AVG.SLOPE     2.79   COMPUTED SLOPE     0.35   CHORD        2.98
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   510
OVERLAP PRIMITIVES    39    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#  39 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1509 TO 2017
START VECTOR => LENGTH  6.92 ANGLE (DEG) 50.39 LINK1   32
END   VECTOR => LENGTH  4.62 ANGLE (DEG) 68.96 LINK2   40
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.0 AREA  5.099 ROTATION -0.0004
AVG.SLOPE     2.79   COMPUTED SLOPE     3.50   CHORD        2.94
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   509
OVERLAP PRIMITIVES    38    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#  40 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM   1748 TO 2020
START VECTOR => LENGTH  4.62 ANGLE (DEG) 69.23 LINK1   39
END   VECTOR => LENGTH  3.93 ANGLE (DEG) 59.83 LINK2    7
TWIN POINTER #    39 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.1 AREA -1.489 ROTATION -0.0006
AVG.SLOPE     1.95   COMPUTED SLOPE     5.08   CHORD        0.98
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=   272 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#  41 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM   2058 TO 2058
START VECTOR => LENGTH  4.62 ANGLE (DEG) 68.96 LINK1   39
END   VECTOR => LENGTH  4.62 ANGLE (DEG) 69.23 LINK2   40
TWIN POINTER #    40 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.051 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     0.0    CHORD        0.02
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
PRIM#  42 TYPE 3 ALT.TYPE 7 COLOR 5 TAG# FROM   2068 TO 2132
START VECTOR => LENGTH  5.00 ANGLE (DEG) 73.18 LINK1   37
END   VECTOR => LENGTH  4.62 ANGLE (DEG) 69.27 LINK2   38
TWIN POINTER #    37 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -0.789 ROTATION -0.0002
AVG.SLOPE     1.96   COMPUTED SLOPE     5.10   CHORD        0.50
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=    64 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
```

```
<<< .INACTIVE PRIMITIVE POINTER LISTS  >>>
-------------------------------------------------------------
-------------------------------------------------------------
-------------------------------------------------------------
NPRMHD     0 NPRMLT   42
NL9HD      0 NL9LST   39
NDOUTH    21 NDOUTL   41
NL1HD      2 NL1LST   32 NL2HD      1 NL2LST   39
NL3HD      4 NL3LST   42 NL4HD      3 NL4LST   38
NC1HD     24 NC1LST   26 NC2HD     33 NC2LST   36
NC3HD     25 NC3LST   31 NC4HD     14 NC4LST   23
NXTCEL    43 LSTCEL   42
-------------------------------------------------------------
-------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
-------------------------------------------------------------
-------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    21 %%  PRIMNO    21 LINK1     0 LINK2     22 COLOR  4
% CELL #    22 %%  PRIMNO    22 LINK1    21 LINK2     28 COLOR  4
% CELL #    28 %%  PRIMNO    28 LINK1    22 LINK2     29 COLOR  3
% CELL #    29 %%  PRIMNO    29 LINK1    28 LINK2     30 COLOR  2
% CELL #    30 %%  PRIMNO    30 LINK1    29 LINK2     41 COLOR  3
% CELL #    41 %%  PRIMNO    41 LINK1    30 LINK2      0 COLOR  4
-------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     2 %%  PRIMNO     2 LINK1     0 LINK2      5 COLOR  2
% CELL #     5 %%  PRIMNO     5 LINK1     2 LINK2      8 COLOR  3
% CELL #     8 %%  PRIMNO     8 LINK1     5 LINK2     11 COLOR  4
% CELL #    11 %%  PRIMNO    11 LINK1     8 LINK2     32 COLOR  5
% CELL #    32 %%  PRIMNO    32 LINK1    11 LINK2      0 COLOR  4
-------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     1 %%  PRIMNO     1 LINK1     0 LINK2     15 COLOR  2
% CELL #    15 %%  PRIMNO    15 LINK1     1 LINK2     20 COLOR  2
% CELL #    20 %%  PRIMNO    20 LINK1    15 LINK2     37 COLOR  4
% CELL #    37 %%  PRIMNO    37 LINK1    20 LINK2     39 COLOR  5
% CELL #    39 %%  PRIMNO    39 LINK1    37 LINK2      0 COLOR  4
-------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #     4 %%  PRIMNO     4 LINK1     0 LINK2      7 COLOR  3
% CELL #     7 %%  PRIMNO     7 LINK1     4 LINK2     10 COLOR  4
% CELL #    10 %%  PRIMNO    10 LINK1     7 LINK2     13 COLOR  5
% CELL #    13 %%  PRIMNO    13 LINK1    10 LINK2     40 COLOR  3
```

```
% CELL #   40 %%  PRIMNO   40 LINK1   13 LINK2   42 COLOR  4
% CELL #   42 %%  PRIMNO   42 LINK1   40 LINK2    0 COLOR  5
------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #    3 %%  PRIMNO    3 LINK1    0 LINK2    6 COLOR  2
% CELL #    6 %%  PRIMNO    6 LINK1    3 LINK2    9 COLOR  3
% CELL #    9 %%  PRIMNO    9 LINK1    6 LINK2   12 COLOR  4
% CELL #   12 %%  PRIMNO   12 LINK1    9 LINK2   16 COLOR  5
% CELL #   16 %%  PRIMNO   16 LINK1   12 LINK2   38 COLOR  3
% CELL #   38 %%  PRIMNO   38 LINK1   16 LINK2    0 COLOR  5
------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   24 %%  PRIMNO   24 LINK1    0 LINK2   26 COLOR  4
% CELL #   26 %%  PRIMNO   26 LINK1   24 LINK2    0 COLOR  1
------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   33 %%  PRIMNO   33 LINK1    0 LINK2   34 COLOR  1
% CELL #   34 %%  PRIMNO   34 LINK1   33 LINK2   35 COLOR  4
% CELL #   35 %%  PRIMNO   35 LINK1   34 LINK2   36 COLOR  4
% CELL #   36 %%  PRIMNO   36 LINK1   35 LINK2    0 COLOR  1
------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   25 %%  PRIMNO   25 LINK1    0 LINK2   27 COLOR  1
% CELL #   27 %%  PRIMNO   27 LINK1   25 LINK2   31 COLOR  5
% CELL #   31 %%  PRIMNO   31 LINK1   27 LINK2    0 COLOR  4
------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   14 %%  PRIMNO   14 LINK1    0 LINK2   17 COLOR  3
% CELL #   17 %%  PRIMNO   17 LINK1   14 LINK2   18 COLOR  4
% CELL #   18 %%  PRIMNO   18 LINK1   17 LINK2   19 COLOR  1
% CELL #   19 %%  PRIMNO   19 LINK1   18 LINK2   23 COLOR  1
% CELL #   23 %%  PRIMNO   23 LINK1   19 LINK2    0 COLOR  5
------------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE7.LIST


     #####################################################
             ======  OUTPUT FOR SCENE 7  ======
     #####################################################

     -------------------------------------------------------------
        **********   OUTPUT FROM MICROMATON   **********
     -------------------------------------------------------------
        **********       PRIMITIVE SET        **********
     -------------------------------------------------------------

     PRIM#    1 TYPE 0 ALT.TYPE 0 COLOR 1 TAG# FROM    914 TO  962
     START VECTOR => LENGTH  4.65 ANGLE (DEG) 31.50 LINK1     3
     END   VECTOR => LENGTH  4.67 ANGLE (DEG) 31.36 LINK2     2
     TWIN POINTER #     0 REDUCTION ID. 1.0
     PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
     AVG.SLOPE     0.0    COMPUTED SLOPE    3.01  CHORD        0.03
     RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
     NON-OVERLAP COUNT=   48 OVERLAP COUNT=      0
     OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
     -------------------------------------------------------------
     PRIM#    2 TYPE 9 ALT.TYPE 0 COLOR 1 TAG# FROM    918 TO  966
     START VECTOR => LENGTH  4.67 ANGLE (DEG) 31.36 LINK1     3
     END   VECTOR => LENGTH  4.67 ANGLE (DEG) 31.50 LINK2     4
     TWIN POINTER #     0 REDUCTION ID. 2.0
     PRIMITIVE VALUES => LENGTH   4.7 AREA  0.0   ROTATION  0.0
     AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.0
     RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
     NON-OVERLAP COUNT=   49 OVERLAP COUNT=      0
     OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
     -------------------------------------------------------------
     PRIM#    3 TYPE 3 ALT.TYPE 7 COLOR 1 TAG# FROM    962 TO 1785
     START VECTOR => LENGTH  2.82 ANGLE (DEG) 60.07 LINK1    34
     END   VECTOR => LENGTH  4.65 ANGLE (DEG) 31.50 LINK2     2
     TWIN POINTER #     0 REDUCTION ID. 1.0
     PRIMITIVE VALUES => LENGTH   3.0 AREA -3.138 ROTATION -0.0001
     AVG.SLOPE     3.14   COMPUTED SLOPE    6.28  CHORD        2.56
     RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
     NON-OVERLAP COUNT=  822 OVERLAP COUNT=      0
     OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
     -------------------------------------------------------------
     PRIM#    4 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM    966 TO 1146
     START VECTOR => LENGTH  4.67 ANGLE (DEG) 31.50 LINK1     2
     END   VECTOR => LENGTH  5.15 ANGLE (DEG) 39.19 LINK2    12
     TWIN POINTER #     0 REDUCTION ID. 2.0
     PRIMITIVE VALUES => LENGTH  0.9 AREA  1.605 ROTATION -0.0001
     AVG.SLOPE     1.58   COMPUTED SLOPE    1.56  CHORD        0.81
     RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
     NON-OVERLAP COUNT=  175 OVERLAP COUNT=      0
     OVERLAP PRIMITIVES     5    7    0    0    0    0    0    0
```

```
------------------------------------------------------------------
PRIM#   5 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM    1004 TO 1093
START VECTOR => LENGTH  6.62 ANGLE (DEG) 37.37 LINK1    11
END   VECTOR => LENGTH  7.42 ANGLE (DEG) 34.45 LINK2     6
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.9 AREA -1.204 ROTATION  0.0004
AVG.SLOPE     2.94   COMPUTED SLOPE    0.21  CHORD        0.88
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=   85 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     4    8    0    0    0    0    0    0
------------------------------------------------------------------
PRIM#   6 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM    1006 TO 1529
START VECTOR => LENGTH  7.42 ANGLE (DEG) 34.52 LINK1     5
END   VECTOR => LENGTH  8.85 ANGLE (DEG) 51.04 LINK2    24
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.8 AREA  9.312 ROTATION -0.0007
AVG.SLOPE     1.77   COMPUTED SLOPE    1.77  CHORD        2.73
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=  482 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    16   19   23    0    0    0    0    0
------------------------------------------------------------------
PRIM#   7 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM    1014 TO 1181
START VECTOR => LENGTH  5.17 ANGLE (DEG) 39.15 LINK1    13
END   VECTOR => LENGTH  6.65 ANGLE (DEG) 34.79 LINK2     8
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -1.270 ROTATION -0.0006
AVG.SLOPE     2.79   COMPUTED SLOPE    0.35  CHORD        1.54
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=  127 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     4   12    0    0    0    0    0    0
------------------------------------------------------------------
PRIM#   8 TYPE 5 ALT.TYPE 1 COLOR 2 TAG# FROM    1016 TO 1093
START VECTOR => LENGTH  6.65 ANGLE (DEG) 34.86 LINK1     7
END   VECTOR => LENGTH  6.57 ANGLE (DEG) 37.37 LINK2    10
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.3 AREA  0.945 ROTATION  0.0008
AVG.SLOPE     2.41   COMPUTED SLOPE    2.45  CHORD        0.30
RADIUS        1.31   CENTER CO-ORD X=     5.36 Y=     0.57
NON-OVERLAP COUNT=   74 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     5    0    0    0    0    0    0    0
------------------------------------------------------------------
PRIM#   9 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM    1094 TO 1141
START VECTOR => LENGTH  6.60 ANGLE (DEG) 37.51 LINK1    11
END   VECTOR => LENGTH  6.62 ANGLE (DEG) 37.37 LINK2     5
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA -0.052 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    3.05  CHORD        0.03
RADIUS        0.0    CENTER CO-ORD X=     0.0  Y=     0.0
```

```
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    48
OVERLAP PRIMITIVES    10    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  10 TYPE 1 ALT.TYPE 5 COLOR 2 TAG# FROM   1094 TO 1896
START VECTOR => LENGTH  6.57 ANGLE (DEG) 37.37 LINK1    8
END   VECTOR => LENGTH  6.65 ANGLE (DEG) 65.08 LINK2   45
TWIN POINTER #   45 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  3.3 AREA 10.168 ROTATION  0.0006
AVG.SLOPE    2.44   COMPUTED SLOPE    2.44  CHORD        3.17
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   803
OVERLAP PRIMITIVES     9   11    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  11 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM   1142 TO 1898
START VECTOR => LENGTH  6.67 ANGLE (DEG) 65.15 LINK1   44
END   VECTOR => LENGTH  6.60 ANGLE (DEG) 37.51 LINK2    5
TWIN POINTER #   41 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  3.3 AREA ****** ROTATION -0.0024
AVG.SLOPE    2.44   COMPUTED SLOPE    5.59  CHORD        3.17
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   757
OVERLAP PRIMITIVES    10    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  12 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM   1146 TO 1242
START VECTOR => LENGTH  5.15 ANGLE (DEG) 39.19 LINK1    4
END   VECTOR => LENGTH  5.20 ANGLE (DEG) 41.25 LINK2   14
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.485 ROTATION  0.0010
AVG.SLOPE    1.84   COMPUTED SLOPE    2.01  CHORD        0.19
RADIUS       0.12   CENTER CO-ORD X=    5.10 Y=    0.71
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    96
OVERLAP PRIMITIVES     7   13    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  13 TYPE 7 ALT.TYPE 3 COLOR 2 TAG# FROM   1182 TO 1249
START VECTOR => LENGTH  5.20 ANGLE (DEG) 41.49 LINK1   15
END   VECTOR => LENGTH  5.17 ANGLE (DEG) 39.15 LINK2    7
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.558 ROTATION  0.0073
AVG.SLOPE    2.00   COMPUTED SLOPE    5.30  CHORD        0.21
RADIUS       0.12   CENTER CO-ORD X=    5.14 Y=    0.70
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    68
OVERLAP PRIMITIVES    12   14    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  14 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM   1242 TO 1626
START VECTOR => LENGTH  5.20 ANGLE (DEG) 41.25 LINK1   12
END   VECTOR => LENGTH  4.15 ANGLE (DEG) 55.67 LINK2   26
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.8 AREA  2.673 ROTATION  0.0011
```

```
AVG.SLOPE     3.13    COMPUTED SLOPE    3.14  CHORD       1.57
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   380
OVERLAP PRIMITIVES    13   15    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  15 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM   1250 TO 1653
START VECTOR => LENGTH  4.18 ANGLE (DEG) 55.78 LINK1   27
END   VECTOR => LENGTH  5.20 ANGLE (DEG) 41.49 LINK2   13
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.7 AREA -2.661 ROTATION -0.0033
AVG.SLOPE     3.13    COMPUTED SLOPE    6.28  CHORD       1.55
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   372
OVERLAP PRIMITIVES    14   26    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  16 TYPE 4 ALT.TYPE 8 COLOR 6 TAG# FROM   1420 TO 1491
START VECTOR => LENGTH  8.90 ANGLE (DEG) 51.04 LINK1   19
END   VECTOR => LENGTH  9.75 ANGLE (DEG) 48.74 LINK2   17
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.9 AREA -1.661 ROTATION  0.0010
AVG.SLOPE     2.69    COMPUTED SLOPE    0.46  CHORD       0.93
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    67 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     6    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  17 TYPE 9 ALT.TYPE 0 COLOR 6 TAG# FROM   1422 TO 1471
START VECTOR => LENGTH  9.75 ANGLE (DEG) 48.81 LINK1   16
END   VECTOR => LENGTH  9.75 ANGLE (DEG) 48.81 LINK2   18
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  9.7 AREA  0.0  ROTATION  0.0
AVG.SLOPE     0.0     COMPUTED SLOPE    0.0   CHORD       0.0
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    49 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  18 TYPE 2 ALT.TYPE 6 COLOR 6 TAG# FROM   1472 TO 1511
START VECTOR => LENGTH  9.75 ANGLE (DEG) 48.81 LINK1   17
END   VECTOR => LENGTH  9.20 ANGLE (DEG) 51.73 LINK2   22
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.7 AREA  2.285 ROTATION  0.0000
AVG.SLOPE     2.99    COMPUTED SLOPE    3.30  CHORD       0.73
RADIUS        0.0     CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    36 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    20    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  19 TYPE 4 ALT.TYPE 8 COLOR 6 TAG# FROM   1492 TO 1734
START VECTOR => LENGTH  7.12 ANGLE (DEG) 57.80 LINK1   31
END   VECTOR => LENGTH  8.90 ANGLE (DEG) 51.04 LINK2   16
```

```
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.0 AREA -3.736 ROTATION -0.0001
AVG.SLOPE     2.68   COMPUTED SLOPE    0.46  CHORD        2.01
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   243
OVERLAP PRIMITIVES     6   24    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  20 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1508 TO 1804
START VECTOR => LENGTH  8.07 ANGLE (DEG) 60.21 LINK1   35
END   VECTOR => LENGTH  9.22 ANGLE (DEG) 51.76 LINK2   21
TWIN POINTER #      0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.7 AREA -5.395 ROTATION -0.0001
AVG.SLOPE     3.00   COMPUTED SLOPE    0.14  CHORD        1.71
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   246
OVERLAP PRIMITIVES    18   22   33    0    0    0    0    0
--------------------------------------------------------------
PRIM#  21 TYPE 4 ALT.TYPE 8 COLOR 5 TAG# FROM   1509 TO 1573
START VECTOR => LENGTH  9.25 ANGLE (DEG) 51.79 LINK1   20
END   VECTOR => LENGTH  9.52 ANGLE (DEG) 52.62 LINK2   25
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.3 AREA  0.584 ROTATION  0.0007
AVG.SLOPE     1.34   COMPUTED SLOPE    1.37  CHORD        0.31
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   65 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  22 TYPE 2 ALT.TYPE 6 COLOR 6 TAG# FROM   1512 TO 1769
START VECTOR => LENGTH  9.20 ANGLE (DEG) 51.73 LINK1   18
END   VECTOR => LENGTH  8.05 ANGLE (DEG) 60.21 LINK2   33
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.7 AREA  5.464 ROTATION  0.0002
AVG.SLOPE     3.01   COMPUTED SLOPE    3.28  CHORD        1.72
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   243
OVERLAP PRIMITIVES    20    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  23 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1514 TO 1524
START VECTOR => LENGTH  8.57 ANGLE (DEG) 51.97 LINK1    0
END   VECTOR => LENGTH  8.47 ANGLE (DEG) 52.31 LINK2    0
TWIN POINTER #      0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    3.58  CHORD        0.11
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     6
OVERLAP PRIMITIVES     6    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  24 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1530 TO 1734
```

```
START VECTOR => LENGTH  8.85 ANGLE (DEG) 51.04 LINK1    6
END   VECTOR => LENGTH  7.10 ANGLE (DEG) 57.80 LINK2   32
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  2.0 AREA  3.711 ROTATION  0.0029
AVG.SLOPE     2.69   COMPUTED SLOPE    3.60  CHORD        1.98
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   205
OVERLAP PRIMITIVES    19    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  25 TYPE 5 ALT.TYPE 1 COLOR 5 TAG# FROM   1574 TO 1829
START VECTOR => LENGTH  9.52 ANGLE (DEG) 52.62 LINK1   21
END   VECTOR => LENGTH  9.85 ANGLE (DEG) 61.06 LINK2   38
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.7 AREA  7.194 ROTATION  0.0064
AVG.SLOPE     2.00   COMPUTED SLOPE    2.34  CHORD        1.46
RADIUS        1.05   CENTER CO-ORD X=   8.92 Y=    1.01
NON-OVERLAP COUNT=  256 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  26 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM   1626 TO 1815
START VECTOR => LENGTH  4.15 ANGLE (DEG) 55.67 LINK1   14
END   VECTOR => LENGTH  3.88 ANGLE (DEG) 62.13 LINK2   36
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.6 AREA  0.898 ROTATION -0.0012
AVG.SLOPE     3.11   COMPUTED SLOPE    3.15  CHORD        0.53
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  182 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    15   27   28    0    0    0    0    0
-------------------------------------------------------------
PRIM#  27 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1654 TO 1674
START VECTOR => LENGTH  4.42 ANGLE (DEG) 57.29 LINK1   30
END   VECTOR => LENGTH  4.18 ANGLE (DEG) 55.78 LINK2   15
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.243 ROTATION -0.0005
AVG.SLOPE     1.41   COMPUTED SLOPE    4.55  CHORD        0.27
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   16 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    26   29    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  28 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1670 TO 1819
START VECTOR => LENGTH  3.90 ANGLE (DEG) 62.09 LINK1   37
END   VECTOR => LENGTH  4.42 ANGLE (DEG) 57.32 LINK2   29
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.6 AREA -0.693 ROTATION -0.0000
AVG.SLOPE     2.67   COMPUTED SLOPE    0.46  CHORD        0.63
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  138 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    26   36    0    0    0    0    0    0
```

```
-----------------------------------------------------------------
PRIM# 29 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM  1671 TO 1874
START VECTOR => LENGTH  4.42 ANGLE (DEG) 57.36 LINK1   28
END   VECTOR => LENGTH  5.70 ANGLE (DEG) 62.61 LINK2   42
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.4 AREA  1.135 ROTATION  0.0000
AVG.SLOPE     1.40   COMPUTED SLOPE     1.40  CHORD        1.36
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   154
OVERLAP PRIMITIVES    27   30   39    0    0    0    0    0
-----------------------------------------------------------------
PRIM# 30 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM  1675 TO 1829
START VECTOR => LENGTH  5.72 ANGLE (DEG) 62.61 LINK1   39
END   VECTOR => LENGTH  4.42 ANGLE (DEG) 57.29 LINK2   27
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.4 AREA -1.176 ROTATION  0.0012
AVG.SLOPE     1.39   COMPUTED SLOPE     4.54  CHORD        1.38
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   150
OVERLAP PRIMITIVES    29    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM# 31 TYPE 3 ALT.TYPE 7 COLOR 6 TAG# FROM  1735 TO 1834
START VECTOR => LENGTH  7.52 ANGLE (DEG) 62.78 LINK1   40
END   VECTOR => LENGTH  7.12 ANGLE (DEG) 57.80 LINK2   19
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -2.325 ROTATION  0.0026
AVG.SLOPE     2.06   COMPUTED SLOPE     5.20  CHORD        0.75
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    95
OVERLAP PRIMITIVES    32    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM# 32 TYPE 1 ALT.TYPE 5 COLOR 4 TAG# FROM  1735 TO 1834
START VECTOR => LENGTH  7.10 ANGLE (DEG) 57.80 LINK1   24
END   VECTOR => LENGTH  7.50 ANGLE (DEG) 62.78 LINK2   46
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  2.309 ROTATION  0.0026
AVG.SLOPE     2.06   COMPUTED SLOPE     2.06  CHORD        0.75
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    95
OVERLAP PRIMITIVES    31    0    0    0    0    0    0    0
-----------------------------------------------------------------
PRIM# 33 TYPE 2 ALT.TYPE 6 COLOR 6 TAG# FROM  1770 TO 1866
START VECTOR => LENGTH  8.05 ANGLE (DEG) 60.21 LINK1   22
END   VECTOR => LENGTH  7.67 ANGLE (DEG) 63.98 LINK2   40
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.6 AREA  2.035 ROTATION  0.0008
AVG.SLOPE     3.01   COMPUTED SLOPE     3.28  CHORD        0.64
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
```

```
NON-OVERLAP COUNT=   97 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    20   35    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  34 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM    1785 TO 1951
START VECTOR => LENGTH  3.55 ANGLE (DEG) 66.73 LINK1   52
END   VECTOR => LENGTH  2.82 ANGLE (DEG) 60.07 LINK2    3
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -0.574 ROTATION -0.0039
AVG.SLOPE     1.59   COMPUTED SLOPE     4.72  CHORD        0.81
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  159 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    51    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  35 TYPE 7 ALT.TYPE 3 COLOR 5 TAG# FROM    1805 TO 1871
START VECTOR => LENGTH  8.60 ANGLE (DEG) 63.81 LINK1   47
END   VECTOR => LENGTH  8.07 ANGLE (DEG) 60.21 LINK2   20
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -2.150 ROTATION -0.0041
AVG.SLOPE     1.96   COMPUTED SLOPE     5.01  CHORD        0.74
RADIUS        0.91   CENTER CO-ORD X=    8.94 Y=     1.02
NON-OVERLAP COUNT=   67 OVERLAP COUNT=      0
OVERLAP PRIMITIVES    33   41    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  36 TYPE 1 ALT.TYPE 5 COLOR 1 TAG# FROM    1815 TO 1973
START VECTOR => LENGTH  3.88 ANGLE (DEG) 62.13 LINK1   26
END   VECTOR => LENGTH  3.70 ANGLE (DEG) 67.72 LINK2   52
TWIN POINTER #    52 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  0.695 ROTATION -0.0019
AVG.SLOPE     3.10   COMPUTED SLOPE     3.15  CHORD        0.41
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    157
OVERLAP PRIMITIVES    28   37    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  37 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM    1820 TO 1977
START VECTOR => LENGTH  3.73 ANGLE (DEG) 67.86 LINK1   51
END   VECTOR => LENGTH  3.90 ANGLE (DEG) 62.09 LINK2   28
TWIN POINTER #    42 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.4 AREA -0.723 ROTATION -0.0017
AVG.SLOPE     6.22   COMPUTED SLOPE     6.27  CHORD        0.42
RADIUS        1.71   CENTER CO-ORD X=    5.39 Y=     1.27
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    158
OVERLAP PRIMITIVES    36    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  38 TYPE 6 ALT.TYPE 2 COLOR 5 TAG# FROM    1830 TO 1871
START VECTOR => LENGTH  9.85 ANGLE (DEG) 61.06 LINK1   25
END   VECTOR => LENGTH  9.02 ANGLE (DEG) 64.22 LINK2   47
TWIN POINTER #    35 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  2.524 ROTATION  0.0198
```

```
AVG.SLOPE     2.74   COMPUTED SLOPE    3.67  CHORD        0.97
RADIUS        0.98   CENTER CO-ORD X=    9.01 Y=     1.01
NON-OVERLAP COUNT=   42 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 39 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1830 TO 1888
START VECTOR => LENGTH  6.45 ANGLE (DEG) 64.63 LINK1    45
END   VECTOR => LENGTH  5.72 ANGLE (DEG) 62.61 LINK2    30
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -0.652 ROTATION  0.0002
AVG.SLOPE     1.40   COMPUTED SLOPE    4.54  CHORD        0.76
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   50 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    29   42   44    0    0    0    0    0
-------------------------------------------------------------
PRIM# 40 TYPE 3 ALT.TYPE 7 COLOR 6 TAG# FROM   1835 TO 1870
START VECTOR => LENGTH  7.67 ANGLE (DEG) 64.05 LINK1    33
END   VECTOR => LENGTH  7.52 ANGLE (DEG) 62.78 LINK2    31
TWIN POINTER #    33 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.2 AREA -0.710 ROTATION  0.0002
AVG.SLOPE     2.00   COMPUTED SLOPE    5.14  CHORD        0.24
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   36 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    41    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 41 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM   1835 TO 1898
START VECTOR => LENGTH  7.50 ANGLE (DEG) 62.78 LINK1    32
END   VECTOR => LENGTH  7.50 ANGLE (DEG) 62.95 LINK2    46
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.084 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.67  CHORD        0.02
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=   64 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    40   35    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 42 TYPE 1 ALT.TYPE 5 COLOR 3 TAG# FROM   1875 TO 2285
START VECTOR => LENGTH  5.70 ANGLE (DEG) 62.61 LINK1    29
END   VECTOR => LENGTH  6.15 ANGLE (DEG) 78.43 LINK2    55
TWIN POINTER #    55 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.8 AREA  4.757 ROTATION  0.0011
AVG.SLOPE     2.54   COMPUTED SLOPE    2.53  CHORD        1.69
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
NON-OVERLAP COUNT=  410 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    39   43    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 43 TYPE 3 ALT.TYPE 7 COLOR 4 TAG# FROM   1879 TO 1992
START VECTOR => LENGTH  7.00 ANGLE (DEG) 68.24 LINK1    46
END   VECTOR => LENGTH  6.37 ANGLE (DEG) 64.50 LINK2    44
```

```
TWIN POINTER #   46 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -1.462 ROTATION  0.0005
AVG.SLOPE    1.78   COMPUTED SLOPE    4.93  CHORD        0.77
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  113 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    42    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  44 TYPE 9 ALT.TYPE 0 COLOR 4 TAG# FROM   1883 TO 1898
START VECTOR => LENGTH  6.42 ANGLE (DEG) 64.63 LINK1   43
END   VECTOR => LENGTH  6.42 ANGLE (DEG) 64.63 LINK2   11
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  6.4 AREA  0.0   ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    16
OVERLAP PRIMITIVES    39   45    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  45 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1889 TO 1898
START VECTOR => LENGTH  6.65 ANGLE (DEG) 65.15 LINK1   10
END   VECTOR => LENGTH  6.45 ANGLE (DEG) 64.63 LINK2   39
TWIN POINTER #   10 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.1 AREA -0.063 ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    4.56  CHORD        0.21
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    10
OVERLAP PRIMITIVES    44    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  46 TYPE 2 ALT.TYPE 6 COLOR 4 TAG# FROM   1899 TO 1988
START VECTOR => LENGTH  7.50 ANGLE (DEG) 62.95 LINK1   32
END   VECTOR => LENGTH  7.00 ANGLE (DEG) 68.20 LINK2   43
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  2.401 ROTATION  0.0002
AVG.SLOPE    2.92   COMPUTED SLOPE    3.36  CHORD        0.83
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   89 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  47 TYPE 2 ALT.TYPE 6 COLOR 5 TAG# FROM   1914 TO 1914
START VECTOR => LENGTH  8.87 ANGLE (DEG) 64.22 LINK1   38
END   VECTOR => LENGTH  8.60 ANGLE (DEG) 63.81 LINK2   35
TWIN POINTER #   38 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.274 ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    4.48  CHORD        0.28
RADIUS      19.62   CENTER CO-ORD X= -19.62 Y=   -0.68
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  48 TYPE 0 ALT.TYPE 0 COLOR 6 TAG# FROM   1919 TO 1919
```

```
START VECTOR => LENGTH  7.67 ANGLE (DEG) 63.98 LINK1   33
END   VECTOR => LENGTH  7.67 ANGLE (DEG) 64.05 LINK2   40
TWIN POINTER #   40 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.035 ROTATION  0.0
AVG.SLOPE     0.0     COMPUTED SLOPE     2.69  CHORD        0.01
RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  49 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   1944 TO 1944
START VECTOR => LENGTH  6.42 ANGLE (DEG) 64.63 LINK1   44
END   VECTOR => LENGTH  6.62 ANGLE (DEG) 65.15 LINK2    0
TWIN POINTER #   43 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.2 AREA  0.191 ROTATION  0.0
AVG.SLOPE     0.0     COMPUTED SLOPE     1.42  CHORD        0.21
RADIUS      11.60     CENTER CO-ORD X=  -11.60 Y=    -0.72
NON-OVERLAP COUNT=     0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  50 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM   1947 TO 2008
START VECTOR => LENGTH  3.52 ANGLE (DEG) 67.00 LINK1   53
END   VECTOR => LENGTH  3.52 ANGLE (DEG) 66.83 LINK2   51
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0     COMPUTED SLOPE     2.74  CHORD        0.01
RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=    61 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  51 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM   1949 TO 1977
START VECTOR => LENGTH  3.52 ANGLE (DEG) 66.83 LINK1   53
END   VECTOR => LENGTH  3.68 ANGLE (DEG) 67.86 LINK2   37
TWIN POINTER #   50 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.1 AREA  0.098 ROTATION -0.0003
AVG.SLOPE     1.65    COMPUTED SLOPE     1.63  CHORD        0.14
RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    29
OVERLAP PRIMITIVES    34   52    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  52 TYPE 2 ALT.TYPE 6 COLOR 1 TAG# FROM   1952 TO 1977
START VECTOR => LENGTH  3.70 ANGLE (DEG) 67.86 LINK1   36
END   VECTOR => LENGTH  3.55 ANGLE (DEG) 66.73 LINK2   34
TWIN POINTER #   36 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.2 AREA -0.130 ROTATION -0.0002
AVG.SLOPE     1.61    COMPUTED SLOPE     4.76  CHORD        0.17
RADIUS        0.0     CENTER CO-ORD X=     0.0  Y=     0.0
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    26
OVERLAP PRIMITIVES    51    0    0    0    0    0    0    0
```

```
-------------------------------------------------------------
PRIM#  53 TYPE 4 ALT.TYPE 8 COLOR 3 TAG# FROM    2008 TO 2142
START VECTOR => LENGTH  3.23 ANGLE (DEG) 71.84 LINK1    55
END   VECTOR => LENGTH  3.52 ANGLE (DEG) 67.00 LINK2    51
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.4 AREA -0.479 ROTATION -0.0007
AVG.SLOPE     2.69   COMPUTED SLOPE     0.45  CHORD       0.41
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  134 OVERLAP COUNT=     0
OVERLAP PRIMITIVES      0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  54 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM    2038 TO 2038
START VECTOR => LENGTH  7.00 ANGLE (DEG) 68.20 LINK1    46
END   VECTOR => LENGTH  7.00 ANGLE (DEG) 68.24 LINK2    43
TWIN POINTER #    43 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.015 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE     2.76  CHORD       0.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES      0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  55 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM    2142 TO 2286
START VECTOR => LENGTH  6.15 ANGLE (DEG) 78.46 LINK1    42
END   VECTOR => LENGTH  3.23 ANGLE (DEG) 71.84 LINK2    53
TWIN POINTER #    42 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  2.9 AREA -1.091 ROTATION -0.0032
AVG.SLOPE     1.51   COMPUTED SLOPE     4.64  CHORD       2.97
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  144 OVERLAP COUNT=     0
OVERLAP PRIMITIVES      0    0    0    0    0    0    0    0
-------------------------------------------------------------
-------------------------------------------------------------
-------------------------------------------------------------
-------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
-------------------------------------------------------------
-------------------------------------------------------------
-------------------------------------------------------------
NPRMHD     0 NPRMLT   55
NL9HD      2 NL9LST   44
NDOUTH     1 NDOUTL   54
NL1HD      6 NL1LST   42 NL2HD     34 NL2LST   55
NL3HD      3 NL3LST   43 NL4HD      4 NL4LST   53
NC1HD      8 NC1LST   25 NC2HD     38 NC2LST   38
NC3HD     13 NC3LST   35 NC4HD     37 NC4LST   37
NXTCEL    56 LSTCEL   55
-------------------------------------------------------------
-------------------------------------------------------------
```

```
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #     2 %%  PRIMNO     2 LINK1     0 LINK2     17 COLOR  1
% CELL #    17 %%  PRIMNO    17 LINK1     2 LINK2     44 COLOR  6
% CELL #    44 %%  PRIMNO    44 LINK1    17 LINK2      0 COLOR  4
------------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #     1 %%  PRIMNO     1 LINK1     0 LINK2      9 COLOR  1
% CELL #     9 %%  PRIMNO     9 LINK1     1 LINK2     41 COLOR  4
% CELL #    41 %%  PRIMNO    41 LINK1     9 LINK2     48 COLOR  4
% CELL #    48 %%  PRIMNO    48 LINK1    41 LINK2     50 COLOR  6
% CELL #    50 %%  PRIMNO    50 LINK1    48 LINK2     54 COLOR  3
% CELL #    54 %%  PRIMNO    54 LINK1    50 LINK2      0 COLOR  4
------------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #     6 %%  PRIMNO     6 LINK1     0 LINK2     10 COLOR  4
% CELL #    10 %%  PRIMNO    10 LINK1     6 LINK2     14 COLOR  2
% CELL #    14 %%  PRIMNO    14 LINK1    10 LINK2     26 COLOR  1
% CELL #    26 %%  PRIMNO    26 LINK1    14 LINK2     32 COLOR  1
% CELL #    32 %%  PRIMNO    32 LINK1    26 LINK2     36 COLOR  4
% CELL #    36 %%  PRIMNO    36 LINK1    32 LINK2     42 COLOR  1
% CELL #    42 %%  PRIMNO    42 LINK1    36 LINK2      0 COLOR  3
------------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #    34 %%  PRIMNO    34 LINK1     0 LINK2     52 COLOR  1
% CELL #    52 %%  PRIMNO    52 LINK1    34 LINK2     18 COLOR  1
% CELL #    18 %%  PRIMNO    18 LINK1    52 LINK2     22 COLOR  6
% CELL #    22 %%  PRIMNO    22 LINK1    18 LINK2     23 COLOR  6
% CELL #    23 %%  PRIMNO    23 LINK1    22 LINK2     24 COLOR  5
% CELL #    24 %%  PRIMNO    24 LINK1    23 LINK2     27 COLOR  4
% CELL #    27 %%  PRIMNO    27 LINK1    24 LINK2     30 COLOR  2
% CELL #    30 %%  PRIMNO    30 LINK1    27 LINK2     33 COLOR  2
% CELL #    33 %%  PRIMNO    33 LINK1    30 LINK2     39 COLOR  6
% CELL #    39 %%  PRIMNO    39 LINK1    33 LINK2     45 COLOR  2
% CELL #    45 %%  PRIMNO    45 LINK1    39 LINK2     46 COLOR  2
% CELL #    46 %%  PRIMNO    46 LINK1    45 LINK2     47 COLOR  4
% CELL #    47 %%  PRIMNO    47 LINK1    46 LINK2     55 COLOR  5
% CELL #    55 %%  PRIMNO    55 LINK1    47 LINK2      0 COLOR  3
------------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------------
% CELL #     3 %%  PRIMNO     3 LINK1     0 LINK2     11 COLOR  1
% CELL #    11 %%  PRIMNO    11 LINK1     3 LINK2     15 COLOR  4
% CELL #    15 %%  PRIMNO    15 LINK1    11 LINK2     31 COLOR  2
% CELL #    31 %%  PRIMNO    31 LINK1    15 LINK2     40 COLOR  6
```

```
% CELL #   40 %%  PRIMNO   40 LINK1   31 LINK2   43 COLOR  6
% CELL #   43 %%  PRIMNO   43 LINK1   40 LINK2    0 COLOR  4
-------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    4 %%  PRIMNO    4 LINK1    0 LINK2   51 COLOR  1
% CELL #   51 %%  PRIMNO   51 LINK1    4 LINK2    5 COLOR  3
% CELL #    5 %%  PRIMNO    5 LINK1   51 LINK2    7 COLOR  4
% CELL #    7 %%  PRIMNO    7 LINK1    5 LINK2   16 COLOR  2
% CELL #   16 %%  PRIMNO   16 LINK1    7 LINK2   19 COLOR  6
% CELL #   19 %%  PRIMNO   19 LINK1   16 LINK2   20 COLOR  6
% CELL #   20 %%  PRIMNO   20 LINK1   19 LINK2   21 COLOR  5
% CELL #   21 %%  PRIMNO   21 LINK1   20 LINK2   28 COLOR  5
% CELL #   28 %%  PRIMNO   28 LINK1   21 LINK2   29 COLOR  3
% CELL #   29 %%  PRIMNO   29 LINK1   28 LINK2   49 COLOR  3
% CELL #   49 %%  PRIMNO   49 LINK1   29 LINK2   53 COLOR  4
% CELL #   53 %%  PRIMNO   53 LINK1   49 LINK2    0 COLOR  3
-------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #    8 %%  PRIMNO    8 LINK1    0 LINK2   12 COLOR  2
% CELL #   12 %%  PRIMNO   12 LINK1    8 LINK2   25 COLOR  1
% CELL #   25 %%  PRIMNO   25 LINK1   12 LINK2    0 COLOR  5
-------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   38 %%  PRIMNO   38 LINK1    0 LINK2    0 COLOR  5
-------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   13 %%  PRIMNO   13 LINK1    0 LINK2   35 COLOR  2
% CELL #   35 %%  PRIMNO   35 LINK1   13 LINK2    0 COLOR  5
-------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
-------------------------------------------------------------
% CELL #   37 %%  PRIMNO   37 LINK1    0 LINK2    0 COLOR  3
-------------------------------------------------------------
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.SCENE8.LIST


            ##########################################################
                    ======  OUTPUT FOR SCENE 8  ======
            ##########################################################

            -------------------------------------------------------------
               **********   OUTPUT FROM MICROMATON   **********
            -------------------------------------------------------------
               **********       PRIMITIVE SET        **********
            -------------------------------------------------------------
            PRIM#   1 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM    633 TO  729
            START VECTOR => LENGTH  3.88 ANGLE (DEG) 23.63 LINK1     3
            END   VECTOR => LENGTH  4.52 ANGLE (DEG) 21.71 LINK2     2
            TWIN POINTER #     0 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  0.7 AREA -0.259 ROTATION -0.0021
            AVG.SLOPE     2.92   COMPUTED SLOPE    0.18  CHORD        0.66
            RADIUS        2.63   CENTER CO-ORD X=    5.39 Y=     0.89
            NON-OVERLAP COUNT=   96 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   2 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM    633 TO 1000
            START VECTOR => LENGTH  4.65 ANGLE (DEG) 21.71 LINK1     1
            END   VECTOR => LENGTH  6.57 ANGLE (DEG) 32.94 LINK2    10
            TWIN POINTER #     0 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  2.3 AREA  3.439 ROTATION  0.0034
            AVG.SLOPE     0.74   COMPUTED SLOPE    1.00  CHORD        2.21
            RADIUS        2.04   CENTER CO-ORD X=    4.99 Y=     0.80
            NON-OVERLAP COUNT=  367 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   3 TYPE 7 ALT.TYPE 3 COLOR 6 TAG# FROM    729 TO 1999
            START VECTOR => LENGTH  3.88 ANGLE (DEG) 66.90 LINK1    41
            END   VECTOR => LENGTH  3.88 ANGLE (DEG) 23.63 LINK2     1
            TWIN POINTER #     0 REDUCTION ID. 1.0
            PRIMITIVE VALUES => LENGTH  3.3 AREA -3.989 ROTATION -0.0011
            AVG.SLOPE     2.75   COMPUTED SLOPE    5.50  CHORD        2.86
            RADIUS        2.04   CENTER CO-ORD X=    5.05 Y=     0.79
            NON-OVERLAP COUNT= 1270 OVERLAP COUNT=     0
            OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
            -------------------------------------------------------------
            PRIM#   4 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM    833 TO  925
            START VECTOR => LENGTH  4.85 ANGLE (DEG) 28.58 LINK1     7
            END   VECTOR => LENGTH  4.37 ANGLE (DEG) 30.36 LINK2     8
            TWIN POINTER #     0 REDUCTION ID. 2.0
            PRIMITIVE VALUES => LENGTH  0.5 AREA  0.293 ROTATION -0.0024
            AVG.SLOPE     2.85   COMPUTED SLOPE    3.36  CHORD        0.50
            RADIUS        1.05   CENTER CO-ORD X=    5.00 Y=     0.71
            NON-OVERLAP COUNT=    0 OVERLAP COUNT=    92
            OVERLAP PRIMITIVES     5    9    0    0    0    0    0    0
```

```
-------------------------------------------------------------
PRIM#   5 TYPE 8 ALT.TYPE 4 COLOR 5 TAG# FROM    833 TO  924
START VECTOR => LENGTH  4.40 ANGLE (DEG) 30.33 LINK1     9
END   VECTOR => LENGTH  4.87 ANGLE (DEG) 28.58 LINK2     6
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -0.298 ROTATION -0.0027
AVG.SLOPE     2.86   COMPUTED SLOPE     0.22  CHORD       0.50
RADIUS        1.14   CENTER CO-ORD X=    5.07 Y=    0.73
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    91
OVERLAP PRIMITIVES     4    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#   6 TYPE 8 ALT.TYPE 4 COLOR 5 TAG# FROM    833 TO 1024
START VECTOR => LENGTH  4.92 ANGLE (DEG) 28.58 LINK1     5
END   VECTOR => LENGTH  5.80 ANGLE (DEG) 33.76 LINK2    11
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  1.357 ROTATION  0.0043
AVG.SLOPE     0.85   COMPUTED SLOPE     1.05  CHORD       1.00
RADIUS        1.07   CENTER CO-ORD X=    4.97 Y=    0.71
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   191
OVERLAP PRIMITIVES     7    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#   7 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM    833 TO 1024
START VECTOR => LENGTH  5.82 ANGLE (DEG) 33.76 LINK1    12
END   VECTOR => LENGTH  4.95 ANGLE (DEG) 28.58 LINK2     4
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.0 AREA -1.369 ROTATION  0.0043
AVG.SLOPE     0.85   COMPUTED SLOPE     4.19  CHORD       1.00
RADIUS        1.07   CENTER CO-ORD X=    4.99 Y=    0.71
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   191
OVERLAP PRIMITIVES     6    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#   8 TYPE 5 ALT.TYPE 1 COLOR 6 TAG# FROM    925 TO 1457
START VECTOR => LENGTH  4.37 ANGLE (DEG) 30.36 LINK1     4
END   VECTOR => LENGTH  4.25 ANGLE (DEG) 48.63 LINK2    19
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  2.666 ROTATION -0.0015
AVG.SLOPE     2.69   COMPUTED SLOPE     2.35  CHORD       1.37
RADIUS        1.05   CENTER CO-ORD X=    5.05 Y=    0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   532
OVERLAP PRIMITIVES     9   18    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#   9 TYPE 7 ALT.TYPE 3 COLOR 5 TAG# FROM    925 TO 1448
START VECTOR => LENGTH  4.25 ANGLE (DEG) 48.32 LINK1    18
END   VECTOR => LENGTH  4.40 ANGLE (DEG) 30.33 LINK2     5
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.5 AREA -2.655 ROTATION -0.0013
AVG.SLOPE     2.69   COMPUTED SLOPE     5.51  CHORD       1.36
RADIUS        1.08   CENTER CO-ORD X=    5.10 Y=    0.70
```

```
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   524
OVERLAP PRIMITIVES     4    8    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  10 TYPE 5 ALT.TYPE 1 COLOR 6 TAG# FROM   1001 TO 1393
START VECTOR => LENGTH  6.57 ANGLE (DEG) 32.94 LINK1     2
END   VECTOR => LENGTH  6.97 ANGLE (DEG) 47.81 LINK2     0
TWIN POINTER #    12 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.9 AREA  6.123 ROTATION  0.0004
AVG.SLOPE      1.89   COMPUTED SLOPE     2.05  CHORD        1.80
RADIUS         2.04   CENTER CO-ORD X=     4.95 Y=     0.79
NON-OVERLAP COUNT=  393 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  11 TYPE 5 ALT.TYPE 1 COLOR 5 TAG# FROM   1025 TO 1432
START VECTOR => LENGTH  5.80 ANGLE (DEG) 33.76 LINK1     6
END   VECTOR => LENGTH  5.70 ANGLE (DEG) 47.78 LINK2    16
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.6 AREA  4.266 ROTATION  0.0003
AVG.SLOPE      2.02   COMPUTED SLOPE     2.35  CHORD        1.41
RADIUS         1.06   CENTER CO-ORD X=     4.92 Y=     0.70
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   408
OVERLAP PRIMITIVES    12    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  12 TYPE 7 ALT.TYPE 3 COLOR 6 TAG# FROM   1025 TO 1432
START VECTOR => LENGTH  5.72 ANGLE (DEG) 47.78 LINK1    17
END   VECTOR => LENGTH  5.82 ANGLE (DEG) 33.76 LINK2     7
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.6 AREA -4.302 ROTATION  0.0003
AVG.SLOPE      2.02   COMPUTED SLOPE     5.49  CHORD        1.41
RADIUS         1.07   CENTER CO-ORD X=     4.93 Y=     0.70
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   408
OVERLAP PRIMITIVES    11    0    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  13 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM   1393 TO 1587
START VECTOR => LENGTH  6.72 ANGLE (DEG) 47.81 LINK1     0
END   VECTOR => LENGTH  5.70 ANGLE (DEG) 53.03 LINK2    24
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.2 AREA  1.615 ROTATION -0.0038
AVG.SLOPE      2.61   COMPUTED SLOPE     3.52  CHORD        1.17
RADIUS         1.58   CENTER CO-ORD X=     7.03 Y=     1.06
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   194
OVERLAP PRIMITIVES    14   23    0    0    0    0    0    0
------------------------------------------------------------
PRIM#  14 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM   1393 TO 1578
START VECTOR => LENGTH  5.75 ANGLE (DEG) 52.72 LINK1    23
END   VECTOR => LENGTH  6.75 ANGLE (DEG) 47.81 LINK2    15
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   1.2 AREA -1.540 ROTATION -0.0035
```

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AVG.SLOPE      2.62   COMPUTED SLOPE     0.39  CHORD        1.13
RADIUS         1.57   CENTER CO-ORD X=     7.05 Y=     1.06
NON-OVERLAP COUNT=      0 OVERLAP COUNT=   185
OVERLAP PRIMITIVES    13     0     0     0     0     0     0     0
-----------------------------------------------------------------
PRIM#  15 TYPE 8 ALT.TYPE 4 COLOR 3 TAG# FROM    1393 TO 1528
START VECTOR => LENGTH  6.92 ANGLE (DEG) 47.81 LINK1    14
END   VECTOR => LENGTH  7.92 ANGLE (DEG) 51.07 LINK2    20
TWIN POINTER #      0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   1.1 AREA  1.588 ROTATION  0.0057
AVG.SLOPE      1.16   COMPUTED SLOPE     1.26  CHORD        1.09
RADIUS         1.73   CENTER CO-ORD X=     6.95 Y=     1.08
NON-OVERLAP COUNT=  135 OVERLAP COUNT=      0
OVERLAP PRIMITIVES     0     0     0     0     0     0     0     0
-----------------------------------------------------------------
PRIM#  16 TYPE 6 ALT.TYPE 2 COLOR 5 TAG# FROM    1433 TO 1504
START VECTOR => LENGTH  5.70 ANGLE (DEG) 47.78 LINK1    11
END   VECTOR => LENGTH  4.95 ANGLE (DEG) 51.62 LINK2    18
TWIN POINTER #     18 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.9 AREA  0.993 ROTATION  0.0024
AVG.SLOPE      2.89   COMPUTED SLOPE     3.56  CHORD        0.83
RADIUS         1.13   CENTER CO-ORD X=     4.96 Y=     0.67
NON-OVERLAP COUNT=      0 OVERLAP COUNT=    72
OVERLAP PRIMITIVES    17     0     0     0     0     0     0     0
-----------------------------------------------------------------
PRIM#  17 TYPE 6 ALT.TYPE 2 COLOR 6 TAG# FROM    1433 TO 1504
START VECTOR => LENGTH  4.97 ANGLE (DEG) 51.62 LINK1    19
END   VECTOR => LENGTH  5.72 ANGLE (DEG) 47.78 LINK2    12
TWIN POINTER #     13 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   0.9 AREA -1.002 ROTATION  0.0024
AVG.SLOPE      2.89   COMPUTED SLOPE     0.42  CHORD        0.83
RADIUS         1.13   CENTER CO-ORD X=     4.98 Y=     0.68
NON-OVERLAP COUNT=      0 OVERLAP COUNT=    72
OVERLAP PRIMITIVES    16     0     0     0     0     0     0     0
-----------------------------------------------------------------
PRIM#  18 TYPE 6 ALT.TYPE 2 COLOR 5 TAG# FROM    1449 TO 1504
START VECTOR => LENGTH  4.85 ANGLE (DEG) 51.62 LINK1    16
END   VECTOR => LENGTH  4.25 ANGLE (DEG) 48.32 LINK2     9
TWIN POINTER #     16 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   0.7 AREA -0.572 ROTATION -0.0012
AVG.SLOPE      1.40   COMPUTED SLOPE     4.43  CHORD        0.65
RADIUS         1.00   CENTER CO-ORD X=     5.00 Y=     0.70
NON-OVERLAP COUNT=      0 OVERLAP COUNT=    56
OVERLAP PRIMITIVES     8    19     0     0     0     0     0     0
-----------------------------------------------------------------
PRIM#  19 TYPE 6 ALT.TYPE 2 COLOR 6 TAG# FROM    1457 TO 1504
START VECTOR => LENGTH  4.25 ANGLE (DEG) 48.63 LINK1     8
END   VECTOR => LENGTH  4.82 ANGLE (DEG) 51.62 LINK2    17
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TWIN POINTER #     3 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.6 AREA   0.516 ROTATION -0.0012
AVG.SLOPE      1.38    COMPUTED SLOPE      1.27  CHORD        0.62
RADIUS         1.00    CENTER CO-ORD X=     4.97 Y=      0.70
NON-OVERLAP COUNT=     0 OVERLAP COUNT=    47
OVERLAP PRIMITIVES     18     0     0     0     0     0     0     0
------------------------------------------------------------------
PRIM#  20 TYPE 5 ALT.TYPE 1 COLOR 3 TAG# FROM    1529 TO 1610
START VECTOR => LENGTH  7.92 ANGLE (DEG) 51.07 LINK1    15
END   VECTOR => LENGTH  8.32 ANGLE (DEG) 55.13 LINK2    28
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.7 AREA   2.350 ROTATION  0.0019
AVG.SLOPE      1.83    COMPUTED SLOPE      1.89  CHORD        0.70
RADIUS         1.74    CENTER CO-ORD X=     6.79 Y=      1.07
NON-OVERLAP COUNT=    78 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     21     0     0     0     0     0     0     0
------------------------------------------------------------------
PRIM#  21 TYPE 8 ALT.TYPE 4 COLOR 2 TAG# FROM    1567 TO 1610
START VECTOR => LENGTH  8.37 ANGLE (DEG) 55.13 LINK1    26
END   VECTOR => LENGTH  8.92 ANGLE (DEG) 53.79 LINK2    22
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   0.6 AREA  -0.785 ROTATION -0.0074
AVG.SLOPE      2.48    COMPUTED SLOPE      0.60  CHORD        0.59
RADIUS         0.84    CENTER CO-ORD X=     8.95 Y=      1.03
NON-OVERLAP COUNT=    39 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     20     0     0     0     0     0     0     0
------------------------------------------------------------------
PRIM#  22 TYPE 8 ALT.TYPE 4 COLOR 2 TAG# FROM    1567 TO 1646
START VECTOR => LENGTH  8.97 ANGLE (DEG) 53.79 LINK1    21
END   VECTOR => LENGTH  9.57 ANGLE (DEG) 55.13 LINK2    27
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH   0.6 AREA   0.950 ROTATION  0.0093
AVG.SLOPE      1.23    COMPUTED SLOPE      1.30  CHORD        0.64
RADIUS         1.82    CENTER CO-ORD X=     8.83 Y=      1.14
NON-OVERLAP COUNT=    79 OVERLAP COUNT=     0
OVERLAP PRIMITIVES      0     0     0     0     0     0     0     0
------------------------------------------------------------------
PRIM#  23 TYPE 7 ALT.TYPE 3 COLOR 3 TAG# FROM    1579 TO 2113
START VECTOR => LENGTH  6.40 ANGLE (DEG) 71.94 LINK1    48
END   VECTOR => LENGTH  5.75 ANGLE (DEG) 52.72 LINK2    14
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH   2.5 AREA  -5.432 ROTATION  0.0005
AVG.SLOPE      2.73    COMPUTED SLOPE      5.49  CHORD        2.13
RADIUS         1.53    CENTER CO-ORD X=     7.05 Y=      1.05
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   518
OVERLAP PRIMITIVES     13    24    33    38    44     0     0     0
------------------------------------------------------------------
PRIM#  24 TYPE 5 ALT.TYPE 1 COLOR 6 TAG# FROM    1587 TO 1884
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START VECTOR => LENGTH  5.70 ANGLE (DEG) 53.03 LINK1   13
END   VECTOR => LENGTH  5.57 ANGLE (DEG) 64.67 LINK2    0
TWIN POINTER #    3 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.2 AREA  3.122 ROTATION  0.0003
AVG.SLOPE     2.85   COMPUTED SLOPE    2.71  CHORD       1.15
RADIUS        1.56   CENTER CO-ORD X=    7.06 Y=    1.05
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   297
OVERLAP PRIMITIVES    23    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  25 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM   1611 TO 1658
START VECTOR => LENGTH  8.32 ANGLE (DEG) 55.13 LINK1   20
END   VECTOR => LENGTH  8.32 ANGLE (DEG) 55.26 LINK2   28
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.083 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.53  CHORD       0.02
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    48
OVERLAP PRIMITIVES    26    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  26 TYPE 4 ALT.TYPE 8 COLOR 2 TAG# FROM   1611 TO 1680
START VECTOR => LENGTH  8.20 ANGLE (DEG) 56.22 LINK1   29
END   VECTOR => LENGTH  8.37 ANGLE (DEG) 55.13 LINK2   21
TWIN POINTER #    0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.2 AREA -0.657 ROTATION -0.0004
AVG.SLOPE     2.87   COMPUTED SLOPE    0.23  CHORD       0.24
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    70
OVERLAP PRIMITIVES    25   28    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  27 TYPE 5 ALT.TYPE 1 COLOR 2 TAG# FROM   1647 TO 1899
START VECTOR => LENGTH  9.57 ANGLE (DEG) 55.13 LINK1   22
END   VECTOR => LENGTH  9.85 ANGLE (DEG) 63.33 LINK2   35
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  7.003 ROTATION  0.0109
AVG.SLOPE     2.09   COMPUTED SLOPE    2.41  CHORD       1.42
RADIUS        1.04   CENTER CO-ORD X=    8.94 Y=    1.05
NON-OVERLAP COUNT=  253 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  28 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM   1659 TO 1720
START VECTOR => LENGTH  8.32 ANGLE (DEG) 55.26 LINK1   20
END   VECTOR => LENGTH  8.07 ANGLE (DEG) 57.32 LINK2   30
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.4 AREA  1.209 ROTATION  0.0006
AVG.SLOPE     3.03   COMPUTED SLOPE    3.26  CHORD       0.39
RADIUS        0.32   CENTER CO-ORD X=    8.39 Y=    1.00
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    62
OVERLAP PRIMITIVES    26   29    0    0    0    0    0    0
```

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-------------------------------------------------------------
PRIM# 29 TYPE 7 ALT.TYPE 3 COLOR 2 TAG# FROM   1681 TO 1904
START VECTOR => LENGTH  8.35 ANGLE (DEG) 65.18 LINK1   36
END   VECTOR => LENGTH  8.20 ANGLE (DEG) 56.22 LINK2   26
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.4 AREA -5.127 ROTATION -0.0047
AVG.SLOPE     2.79   COMPUTED SLOPE    5.66  CHORD        1.30
RADIUS        1.07   CENTER CO-ORD X=    9.09 Y=     1.05
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   219
OVERLAP PRIMITIVES    28   30    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 30 TYPE 5 ALT.TYPE 1 COLOR 3 TAG# FROM   1721 TO 1904
START VECTOR => LENGTH  8.07 ANGLE (DEG) 57.32 LINK1   28
END   VECTOR => LENGTH  8.32 ANGLE (DEG) 65.18 LINK2   39
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.3 AREA  4.463 ROTATION -0.0055
AVG.SLOPE     2.65   COMPUTED SLOPE    2.42  CHORD        1.15
RADIUS        1.03   CENTER CO-ORD X=    9.02 Y=     1.05
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   179
OVERLAP PRIMITIVES    29    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 31 TYPE 8 ALT.TYPE 4 COLOR 6 TAG# FROM   1882 TO 2005
START VECTOR => LENGTH  5.35 ANGLE (DEG) 64.60 LINK1    0
END   VECTOR => LENGTH  4.65 ANGLE (DEG) 68.78 LINK2   41
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.8 AREA  0.801 ROTATION -0.0017
AVG.SLOPE     2.32   COMPUTED SLOPE    3.82  CHORD        0.79
RADIUS        1.07   CENTER CO-ORD X=    5.52 Y=     1.32
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   123
OVERLAP PRIMITIVES    32    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 32 TYPE 8 ALT.TYPE 4 COLOR 4 TAG# FROM   1882 TO 2014
START VECTOR => LENGTH  4.67 ANGLE (DEG) 68.75 LINK1   42
END   VECTOR => LENGTH  5.37 ANGLE (DEG) 64.60 LINK2   33
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.8 AREA -0.810 ROTATION -0.0022
AVG.SLOPE     2.32   COMPUTED SLOPE    0.68  CHORD        0.79
RADIUS        1.13   CENTER CO-ORD X=    5.59 Y=     1.33
NON-OVERLAP COUNT=     0 OVERLAP COUNT=   121
OVERLAP PRIMITIVES    31    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM# 33 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   1882 TO 1938
START VECTOR => LENGTH  5.45 ANGLE (DEG) 64.60 LINK1   32
END   VECTOR => LENGTH  5.57 ANGLE (DEG) 64.84 LINK2   38
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.1 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    1.31  CHORD        0.13
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=     0.0
```

```
NON-OVERLAP COUNT=    0 OVERLAP COUNT=    56
OVERLAP PRIMITIVES    34   23    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  34 TYPE 0 ALT.TYPE 0 COLOR 6 TAG# FROM    1885 TO 1885
START VECTOR => LENGTH  5.57 ANGLE (DEG) 64.70 LINK1     0
END   VECTOR => LENGTH  5.57 ANGLE (DEG) 64.70 LINK2     0
TWIN POINTER #     0 REDUCTION ID. 0.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.0   ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.0
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    33    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  35 TYPE 6 ALT.TYPE 2 COLOR 2 TAG# FROM    1900 TO 1938
START VECTOR => LENGTH  9.85 ANGLE (DEG) 63.33 LINK1    27
END   VECTOR => LENGTH  9.02 ANGLE (DEG) 66.52 LINK2    40
TWIN POINTER #   36 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.0 AREA  2.551 ROTATION  0.0206
AVG.SLOPE     2.71   COMPUTED SLOPE    3.71  CHORD        0.98
RADIUS        1.07   CENTER CO-ORD X=    8.96 Y=     1.04
NON-OVERLAP COUNT=   39 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  36 TYPE 3 ALT.TYPE 7 COLOR 2 TAG# FROM    1905 TO 1938
START VECTOR => LENGTH  8.62 ANGLE (DEG) 66.18 LINK1    40
END   VECTOR => LENGTH  8.35 ANGLE (DEG) 65.18 LINK2    29
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.625 ROTATION -0.0010
AVG.SLOPE     1.65   COMPUTED SLOPE    4.78  CHORD        0.31
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   34 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    37    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  37 TYPE 0 ALT.TYPE 0 COLOR 3 TAG# FROM    1905 TO 1963
START VECTOR => LENGTH  8.32 ANGLE (DEG) 65.18 LINK1    30
END   VECTOR => LENGTH  8.32 ANGLE (DEG) 65.35 LINK2    39
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.104 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    2.71  CHORD        0.02
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=   59 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    36    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  38 TYPE 5 ALT.TYPE 1 COLOR 4 TAG# FROM    1939 TO 2107
START VECTOR => LENGTH  5.57 ANGLE (DEG) 64.84 LINK1    33
END   VECTOR => LENGTH  6.45 ANGLE (DEG) 72.15 LINK2    44
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.2 AREA  2.198 ROTATION -0.0043
```

```
AVG.SLOPE     2.10   COMPUTED SLOPE    1.92  CHORD        1.16
RADIUS        1.49   CENTER CO-ORD X=    6.98 Y=    1.05
NON-OVERLAP COUNT=    0 OVERLAP COUNT=   163
OVERLAP PRIMITIVES    23    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  39 TYPE 6 ALT.TYPE 2 COLOR 3 TAG# FROM   1964 TO 2113
START VECTOR => LENGTH  8.32 ANGLE (DEG) 65.35 LINK1   30
END   VECTOR => LENGTH  6.87 ANGLE (DEG) 72.53 LINK2   48
TWIN POINTER #    23 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.8 AREA  3.888 ROTATION  0.0071
AVG.SLOPE     2.80   COMPUTED SLOPE    3.76  CHORD        1.73
RADIUS        1.48   CENTER CO-ORD X=    7.01 Y=    1.05
NON-OVERLAP COUNT=  150 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  40 TYPE 2 ALT.TYPE 6 COLOR 2 TAG# FROM   1979 TO 1979
START VECTOR => LENGTH  8.87 ANGLE (DEG) 66.52 LINK1   35
END   VECTOR => LENGTH  8.62 ANGLE (DEG) 66.18 LINK2   36
TWIN POINTER #    35 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.229 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.51  CHORD        0.26
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  41 TYPE 2 ALT.TYPE 6 COLOR 6 TAG# FROM   1999 TO 2005
START VECTOR => LENGTH  4.65 ANGLE (DEG) 68.82 LINK1   31
END   VECTOR => LENGTH  3.88 ANGLE (DEG) 66.90 LINK2    3
TWIN POINTER #    31 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.5 AREA -0.251 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    4.55  CHORD        0.64
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    6 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  42 TYPE 4 ALT.TYPE 8 COLOR 4 TAG# FROM   2014 TO 2133
START VECTOR => LENGTH  4.55 ANGLE (DEG) 71.50 LINK1   47
END   VECTOR => LENGTH  4.67 ANGLE (DEG) 68.75 LINK2   32
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.3 AREA -0.508 ROTATION -0.0005
AVG.SLOPE     2.93   COMPUTED SLOPE    0.17  CHORD        0.25
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=  119 OVERLAP COUNT=     0
OVERLAP PRIMITIVES     0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  43 TYPE 0 ALT.TYPE 0 COLOR 6 TAG# FROM   2053 TO 2053
START VECTOR => LENGTH  4.65 ANGLE (DEG) 68.78 LINK1   31
END   VECTOR => LENGTH  4.65 ANGLE (DEG) 68.82 LINK2   41
```

```
TWIN POINTER #    41 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.0 AREA  0.006 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    0.0   CHORD        0.00
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  44 TYPE 5 ALT.TYPE 1 COLOR 4 TAG# FROM   2107 TO 2295
START VECTOR => LENGTH  6.45 ANGLE (DEG) 72.15 LINK1   38
END   VECTOR => LENGTH  6.47 ANGLE (DEG) 77.09 LINK2   50
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.6 AREA  1.807 ROTATION  0.0012
AVG.SLOPE     2.75   COMPUTED SLOPE    2.83  CHORD        0.56
RADIUS        2.05   CENTER CO-ORD X=    4.43 Y=    1.32
NON-OVERLAP COUNT=  188 OVERLAP COUNT=     0
OVERLAP PRIMITIVES   23   45    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  45 TYPE 8 ALT.TYPE 4 COLOR 1 TAG# FROM   2128 TO 2338
START VECTOR => LENGTH  7.02 ANGLE (DEG) 78.56 LINK1   51
END   VECTOR => LENGTH  7.90 ANGLE (DEG) 73.04 LINK2   46
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.2 AREA -2.470 ROTATION -0.0074
AVG.SLOPE     2.28   COMPUTED SLOPE    0.63  CHORD        1.13
RADIUS        1.09   CENTER CO-ORD X=    8.08 Y=    1.41
NON-OVERLAP COUNT=  210 OVERLAP COUNT=     0
OVERLAP PRIMITIVES   44   50    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  46 TYPE 4 ALT.TYPE 8 COLOR 1 TAG# FROM   2128 TO 2191
START VECTOR => LENGTH  7.97 ANGLE (DEG) 73.04 LINK1   45
END   VECTOR => LENGTH  8.30 ANGLE (DEG) 73.52 LINK2   49
TWIN POINTER #     0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  0.3 AREA  0.202 ROTATION  0.0041
AVG.SLOPE     1.49   COMPUTED SLOPE    1.49  CHORD        0.33
RADIUS        1.02   CENTER CO-ORD X=    7.99 Y=    1.40
NON-OVERLAP COUNT=   63 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  47 TYPE 7 ALT.TYPE 3 COLOR 4 TAG# FROM   2133 TO 2492
START VECTOR => LENGTH  5.32 ANGLE (DEG) 85.50 LINK1   50
END   VECTOR => LENGTH  4.55 ANGLE (DEG) 71.50 LINK2   42
TWIN POINTER #     0 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.7 AREA -2.650 ROTATION -0.0022
AVG.SLOPE     2.78   COMPUTED SLOPE    5.51  CHORD        1.43
RADIUS        1.00   CENTER CO-ORD X=    5.50 Y=    1.31
NON-OVERLAP COUNT=  359 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
--------------------------------------------------------------
PRIM#  48 TYPE 2 ALT.TYPE 6 COLOR 3 TAG# FROM   2148 TO 2148
```

```
START VECTOR => LENGTH  6.80 ANGLE (DEG) 72.53 LINK1   39
END   VECTOR => LENGTH  6.40 ANGLE (DEG) 71.94 LINK2   23
TWIN POINTER #   39 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.4 AREA -0.222 ROTATION  0.0
AVG.SLOPE    0.0    COMPUTED SLOPE    4.57  CHORD       0.41
RADIUS       0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  49 TYPE 5 ALT.TYPE 1 COLOR 1 TAG# FROM   2192 TO 2427
START VECTOR => LENGTH  8.30 ANGLE (DEG) 73.52 LINK1   46
END   VECTOR => LENGTH  8.97 ANGLE (DEG) 81.58 LINK2   52
TWIN POINTER #    0 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.6 AREA  5.477 ROTATION  0.0171
AVG.SLOPE    2.16   COMPUTED SLOPE    2.42  CHORD       1.39
RADIUS       1.01   CENTER CO-ORD X=    7.98 Y=    1.40
NON-OVERLAP COUNT=  236 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  50 TYPE 6 ALT.TYPE 2 COLOR 4 TAG# FROM   2295 TO 2492
START VECTOR => LENGTH  6.47 ANGLE (DEG) 77.09 LINK1   44
END   VECTOR => LENGTH  5.40 ANGLE (DEG) 85.53 LINK2   47
TWIN POINTER #   47 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.5 AREA  2.818 ROTATION  0.0039
AVG.SLOPE    2.73   COMPUTED SLOPE    3.86  CHORD       1.37
RADIUS       1.05   CENTER CO-ORD X=    5.46 Y=    1.30
NON-OVERLAP COUNT=  197 OVERLAP COUNT=     0
OVERLAP PRIMITIVES   45   51    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  51 TYPE 7 ALT.TYPE 3 COLOR 1 TAG# FROM   2339 TO 2546
START VECTOR => LENGTH  7.90 ANGLE (DEG) 87.38 LINK1   52
END   VECTOR => LENGTH  7.02 ANGLE (DEG) 78.56 LINK2   45
TWIN POINTER #   52 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  1.6 AREA -3.944 ROTATION -0.0019
AVG.SLOPE    2.78   COMPUTED SLOPE    5.51  CHORD       1.44
RADIUS       1.01   CENTER CO-ORD X=    8.02 Y=    1.40
NON-OVERLAP COUNT=  208 OVERLAP COUNT=     0
OVERLAP PRIMITIVES   50    0    0    0    0    0    0    0
-------------------------------------------------------------
PRIM#  52 TYPE 6 ALT.TYPE 2 COLOR 1 TAG# FROM   2428 TO 2546
START VECTOR => LENGTH  8.97 ANGLE (DEG) 81.58 LINK1   49
END   VECTOR => LENGTH  7.97 ANGLE (DEG) 87.38 LINK2   51
TWIN POINTER #   51 REDUCTION ID. 2.0
PRIMITIVE VALUES => LENGTH  1.4 AREA  3.811 ROTATION  0.0031
AVG.SLOPE    2.69   COMPUTED SLOPE    3.91  CHORD       1.32
RADIUS       1.03   CENTER CO-ORD X=    7.97 Y=    1.40
NON-OVERLAP COUNT=  119 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
```

```
------------------------------------------------------------
PRIM#  53 TYPE 0 ALT.TYPE 0 COLOR 4 TAG# FROM   2540 TO 2540
START VECTOR => LENGTH  5.40 ANGLE (DEG) 85.53 LINK1   50
END   VECTOR => LENGTH  5.32 ANGLE (DEG) 85.50 LINK2   47
TWIN POINTER #   50 REDUCTION ID. 1.0
PRIMITIVE VALUES => LENGTH  0.1 AREA -0.009 ROTATION  0.0
AVG.SLOPE     0.0    COMPUTED SLOPE    1.54  CHORD       0.08
RADIUS        0.0    CENTER CO-ORD X=    0.0  Y=    0.0
NON-OVERLAP COUNT=    0 OVERLAP COUNT=     0
OVERLAP PRIMITIVES    0    0    0    0    0    0    0    0
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
<<<  INACTIVE PRIMITIVE POINTER LISTS  >>>
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
NPRMHD    0 NPRMLT   53
NL9HD     0 NL9LST   48
NDOUTH   25 NDOUTL   53
NL1HD     0 NL1LST    0 NL2HD     28 NL2LST   48
NL3HD    36 NL3LST   36 NL4HD     26 NL4LST   46
NC1HD     8 NC1LST   49 NC2HD     16 NC2LST   52
NC3HD     3 NC3LST   51 NC4HD      1 NC4LST   45
NXTCEL   54 LSTCEL   53
------------------------------------------------------------
------------------------------------------------------------
UNDETERMINED (TYPE 9) CHAIN CONSISTS OF :
------------------------------------------------------------
------------------------------------------------------------
DOT PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   25 %%  PRIMNO   25 LINK1    0 LINK2    34 COLOR  3
% CELL #   34 %%  PRIMNO   34 LINK1   25 LINK2    37 COLOR  6
% CELL #   37 %%  PRIMNO   37 LINK1   34 LINK2    43 COLOR  3
% CELL #   43 %%  PRIMNO   43 LINK1   37 LINK2    53 COLOR  6
% CELL #   53 %%  PRIMNO   53 LINK1   43 LINK2     0 COLOR  4
------------------------------------------------------------
ST.LINE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
------------------------------------------------------------
ST.LINE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
------------------------------------------------------------
% CELL #   28 %%  PRIMNO   28 LINK1    0 LINK2    40 COLOR  3
% CELL #   40 %%  PRIMNO   40 LINK1   28 LINK2    41 COLOR  2
% CELL #   41 %%  PRIMNO   41 LINK1   40 LINK2    48 COLOR  6
% CELL #   48 %%  PRIMNO   48 LINK1   41 LINK2     0 COLOR  3
```

```
--------------------------------------------------------------
ST.LINE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #   36 %%  PRIMNO   36 LINK1    0 LINK2    0 COLOR  2
--------------------------------------------------------------
ST.LINE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #   26 %%  PRIMNO   26 LINK1    0 LINK2   33 COLOR  2
% CELL #   33 %%  PRIMNO   33 LINK1   26 LINK2   42 COLOR  4
% CELL #   42 %%  PRIMNO   42 LINK1   33 LINK2   46 COLOR  4
% CELL #   46 %%  PRIMNO   46 LINK1   42 LINK2    0 COLOR  1
--------------------------------------------------------------
CURVE TYPE 1 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #    8 %%  PRIMNO    8 LINK1    0 LINK2   10 COLOR  6
% CELL #   10 %%  PRIMNO   10 LINK1    8 LINK2   11 COLOR  6
% CELL #   11 %%  PRIMNO   11 LINK1   10 LINK2   20 COLOR  5
% CELL #   20 %%  PRIMNO   20 LINK1   11 LINK2   24 COLOR  3
% CELL #   24 %%  PRIMNO   24 LINK1   20 LINK2   27 COLOR  6
% CELL #   27 %%  PRIMNO   27 LINK1   24 LINK2   30 COLOR  2
% CELL #   30 %%  PRIMNO   30 LINK1   27 LINK2   38 COLOR  3
% CELL #   38 %%  PRIMNO   38 LINK1   30 LINK2   44 COLOR  4
% CELL #   44 %%  PRIMNO   44 LINK1   38 LINK2   49 COLOR  4
% CELL #   49 %%  PRIMNO   49 LINK1   44 LINK2    0 COLOR  1
--------------------------------------------------------------
CURVE TYPE 2 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #   16 %%  PRIMNO   16 LINK1    0 LINK2   17 COLOR  5
% CELL #   17 %%  PRIMNO   17 LINK1   16 LINK2   18 COLOR  6
% CELL #   18 %%  PRIMNO   18 LINK1   17 LINK2   19 COLOR  5
% CELL #   19 %%  PRIMNO   19 LINK1   18 LINK2   35 COLOR  6
% CELL #   35 %%  PRIMNO   35 LINK1   19 LINK2   39 COLOR  2
% CELL #   39 %%  PRIMNO   39 LINK1   35 LINK2   50 COLOR  3
% CELL #   50 %%  PRIMNO   50 LINK1   39 LINK2   52 COLOR  4
% CELL #   52 %%  PRIMNO   52 LINK1   50 LINK2    0 COLOR  1
--------------------------------------------------------------
CURVE TYPE 3 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
% CELL #    3 %%  PRIMNO    3 LINK1    0 LINK2    9 COLOR  6
% CELL #    9 %%  PRIMNO    9 LINK1    3 LINK2   12 COLOR  5
% CELL #   12 %%  PRIMNO   12 LINK1    9 LINK2   23 COLOR  6
% CELL #   23 %%  PRIMNO   23 LINK1   12 LINK2   29 COLOR  3
% CELL #   29 %%  PRIMNO   29 LINK1   23 LINK2   47 COLOR  2
% CELL #   47 %%  PRIMNO   47 LINK1   29 LINK2   51 COLOR  4
% CELL #   51 %%  PRIMNO   51 LINK1   47 LINK2    0 COLOR  1
--------------------------------------------------------------
CURVE TYPE 4 PRIMITIVE CHAIN CONSISTS OF :
--------------------------------------------------------------
```

```
% CELL #    1 %%  PRIMNO   1 LINK1   0 LINK2   2 COLOR 6
% CELL #    2 %%  PRIMNO   2 LINK1   1 LINK2   4 COLOR 6
% CELL #    4 %%  PRIMNO   4 LINK1   2 LINK2   5 COLOR 6
% CELL #    5 %%  PRIMNO   5 LINK1   4 LINK2   6 COLOR 5
% CELL #    6 %%  PRIMNO   6 LINK1   5 LINK2   7 COLOR 5
% CELL #    7 %%  PRIMNO   7 LINK1   6 LINK2  13 COLOR 6
% CELL #   13 %%  PRIMNO  13 LINK1   7 LINK2  14 COLOR 6
% CELL #   14 %%  PRIMNO  14 LINK1  13 LINK2  15 COLOR 3
% CELL #   15 %%  PRIMNO  15 LINK1  14 LINK2  21 COLOR 3
% CELL #   21 %%  PRIMNO  21 LINK1  15 LINK2  22 COLOR 2
% CELL #   22 %%  PRIMNO  22 LINK1  21 LINK2  31 COLOR 2
% CELL #   31 %%  PRIMNO  31 LINK1  22 LINK2  32 COLOR 6
% CELL #   32 %%  PRIMNO  32 LINK1  31 LINK2  45 COLOR 4
% CELL #   45 %%  PRIMNO  45 LINK1  32 LINK2   0 COLOR 1
----------------------------------------------------------
```

APPENDIX D

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=USYS002.OUTPUT.LIST


         ****************************************************
            ...... MACROMATON OUTPUT FOR SCENE # 1 ......
         ****************************************************


          PATTERN TYPE       =    1 COLOR =  1

          FULL PRIMITIVE #   =   3
          FULL PRIMITIVE #   =   8
          FULL PRIMITIVE #   =   4
          FULL PRIMITIVE #   =   1
          FULL PRIMITIVE #   =   2

          PATTERN TYPE       =    2 COLOR =  2

          FULL PRIMITIVE #   =  14
          FULL PRIMITIVE #   =  13
          FULL PRIMITIVE #   =   9
          FULL PRIMITIVE #   =  10
          FULL PRIMITIVE #   =  11

          PATTERN TYPE       =    3 COLOR =  4

          FULL PRIMITIVE #   =  18
          FULL PRIMITIVE #   =  19
          FULL PRIMITIVE #   =  15
          FULL PRIMITIVE #   =  16
          FULL PRIMITIVE #   =  17

          PATTERN TYPE       =    4 COLOR =  3

          FULL PRIMITIVE #   =   7
          FULL PRIMITIVE #   =  12
          FULL PRIMITIVE #   =   5
          FULL PRIMITIVE #   =   6

          PATTERN TYPE       =    5 COLOR =  5

          FULL PRIMITIVE #   =  22
          FULL PRIMITIVE #   =  23
          FULL PRIMITIVE #   =  20
```

```
**************************************************
    ...... MACROMATON OUTPUT FOR SCENE # 2 ......
**************************************************

 PATTERN TYPE       =    1 COLOR =  5

 FULL PRIMITIVE #  =  21
 FULL PRIMITIVE #  =  23
 FULL PRIMITIVE #  =  22
 FULL PRIMITIVE #  =  19
 FULL PRIMITIVE #  =  20


 PATTERN TYPE       =    2 COLOR =  3

 FULL PRIMITIVE #  =  13
 FULL PRIMITIVE #  =  16
 FULL PRIMITIVE #  =  10
 FULL PRIMITIVE #  =   9
 FULL PRIMITIVE #  =  11


 PATTERN TYPE       =    3 COLOR =  2

 FULL PRIMITIVE #  =   6
 FULL PRIMITIVE #  =  12
 FULL PRIMITIVE #  =   7
 FULL PRIMITIVE #  =   5


 PATTERN TYPE       =    4 COLOR =  1

 FULL PRIMITIVE #  =   1
 FULL PRIMITIVE #  =   3
 FULL PRIMITIVE #  =   4


 PATTERN TYPE       =    5 COLOR =  4

 FULL PRIMITIVE #  =  18
 FULL PRIMITIVE #  =  14
 FULL PRIMITIVE #  =  15
```

```
**************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 3 ......
**************************************************

 PATTERN TYPE       =    1 COLOR =  2

 FULL PRIMITIVE #   =    7
 FULL PRIMITIVE #   =   13
 FULL PRIMITIVE #   =   14
 FULL PRIMITIVE #   =    3
 FULL PRIMITIVE #   =    1
 FULL PRIMITIVE #   =    2


 PATTERN TYPE       =    1 COLOR =  3

 FULL PRIMITIVE #   =   12
 FULL PRIMITIVE #   =   19
 FULL PRIMITIVE #   =   21
 FULL PRIMITIVE #   =   11
 FULL PRIMITIVE #   =    9
 FULL PRIMITIVE #   =   10


 PATTERN TYPE       =    3 COLOR =  1

 FULL PRIMITIVE #   =    4
 FULL PRIMITIVE #   =    5
 FULL PRIMITIVE #   =    6
 FULL PRIMITIVE #   =    8
 FULL PRIMITIVE #   =   34


 PATTERN TYPE       =    3 COLOR =  5

 FULL PRIMITIVE #   =   23
 FULL PRIMITIVE #   =   15
 FULL PRIMITIVE #   =   16
 FULL PRIMITIVE #   =   26


 PATTERN TYPE       =    4 COLOR =  2

 FULL PRIMITIVE #   =   33
 FULL PRIMITIVE #   =   31
 FULL PRIMITIVE #   =   32
```

```
PATTERN TYPE       =   5 COLOR =  1

FULL PRIMITIVE #  =  30
FULL PRIMITIVE #  =  24
FULL PRIMITIVE #  =  25


PATTERN TYPE       =   2 COLOR =  4

PART *** PRIM  #  =  17
PART *** PRIM  #  =  18
PART *** PRIM  #  =  20
```

```
***************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 4 ......
***************************************************

 PATTERN TYPE       =    1 COLOR =  1

 FULL PRIMITIVE #   =   7
 FULL PRIMITIVE #   =   1
 FULL PRIMITIVE #   =   2
 FULL PRIMITIVE #   =  12
 FULL PRIMITIVE #   =  39


 PATTERN TYPE       =    2 COLOR =  2

 FULL PRIMITIVE #   =  26
 FULL PRIMITIVE #   =  28
 FULL PRIMITIVE #   =  38
 FULL PRIMITIVE #   =  36
 FULL PRIMITIVE #   =   4
 FULL PRIMITIVE #   =   5


 PATTERN TYPE       =    3 COLOR =  3

 FULL PRIMITIVE #   =  25
 FULL PRIMITIVE #   =  35
 FULL PRIMITIVE #   =   9
 FULL PRIMITIVE #   =  11


 PATTERN TYPE       =    4 COLOR =  5

 FULL PRIMITIVE #   =  23
 FULL PRIMITIVE #   =  31
 FULL PRIMITIVE #   =  19
 FULL PRIMITIVE #   =  21


 PATTERN TYPE       =    5 COLOR =  4

 FULL PRIMITIVE #   =  14
 FULL PRIMITIVE #   =  16
 FULL PRIMITIVE #   =  17
 FULL PRIMITIVE #   =  33
```

```
****************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 5 ......
****************************************************

PATTERN TYPE       =    1 COLOR =   1

FULL PRIMITIVE #   =   36
FULL PRIMITIVE #   =   41
FULL PRIMITIVE #   =   39
FULL PRIMITIVE #   =   28
FULL PRIMITIVE #   =   29


PATTERN TYPE       =    3 COLOR =   4

FULL PRIMITIVE #   =   13
FULL PRIMITIVE #   =   16
FULL PRIMITIVE #   =   21
FULL PRIMITIVE #   =   26
FULL PRIMITIVE #   =   37
FULL PRIMITIVE #   =   24
FULL PRIMITIVE #   =   12
FULL PRIMITIVE #   =    6
FULL PRIMITIVE #   =    7
FULL PRIMITIVE #   =    9


PATTERN TYPE       =    5 COLOR =   3

PART *** PRIM   #  =   15
PART *** PRIM   #  =   10
PART *** PRIM   #  =    4
PART *** PRIM   #  =    5
PART *** PRIM   #  =   30
PART *** PRIM   #  =   19
PART *** PRIM   #  =   17


PATTERN TYPE       =    3 COLOR =   2

PART *** PRIM   #  =   22
PART *** PRIM   #  =   27
PART *** PRIM   #  =   35
PART *** PRIM   #  =   32
PART *** PRIM   #  =   23
PART *** PRIM   #  =   18
```

PATTERN TYPE = 2 COLOR = 5

PART *** PRIM # = 40
PART *** PRIM # = 33
PART *** PRIM # = 1
PART *** PRIM # = 2
PART *** PRIM # = 3
PART *** PRIM # = 14
PART *** PRIM # = 25
PART *** PRIM # = 34
PART *** PRIM # = 38

```
***************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 6 ......
***************************************************

 PATTERN TYPE       =    1 COLOR =  1

 FULL PRIMITIVE #   =   26
 FULL PRIMITIVE #   =   33
 FULL PRIMITIVE #   =   36
 FULL PRIMITIVE #   =   25
 FULL PRIMITIVE #   =   18
 FULL PRIMITIVE #   =   19


 PATTERN TYPE       =    4 COLOR =  2

 FULL PRIMITIVE #   =    3
 FULL PRIMITIVE #   =    2
 FULL PRIMITIVE #   =   15
 FULL PRIMITIVE #   =    1


 PATTERN TYPE       =    5 COLOR =  3

 PART *** PRIM  #   =    5
 PART *** PRIM  #   =   13
 PART *** PRIM  #   =   14
 PART *** PRIM  #   =   16
 PART *** PRIM  #   =    4
 PART *** PRIM  #   =    6


 PATTERN TYPE       =    3 COLOR =  4

 PART *** PRIM  #   =   20
 PART *** PRIM  #   =   17
 PART *** PRIM  #   =   24
 PART *** PRIM  #   =   35
 PART *** PRIM  #   =   34
 PART *** PRIM  #   =   31
 PART *** PRIM  #   =   32
 PART *** PRIM  #   =   39
 PART *** PRIM  #   =   40
 PART *** PRIM  #   =    7
 PART *** PRIM  #   =    9
 PART *** PRIM  #   =    8
```

```
PATTERN TYPE      =   2 COLOR =  5

PART *** PRIM  #  =  11
PART *** PRIM  #  =  37
PART *** PRIM  #  =  42
PART *** PRIM  #  =  38
PART *** PRIM  #  =  27
PART *** PRIM  #  =  23
PART *** PRIM  #  =  10
PART *** PRIM  #  =  12
```

```
****************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 7 ......
****************************************************

 PATTERN TYPE       =    5 COLOR =  6

 FULL PRIMITIVE #   =   16
 FULL PRIMITIVE #   =   17
 FULL PRIMITIVE #   =   18
 FULL PRIMITIVE #   =   22
 FULL PRIMITIVE #   =   33
 FULL PRIMITIVE #   =   40
 FULL PRIMITIVE #   =   31
 FULL PRIMITIVE #   =   19


 PATTERN TYPE       =    1 COLOR =  5

 PART *** PRIM  #   =   25
 PART *** PRIM  #   =   38
 PART *** PRIM  #   =   47
 PART *** PRIM  #   =   35
 PART *** PRIM  #   =   20
 PART *** PRIM  #   =   21


 PATTERN TYPE       =    2 COLOR =  4

 PART *** PRIM  #   =    6
 PART *** PRIM  #   =   24
 PART *** PRIM  #   =   32
 PART *** PRIM  #   =   46
 PART *** PRIM  #   =   43
 PART *** PRIM  #   =   44
 PART *** PRIM  #   =   11
 PART *** PRIM  #   =    5


 PATTERN TYPE       =    4 COLOR =  2

 PART *** PRIM  #   =   10
 PART *** PRIM  #   =   45
 PART *** PRIM  #   =   39
 PART *** PRIM  #   =   30
 PART *** PRIM  #   =   27
 PART *** PRIM  #   =   15
 PART *** PRIM  #   =   13
 PART *** PRIM  #   =    7
 PART *** PRIM  #   =    8
```

```
PATTERN TYPE      =   3 COLOR =  1

PART *** PRIM  #  =  14
PART *** PRIM  #  =  26
PART *** PRIM  #  =  36
PART *** PRIM  #  =  52
PART *** PRIM  #  =  34
PART *** PRIM  #  =   3
PART *** PRIM  #  =   2
PART *** PRIM  #  =   4
PART *** PRIM  #  =  12

PATTERN TYPE      =   4 COLOR =  3

PART *** PRIM  #  =  42
PART *** PRIM  #  =  55
PART *** PRIM  #  =  53
PART *** PRIM  #  =  51
PART *** PRIM  #  =  37
PART *** PRIM  #  =  28
PART *** PRIM  #  =  29
```

```
*****************************************************
   ...... MACROMATON OUTPUT FOR SCENE # 8 ......
*****************************************************

 PATTERN TYPE      =    1 COLOR =  5

 FULL PRIMITIVE #  =   11
 FULL PRIMITIVE #  =   16
 FULL PRIMITIVE #  =   18
 FULL PRIMITIVE #  =    9
 FULL PRIMITIVE #  =    5
 FULL PRIMITIVE #  =    6


 PATTERN TYPE      =    1 COLOR =  1

 FULL PRIMITIVE #  =   49
 FULL PRIMITIVE #  =   52
 FULL PRIMITIVE #  =   51
 FULL PRIMITIVE #  =   45
 FULL PRIMITIVE #  =   46


 PATTERN TYPE      =    1 COLOR =  6

 PART *** PRIM  #  =   31
 PART *** PRIM  #  =   41
 PART *** PRIM  #  =    3
 PART *** PRIM  #  =    1
 PART *** PRIM  #  =    2
 PART *** PRIM  #  =   10


 PATTERN TYPE      =    1 COLOR =  3

 PART *** PRIM  #  =   20
 PART *** PRIM  #  =   28
 PART *** PRIM  #  =   30
 PART *** PRIM  #  =   39
 PART *** PRIM  #  =   48
 PART *** PRIM  #  =   23
 PART *** PRIM  #  =   14
 PART *** PRIM  #  =   15
```

```
PATTERN TYPE       =   1 COLOR =  2

PART *** PRIM  #  =  27
PART *** PRIM  #  =  35
PART *** PRIM  #  =  40
PART *** PRIM  #  =  36
PART *** PRIM  #  =  29
PART *** PRIM  #  =  26
PART *** PRIM  #  =  21
PART *** PRIM  #  =  22

PATTERN TYPE       =   1 COLOR =  4

PART *** PRIM  #  =  44
PART *** PRIM  #  =  50
PART *** PRIM  #  =  47
PART *** PRIM  #  =  42
PART *** PRIM  #  =  32
PART *** PRIM  #  =  33
PART *** PRIM  #  =  38
```

PATTERN TYPE	DESCRIPTION
1	CIRCLE
2	SQUARE
3	RECTANGLE
4	EQUILATERAL TRIANGLE
5	RIGHT ANGLE TRIANGLE

APPENDIX E

PROOF OF THE RECOGNIZER'S CORRECTNESS

The symbols used in the proof have the following meaning. P represents the source pattern recognized while p represents the source primitives such that $p \varepsilon P$. The target pattern set τ consists of individual target patterns T to be recognized while t represents the target primitive such that $t \varepsilon T$ and $T \varepsilon \tau$. $\hat{P}$ is used in place of P where partial patterns are involved.

1. Assume that the recognizer recognizes a pattern $P = T$. In addition assume that for a fully visible pattern $P = T$, for any t_i, $t_j \varepsilon \tau$, $\exists$ at least one $t_i \varepsilon T_i$ which is distinct from all $t_j \varepsilon T \varepsilon \tau$.
2. For partially obscured patterns, assume that $\{t_i\} = \{p_i\} \sqsubseteq \hat{P}_1$ and $\{t_j\} = \{p_j\} \sqsubseteq \hat{P}_2$. Further assume that if $|\{t_i\}| > |\{t_j\}|$ matching $\hat{P}$, then $\{t_i\} \sqsubseteq T_i$ is picked in preference to $\{t_j\} \sqsubseteq T_j$.
3. Suppose the recognizer mistakes $P = T_1 \varepsilon \tau$ for $P = T_2 \varepsilon \tau$ and all $t_i \varepsilon T_1$ are fully visible. Then $\exists t_j \varepsilon T_2$ such that $t_j = t_i \varepsilon T_1$, $\forall t_i$. This is a contradiction since $\exists t_k \varepsilon T_2$ such that $t_k \not\varepsilon T_1$.
4. Given that $\hat{P} = P$ is recognized as a partial pattern. Suppose some $\{t_i\} \sqsubseteq T_1$ matches some $\{p_j\} \sqsubseteq \hat{P}$ and some $\{t_k\} \sqsubseteq T_2$ matches some $\{p_\ell\} \sqsubseteq \hat{P}$. Then $|\{p_j\}| = |\{p_\ell\}|$ or $|\{p_j\}| \neq |\{\hat{p}_\ell\}|$
5. If $|\{p_j\}| = |\{p_\ell\}|$ then the recognizer has no way

of determining whether $\hat{P}$ is T_1 or T_2.

6. Assume that $|\{p_j\}| > |\{p_\ell\}|$ and the recognizer mistakes $\{p_j\}$ for T_2. This is a contradiction of the assumption in 2. Q.E.D.