



ADDING INTELLIGENT FEATURES
TO AUTOCAD

BY

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ABSTRACT :

The generation of exact drawing from a given sketch is an important step in the manufacturing process. This feature does not exist in any computerized system, so the objective of this work is to add it to a computer-aided design (CAD) package.

The reconstruction of the exact drawing from the sketch will be dependent on the values of the different types of dimensions allocated on the drawing.

The suggested system will be added to AutoCAD which will be able to read the sketch drawing file drawn by AutoCAD. The sketch contains both the geometrical elements and dimensions then, by one or more Commands of AutoCAD, the Exact Drawing can be reconstructed.

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1. INTRODUCTION

In this work we look forward to add an intelligent feature to AUTOCAD system. This feature concerns the process of automatic generation of exact drawings from the corresponding sketch.

In the design process of any engineering object, the designer at first, produces some sketches for this object. A sketch is represented by a drawing or more. A drawing consists of two sets :E set of elements (points, segments, arcs,..) and D set of dimensions (distance, angle,..). Usually the sketch is drawn by hand, so two important problems must be stated :

1. The elements are incorrectly drawn. A segment of straight line may not be linear for example.
- 2- The drawing is not to scale. In other words the values of dimensions are not consistent with the real size of the object

In next step the draftsman starts to produce the exact drawing manually. In case of changing any dimensions values on the sketch , the draftsman must regenerate the exact drawing from the beginning again. The process of generating the exact drawing from sketch is called reconstruction of the drawing.

In this work we will add an intelligent feature that automates the manual process of the reconstruction to AutoCAD package. This work handles only the second problem, while it is supposed that the manipulation and solution of the first problem is out of the scope of this work. In other words a sketch will be generated by AutoCAD. The values of dimensions allocated on the drawing will be chosen by the user. The reconstruction of the exact drawing depending on these values will be generated automatically within AutoCAD through the added feature.

The idea of automatic reconstruction of a drawing began with a search of PH.D thesis [10] that reconstructs a drawing depending on new values of the dimensions. The system was implemented on a UNIX station in 1986.

Another effort in this field is a master thesis [11] which deals with a sketch drawing by AutoCAD (version 2.53j) and stored in DXF format. The reconstruction process was not fully implemented by this thesis. In this work, the whole system tasks are completed and implemented. Fig.1 gives the architecture of the whole system.

This paper consists of the ABSTRACT, SIX sections.

- Section 1 : contains an introduction to the paper.
Section 2 : discusses the CAD system and the AutoCAD package.
Section 3 : gives the description of the drawing.
Section 4 : introduces the reconstruction process phases and how their phases are implemented.
Section 5 : presents how to add and use the new system within AUTOCAD.
Section 6 : gives the conclusion of the work.

2. CAD SYSTEMS

The meaning of computer aided design (CAD) refers to any application of a computer to the solution of design problems. One famous CAD system is called AutoCAD package which has different releases start from release 1 to release 12. It is a DOS based package.

The objective of this work is to add an intelligent feature to AutoCAD package, so CAD and AutoCAD package in particular will be introduced in this section.

A typical CAD system consists of the following components :

- Data Base
- Program Library
- Data I/O Query
- Application Program
- Dialogue
- Graphics

2.1 Drawing interchange files

A drawing interchange file is the file which has the different information of the engineering drawing. A CAD drawing database (*.dwg files) is written in a very compact format.

All implementation of a CAD accept this format and able to convert it to and from their internal CAD format. In order to use the drawing file it must be in some format which generated by a common drafting package.

Some common used drawing interchange files are :-

- The ASCII Drawing Interchange (DXF) files .
- The Binary Drawing Interchange (DXB) files .
- The Initial Graphics Exchange Standard (IGES) files .

2.2 The history of autoCAD package

Release 1 of AutoCAD is designed in December 1982 with a specific features then every some time some features are added to the old release to generate a new release. The modern versions of AutoCAD have more features.

The recent version which is designed at 1992 is called Release 12. AutoCAD has the following features [4] :

- It follows your instruction to produce the drawing quickly.
- It could correct errors easily and make large revisions without redoing an entire drawing.
- It produces clean, precise final drawing.
- It can improve accuracy over hand drawing.
- It has several color plates and It is easy to use.

AutoCAD provides a set of entities for use in constructing your drawing. An entity is a drawing element such as a point, line, arc, circle, text string, etc. It is required to enter commands to tell AutoCAD which entity to draw [4].

3. ENGINEERING DRAWINGS DESCRIPTION

3.1 Difference between sketch and exact drawing

The sketch is in general a drawing produced by a designer to describe an object without taking into consideration the values of exact dimensions of the drawing. In other words the sketch has exact shape but it does not have exact size. The exact drawing can be defined as that drawing describing an object, taking into consideration the exact dimensions of the drawing. In other words the exact drawing has both exact shape and size.

3.2 Drawing description

As previously defined, the drawing consists of two sets, geometrical elements and dimensional elements. There is another set of relationships relating the elements. The relationships are not explicitly existed in the DXF file. They will be recognized by the proposed system. The description of each component : (elements, dimensions, and relationships) will be introduced.

- Geometrical elements :-

These elements describe the shape of the object.

The most common geometrical elements used in engineering drawing are :

- | | |
|-------------------|--------------------|
| - Point | - Straight line |
| - Circle | - Arc of circle |
| - ellipse | - Arc of ellipse |
| - Arc of parabola | - Arc of hyperbole |

In our context we will be limited to

- point
- segment (actually any line will be represented as a segment since there is no real infinite lines in engineering drawings).
- Arc of circle (a circle can be considered as a special case of an arc).

The points, segments, and arcs are represented as follows :

* POINT

A point is represented by its cartesian coordinates (x, y)

* SEGMENT

A segment of a straight line is represented by its two end point (x_1, y_1) and (x_2, y_2)

* ARC.

An arc of a circle is represented by its center (x_c, y_c) , its start point (x_s, y_s) , and its angle "a" measured in counter clockwise

- Dimensional elements:-

The dimensions describe the size of the object. The number of dimensions located on a drawing may be one or more of the following types :-

* Linear Dimension

It is defined as the linear distance between two geometrical elements, and it is represented by two extension lines as follow $((x_1, y_1), (x_2, y_2))$, and $((x_3, y_3), (x_4, y_4))$, a dimension line $(x_1, y_1), (x_3, y_3)$, and a angular dimension value "v"

* Angular Dimension

It is defined as the angle between two segments, and is represented by : the value of dimension "v", an arc defined by its center (x_c, y_c) , its origin (x_o, y_o) , and the angle value "a"

* Circular Dimension

It is defined as the radius of a circle, and is represented by : the value of dimension "v" and a segment $((x, y), (x_c, y_c))$ where (x, y) is a point on the dimensioned arc, and (x_c, y_c) is the center point of that arc.

- Geometrical Relationships

These are the set of relationships that can be found between the elements of the drawing.

These relationships are of the following types :

- 1- Two coincident points.
- 2- A point lies on a segment or on an arc.
- 3- A point is the center of an arc.
- 4- A segment is parallel to another segment.
- 5- A segment is perpendicular to another segment.
- 6- Two segments are co-linear.
- 7- A segment intersects with another segment.
- 8- A segment intersects with an arc.
- 9- A segment is tangent to an arc.
- 10- An arc is tangent to another arc.
- 11- Two arcs are concentric.
- 12- Two Arcs belonging to the same circle.
- 13- An arc intersects with another arc.
- 14- Circular dimension (radius of an arc).
- 15- Angle between two segments.
- 16- Linear distance between two points.
- 17- Linear distance between two parallel segments.
- 18- Linear distance between a point and a segment.

Actually a set of 6 relationships are unified, which express all other types of relationships. They are :-

- 1- Incidence
It shows that a point lies on a certain line (supporting a segment) or circle (supporting an arc).
- 2- Tangency
It indicates that a circle is tangent to another circle or a line.
- 3- Center
Where a point is a center of a circle.
- 4- Radius
Where a scalar value represents the radius of a circle.
- 5- Distance
It represents the distance between two parallel lines.
- 6- Angle
It defines the angle between two lines. A special case is the zero angle which indicates two parallel lines.

3.3 Geometrical support concept

Every segment has a supporting line. Also every arc has a supporting circle. It was found that the support concept is heavily used in both manual drafting and automated drafting packages.

4. RECONSTRUCTION PROCESS

4.1 Manual drafting approach

In this section the behavior of a draftsman during the process of reconstruction for a given exact drawing will be studied. The geometrical elements are assumed to be limited to segments of lines and arcs of circles. The draftsman can not plot an arc directly on the drawing sheet without tracing a support circle passing through the arc and its two end points. Similarly the draftsman plots a segment by determining its support line and the two end points of that segment lying on the line. So to draw a geometrical element, the draftsman have to determine its geometrical support, together with the two end points lying on that support.

Taking into consideration that the points are supports for themselves, one can say that a geometrical element is totally defined by three supports: geometrical support and two end points.

The draftsman also have to visually interpret the sketch to recognize the different relationships between different supports of the drawing. the draftsman then starts to draw any support which has enough relationships with previously known supports.

These relationships can be of geometrical nature (parallelism, tangency, ... etc) and / or of dimensional nature (angle, radius, distance, .. etc). The process of relating supports to each other and drawing them is iteratively done until all supports of the drawing are drawn, which means that the drawing process is finished.

Note that the draftsman must suppose at least two initial supports. They will be used as reference supports and relative to them, the rest supports of the sketch are to be drawn. Analyzing the relationships between these two known supports and unknown ones, may lead to more than one sequence of plotting. This depends on which one of the completely related unknown supports will be drawn first.

4.2 System phases

As shown in Fig.1, the automatic reconstruction system consists of seven phases. They are :

- Elements and dimensions isolation
- Supports recognition
- Relationships recognition
- Reconstruction order
- Supports recalculation
- Elements recalculation
- Exact drawing plotting

The seven phases are implemented in four modules as shown in Fig.2, They are :

- MODULE 1 : ELEMENTS AND DIMENSIONS ISOLATION
- MODULE 2 : RECOGNITION OF SUPPORTS AND RELATIONS
- MODULE 3 : RECONSTRUCTION ORDER
- MODULE 4 : SUPPORTS AND ELEMENTS RECALCULATION

4.3 Elements and dimensions isolation

In this module an input DXF file representing the sketch will be processed to generate two sets of tables. These two sets describe the geometrical elements and the dimensional elements of the sketch.

1- Elements Tables

- a- points
- b- segments
- c- arcs

2- Dimensional tables

- a- linear dimensions
- b- angular dimensions
- c- circular dimensions

Each table contains the geometrical attributes of the corresponding elements.

4.4 Recognition of supports and relationships

-RECOGNITION OF SUPPORTS

The system finds out the set of geometrical supports (points, lines, and circles) corresponding to the geometrical elements of the input drawing in the following tables :

1- SUPPORT TABLES

- a- points
- b- lines
- c- circles

2- SCALARS TABLE

3- MAPPING TABLES

-RECOGNITION OF RELATIONS

The relations recognition module is divided into several submodules, each of them is responsible for recognizing certain type of relationship. The recognition process is done by solving a set of mathematical equations. For each relationship like :

- Intersection of two segments
- Intersection of two arcs
- Intersection of a segment with an arc
- Tangency
-

The result of each submodule will be a relationship. A set of actions are performed for each relationship. The relationship is to be referred to the supports of elements, rather than the elements.

4.5 Reconstruction order

This module receives as an input a set of geometrical supports and a set of relationships between these supports. Also two supports are supposed to be initially known. The supports are divided into two sets :

Known set (K), and Unknown set (U). Each support in K may have some relationships with other supports S_i where $S_i \in U$. These relationships will be used to transfer the support S_u from U to K. The reconstruction order is achieved in a recursive way. One unknown support $s \in U$ is to be transferred from U to K if and only if there are sufficient number of relationships connecting with supports belonging to K. This action is repeated until U is empty.

4.6 Supports and elements recalculation

In this module the new geometrical parameters of all supports will be calculated. Then the new geometrical parameters of the elements of set E will be calculated. The supports recalculation depends on the reconstruction order obtained by the previous module, which has a set of relationships associated with each support in the order. To calculate a support S_i the associated relationship with support are transferred into equations. The equations are to be solved in the support parameters.

5. ADDING RECONSTRUCTION TO AUTOCAD

The whole system is incorporated within AutoCAD package (ver. 10.0) such that the generation of sketch is done by AutoCAD and all phases are executed from a menu of AutoCAD. The different modules are added to AutoCAD in the following way :

- 1- Put the compiled modules in AutoCAD directory.
- 2- Put the names and volumes of compiled modules in the ACAD.PGP file of the AutoCAD package.
- 3- Make a menu and submenus for the reconstruction process in the ACAD.MNU file of the AutoCAD package.
- 4- Now every module becomes one of the external commands of AutoCAD that can be used from the reconstruction menu in the package.

Next is the sequence to generate the exact drawing for certain sketch :

- 1- Plot the sketch drawing by AutoCAD drawing editor.
- 2- Transfer drawing file to DXF format by AutoCAD built-in DXF translator (text file .dxf which will be processed next).
- 3- Extract geometrical elements and dimensions from DXF file by command in menu that will put it in tables in output file.
- 4- Recognize different supports and relations from last file by command in menu.
- 5- Obtain Reconstruction order and read initial supports from last files by command in menu.
- 6- Calculate the exact supports and elements and generates new DXF file from last files by command in menu.
- 7- Redraw the exact drawing by DXFIN command again.

Fig.3 and Fig.4 give an example which is a sketch drawn by AUTOCAD and reconstructed by the system.

6. CONCLUSION

This system is initially implemented to reconstruct mechanical drawings, however it can be applied to solve other problems. It can also be used alone or with other modules in different applications.

The reconstruction system is expected to help solving different problems in the domain of mechanical drawing. For example, the system can be used as an interface module between different drafting systems, analyzing of dimensioning problems, checking of mechanical drawings and documentation of old drawing....etc.

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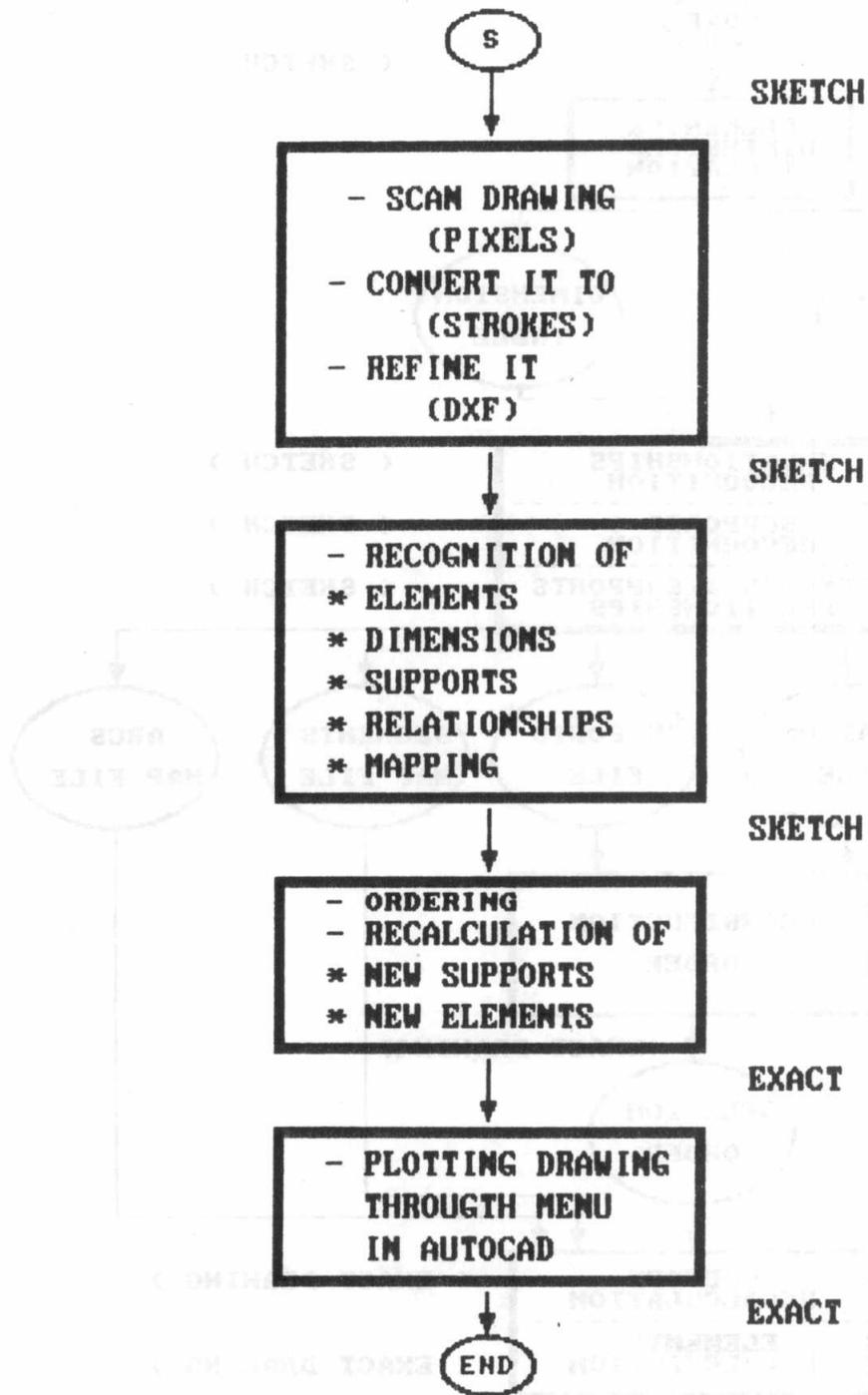


Fig.1. AUTOMATED DRAFTING PROCESS

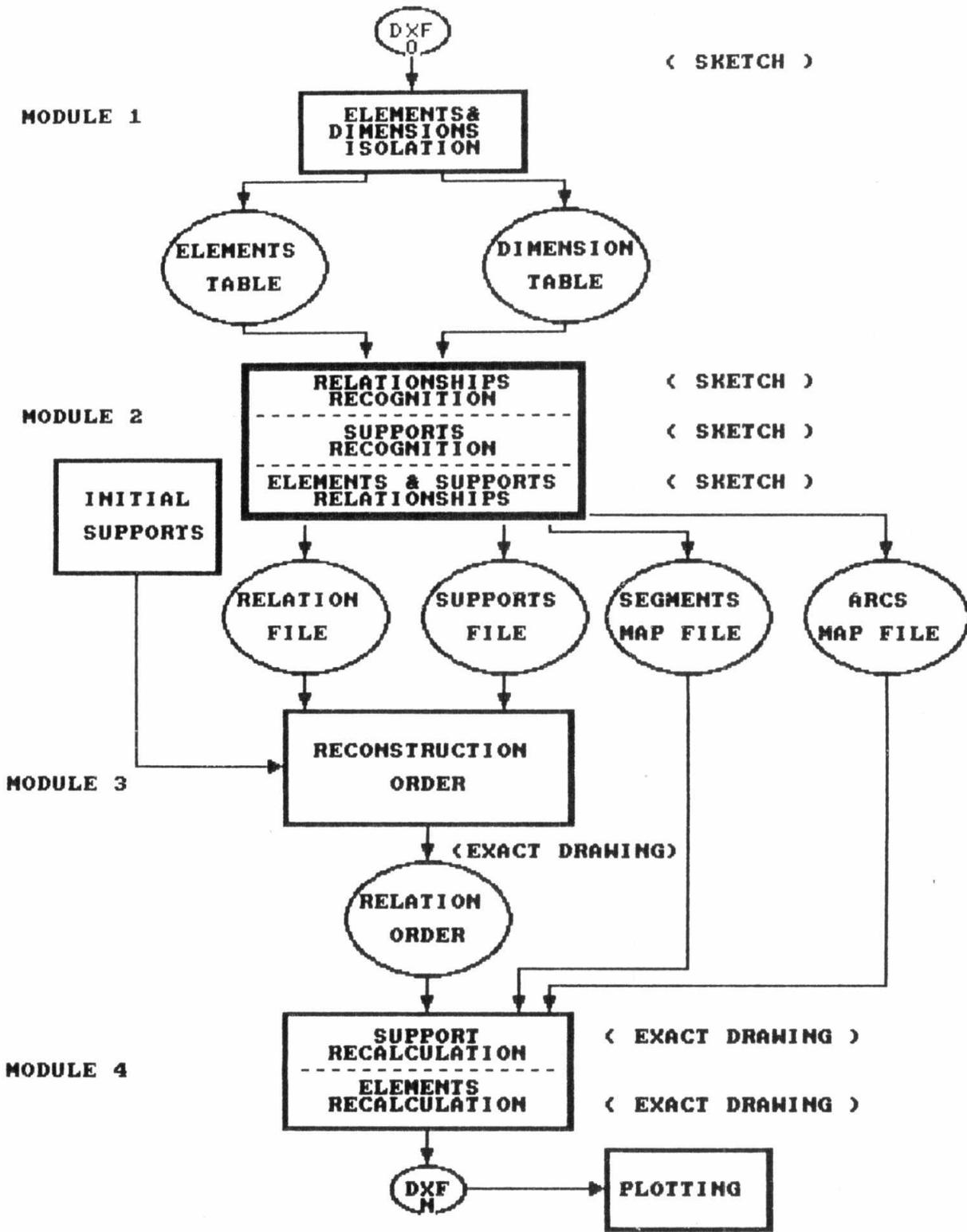


Fig. 2. SYSTEM PHASES

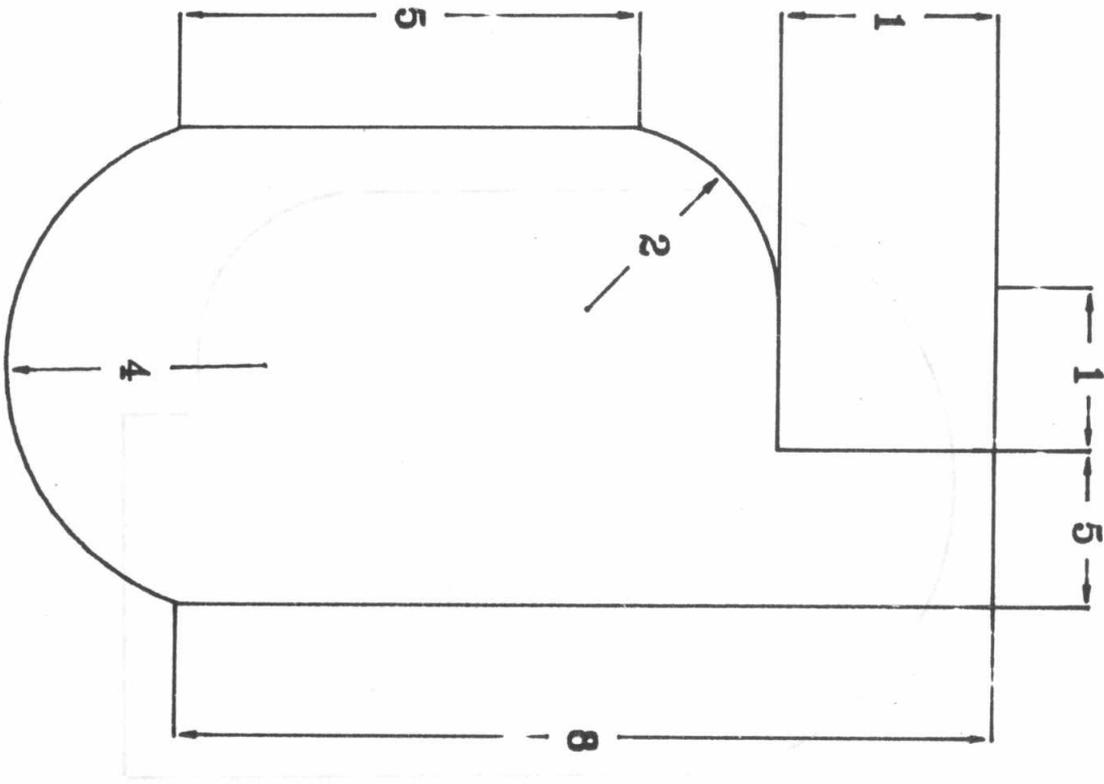


Fig.3. sketch drawing

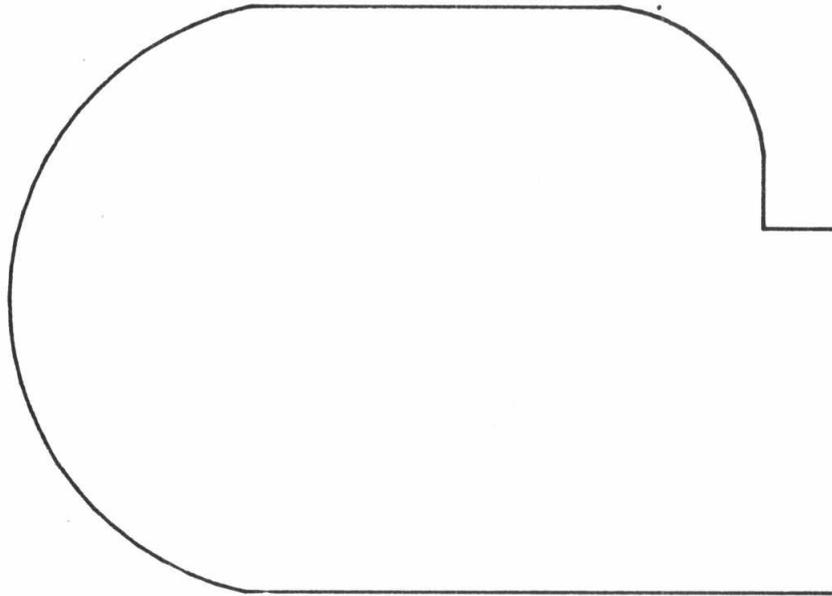


Fig.4. exact drawing