

APPROVAL SHEET

DIPLOMA PROJECT ENTITLED
AN AID FOR GEOMETRIC
SIMULATION OF MECHANISMS
BY MANGESH P. BEHALERAO IS
APPROVED FOR THE POSTGRADUATE
DIPLOMA IN INDUSTRIAL DESIGN

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I. D. C. Library
L. I. T. Bombay.

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My acknowledgement to my guide || 2
Shri L.K.Das for the useful
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this work.

SYNOPSIS

For investigation of any kinematic scheme, at present no conceptualisation aid exists, that is flexible enough to respond to the imagination of the designer, in a manner that may aid the thinking process. So an aid for geometric conceptualisation and simulation of planer link mechanisms was designed. The aid, consist of links of various lengths and pins of various sizes which can be combined to construct any planer link mechanism, it also enables quick changing of proportions of various kinematic links. Paths of various points on links can be recorded so the various kinematic schemes can be compared. This aid is designed to help designers, engineers, students in their work. The system has been named as LINKIT.



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1. CONTEXT OF THE PROBLEM

Man is ever trying to utilise more fully the various forces of nature. To do this sundry means must be designed to meet the desired results. As an example the locomotive is given a linear motion by rotation of the wheels moved by connecting rod attached to a piston having only a reciprocatory linear movement.

The design of such transformation devices in the field of mechanical engineering is carried on in the following conceptual context.

MACHINE AND MECHANISMS

A mechanism is a combination of moving resistant paths arranged in such a way that motion of one part causes in the other parts motion according to a fixed pattern, depending on the combination formed. It is a device which changes or transmits the form of a motion e.g. linkages, cams, gear trains, flexible connectors etc. When such mechanisms or their combinations are connected to a source of energy to do useful work they are termed as machines.

2
The design of mechanisms primarily incorporates the study of kinematics. This constitutes the study of displacements, velocities, acceleration without regard to the forces involved in the motion. The choice of material for the design of such links and the load bearing cross-sectional areas are determined by the study of forces. The engineering disciplines of dynamics and strength of materials provide the necessary conceptual framework.

In view of the time constraints, in this study we will confine our attention to design of planer link mechanisms.

LINKAGES

A link has been defined as a rigid connector in a machine or a mechanism. It is a combination of a number of link pairs connected in such a way that they allow relative ~~motion~~ motion between the paths.

All links must be so connected that if one link is moved it causes a definite motion in the other parts with the exception of one or more points called as dead points. Linkages are used to

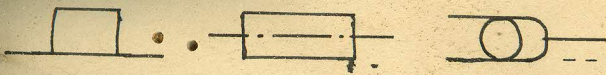
produce rotating, oscillatory and reciprocating motions from the rotation or oscillation of a crank.

There are four general types of links :

1. Rotating or oscillating links called cranks.
2. Links sliding between guides called sliders.
3. Links connecting cranks and sliders called connecting rods or floating links.
4. Links fixed between two points called frames.

The following constitutes the necessary geometric elements for the design of link mechanisms :

DESCRIPTION

1.  ----- Fixed axis of rotation
2.  ----- Pin joint at an end of rigid link
3.  ----- Pin joint at point other than end of a rigid link.
4.  ----- Sliding pair
5.  ----- Fixed guide
6.  ----- Rigid link having three connections not in straight line i.e. structure.

2. SOURCE OF THE PROBLEM

For investigation of any kinematic scheme the following methods are used :

1. Mathematical evaluation and computation with an aid of computers or otherwise.
2. Use of drawing board techniques involving lot of link paths.
3. Use of scaled models for quick visualization.

Mathematical and drawing board techniques are not only time consuming, costly but also only suitable for final refinement of a conceptual scheme. At present no conceptualisation aid exists, that is flexible enough to respond to the imagination of the designer, in a manner that may not retract him for the thinking process. This necessity constitutes the source of the problem worthy of attention.

3. STATEMENT OF THE NEED

To design an aid for geometric conceptualization and simulation of a planer mechanisms that can be effectively completed in twelve weeks time. The aid should be flexible to respond to requirements of machine designers.

6

4. DESIRABLE ATTRIBUTES OF THE SOLUTION

- 4.1 It should be possible to choose from among the basic geometric elements in link mechanisms such as sliders, cranks, fixed axis, fixed guides, structures and so on.
- 4.2 The aid should be such that it should be possible to form various kinematic schemes quickly and easily. The time in construction of any scheme should not ^{be} more than half an hour. The construction should not involve any special tools for machining or making it.
- 4.3 It should be possible to trace out the paths of various points on the kinematic links so that the various motions can be recorded and studied.
- 4.4 It should be possible to change the proportions of the links to get different results.
- 4.5 The aid should be sufficiently durable. It should have life of five years in the regular office use.
- 4.6 The cost should range between Rs. 100/- to Rs. 200/- considering the cost of instruments generally.

used by designers, students, such as slide rules, instrument box, draughters, roterings etc.

4.7 The design should be simple from the manufacturing point of view, should not involve complex tooling or using of special materials.

4.8 There should be minimum number of parts to achieve simplicity.

4.9 It should appeal to users.

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5. PROBABLE SOLUTIONS OF COMPONENTS.

After carefully studying a number of mechanisms, various probable solutions of the constituent components were sketched, considering the different requirements of the individual components.

DESIRABLE ATTRIBUTES OF INDIVIDUAL COMPONENTS :

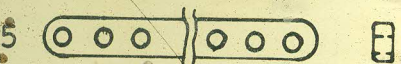
5.1 Link

- It should be possible to prolong the length of a link.
- It should be possible to form structures using links.
- It should be possible to form bell-crank levers.
- It should be possible to judge various proportions.

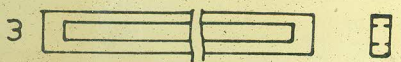
Considering the above points some types of links were designed. More promising of them are illustrated in the fig. 5.1

5.2 Slider Link

It should be designed in such a way that this link can be used as a fixed guide and as a crank with sliding pair. Probable solutions are illustrated in the fig. 5.2 .



5.1 LINKS



5.2 SLIDERS

5.3 Pins

- a) The pins should be designed so that they will provide turning pairs for kinematic links i.e. pin will allow turning motion between links.
- b) It should be possible to provide the turning pair at the ends of link and also at the points other than the ends.
- c) It should be possible to connect two or more number of links.

Some of the probable solutions are illustrated in fig. 5.3 .

5.4 Sliding pair

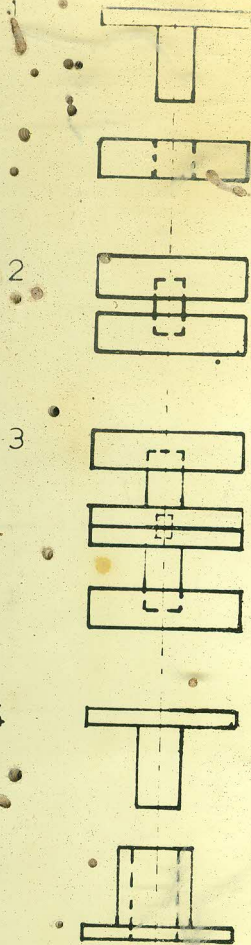
It should allow sliding ~~motion~~ motion between the elements of mechanisms.

Some of the probable solutions are illustrated in fig. 5.4 .

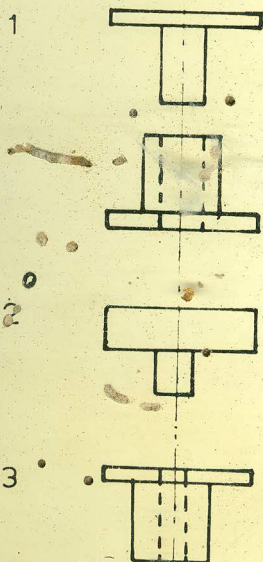
5.5 Fixed Pins

In any mechanisms there are points called dead points which don't have any relative motions. These are fixed axes of rotations, fixed pins should provide this requirement.

Some solutions are illustrated in fig. 5.5



5.3 PINS

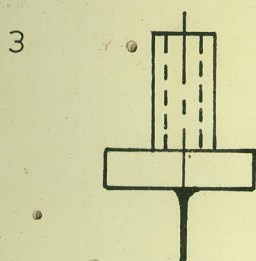
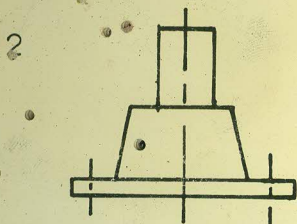
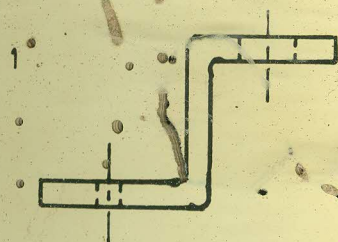


5.4 SLIDING PAIR

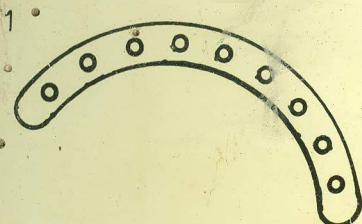
5.6 Link to form Bell-Crank/Lever

It should be possible to form bell-crank levers between two links using some intermediate element.

Two solutions are illustrated in fig. 5.6



5.5 FIXING PINS



5.6 BELL CRANK
LEVER LINK

6. DESIGN SELECTION

In order to satisfy many constraints, - and requirements on the design and at the same time to achieve simplicity, to minimise number of parts, enhance versatility many of the solutions listed in chapter 5 had to be discarded.

6.1 Link

From the six types of links, link number 5 was selected.

No.1 link was all right for forming end pin joints but to form pin joint at points other than ends some other element was required.

No.2 link : To form structure using this type of links was difficult. A special joining detail to connect two or more than two links has to be designed. See fig. 6.1

No.3 and No.4 Links : Again the joining detail was difficult and more complex.

No.6 Link : Complete rotation was obstructed.

Moreover in the designing of links it was required to see that relative motion between the links should be possible, for this the links should be

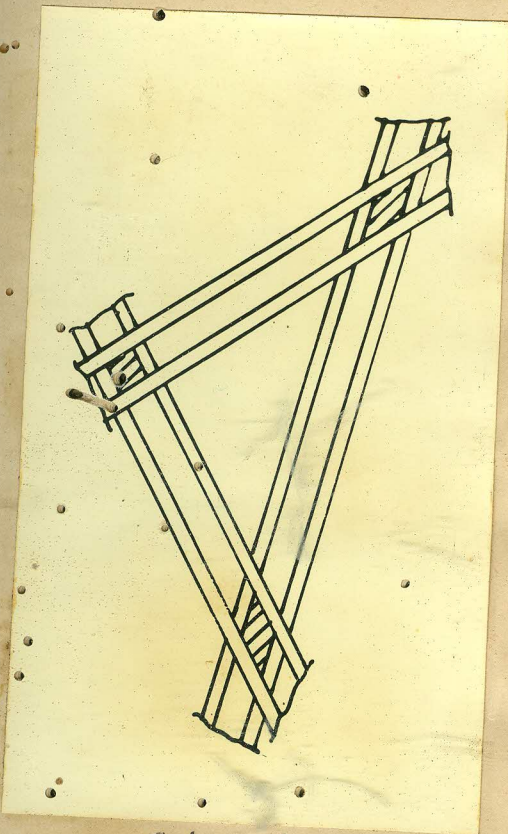


FIG 6.1 Structure formed by using slotted links.

parallel
in different planes, at the same time the distance between the links should be minimised. Considering all these points Link No.5 was selected.

The attributes of Link No.5 are :

- a) Prolongation of length of a link is easy.
- b) Rigid structures can be formed using three links.
- c) Bell-crank lever can be made using third element.
- d) The holes at regular intervals provide sort of callibrations.
- e) Tracer can be fixed in any hole.
- f) Pin joint can be formed at the ends or at the points other than ends.
- g) Two or more links can be pin jointed at one point.

6.2 Slider Link

No. 1 link was selected because it was similiar to Link No. 5. It is easy to use as a fixed guide as well as a sliding crank so fulfilling the requirements for the slider links. The other links were rejected because

they were increasing the complexity of the design by increasing the number of parts.

6.3 Pins

No.4 design was selected because

- a) it was very much suitable for connecting two or more number of links.
- b) same pin can be used as a sliding pair as shown in the fig. 6.3.
- c) it was easy to put washers between the links using this type of link pin.
- d) modification of this pin can be used as a ~~fixed~~ fix pin.

Other pins were suitable to connect only two links. They were increasing the distance between the links. They were more complex .

6.4 Sliding Pair

Pin No.1 was selected to minimise the number of parts ~~of~~ and to achieve simplicity.

6.5 Fix Pin

Pin No.3 was selected as stated before it is just the modification of pin. No. 1 and 2 were increasing number of parts. They were complex requiring additional elements like drawing clips.



BOTH KINAMATICALLY
EQUIVALENT

FIG 6.3

6.6 Link For Forming Bell-Crank Lever.

Link No. 1 was rejected as the form of this link is circular where as all other links are straight.

Link No. 2 was hence selected.

7. DESCRIPTION OF THE [REDACTED] AID

The various elements of the product are illustrated in the figures.

7.1 Link

There are five type of basic links, of various lengths. They are 10 cm., 20 cm., 30 cm., 40 cm., and 50 cm., A dimensional basic link is illustrated in ~~fig.~~ ~~[REDACTED]~~ the drawing.

The Links are illustrated in fig. 7.1.2

7.2 Slider Link

It is illustrated in fig. 7.2.1

7.3 Pins

Pin is consisting of two parts - male and female. There are ~~three~~ types of female pins viz. for 2 links (6 cm.), for 3 links (9 cm.), and for 4 links (12 cm.).Male part remaining same for all. They are illustrated in fig. 7.3.1 .

7.4 Fix Pins

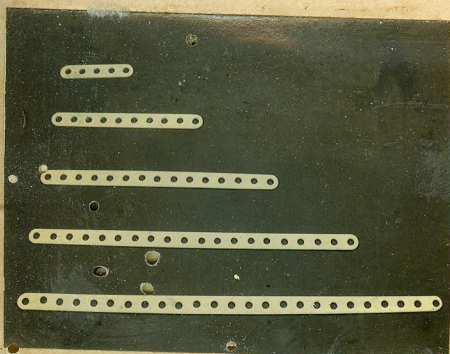
There are three types as illustrated in the fig. 7.4.1 . They are 6 cm., 10 cm., and 15 cm.

7.5 Bell Crank Lever

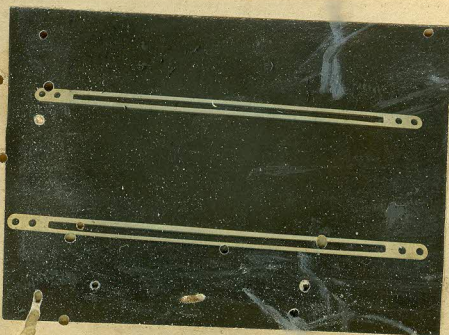
It is illustrated in fig. ~~7.5.6.2~~

7.6 Tracer

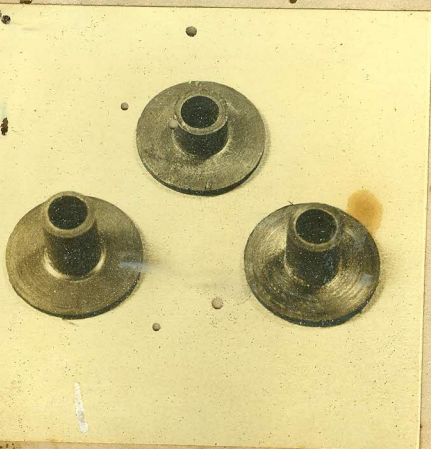
It is illustrated in fig. 7.6.1



7.1.2



7.2.1



7.3.1



7.3.1

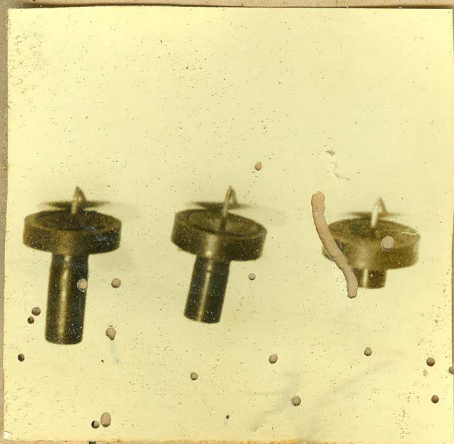
7.7 Washers

They are provided to enable the links to be in different planes to avoid obstruction. See fig. 7.7.1

7.8 Clip

This was specially designed so that a link of variable length can be obtained by means of this. See fig.

7.8.1 .



7.4.1

7.9 Package Along With Board

A package system to store the different elements neatly is designed alongwith a light weight board for demonstration.

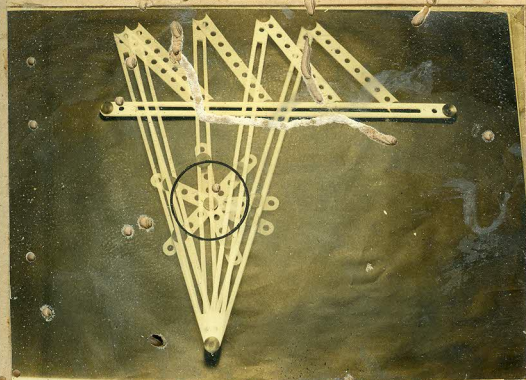
The material used for model is polystyrene for links and P.V.C. for pins. The material recommended for the links is aluminium.

The Links can be obtained as extruded sections and can be punched afterwards.

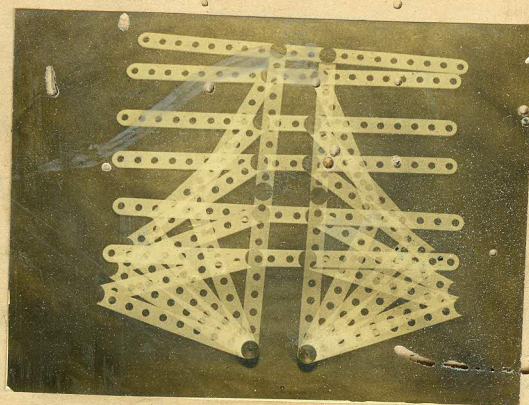
The Pins are to be injection moulded, the material of pins can be either P.V.C. or polypropylene.



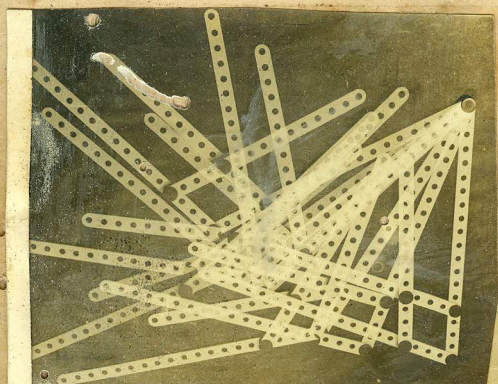
7.7.1



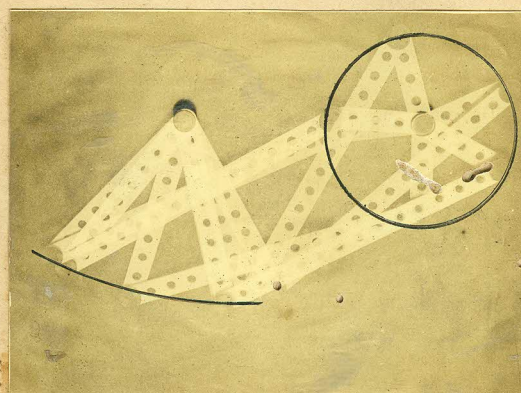
SHAPER MECHANISM



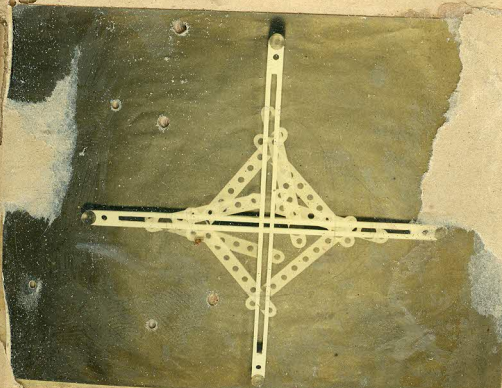
SCREW JACK



FOUR BAR INVERSION
ELLIPTICAL TRAMMEL



PENTOGRAPH



CRANK LEVER MECHANISM



PENTOGRAPH

8. PACKAGING

To pack the various elements of the aid as well as to store them, handling them considering cost of packaging, life required for the packaging, display value of the pack, appealing of the pack, some alternatives were tried, few of them are ~~xxx~~ proposed. They are illustrated in fig. .

9. INSTRUCTION FOLDER

To use the aid correctly and effectively, to facilitate quick and easy investigations of different link mechanisms, to enable to study different link mechanisms and to record the results and to compare them an ' INSTRUCTION FOLDER ' was designed to give an idea of the various operations to be carried out in constructing any kinematic scheme. The Instruction Folder is provided ^{with} in the report.

10. PRODUCT EVALUATION

To evaluate the product a questionnaire was made and it was given to different people in the field of designing, engineering and education.

1. The operations involved in constructing any mechanism are
Complex / All right / Very simple
2. The time required to construct any mechanism is
Much / Appropriate / Short
3. The general size of links are
Big / Appropriate / Small
4. To carry out investigation of mechanisms the designed aid serves the purpose
Very Good/ Adequate / Need for improvement
5. Did you feel need of such an aid before ?
Yes / No
6. Do you find the links are
Flexible / All right / Rigid
7. Do you like to have a drawing board along with the aid ?
Yes / No.
8. Do you think such type of product should have
Appeal / No need of appeal

9. Do you think the designed product
~~has~~ has

Appeal / No appeal

10. Do you think that the designed product
should be modified for investigation
of kinematic terms like velocity and
acceleration

Yes / No

11. Do you find the cost of the product
is

High / All right / Low

12. Whether you will buy such a product
for

Yourself / For Design Office / As a

~~Gift~~ Gift / As an ~~Educational Aid~~ Educational Aid/

13. Any suggestions and remarks .

EVALUATION SUMMARY

The questionnaire was given to 10 people.
The various answers received are listed below :

1. Operations involved in constructing mechanism are

Complex	-
All Right	3
Very Simple	7

2. Time for construction of mechanism

Much	1
Appropriate	3
Short	6

3. The general size of links

Big	7
Appropriate	3
Small	-

5. Did you feel need for such product before

Yes	4
No	6

7. Need for drawing board

Yes	5
No	5

8. Such type of product should have appeal

Appeal	3
No need of appeal	7

12. Such product will be purchased ~~by~~ for

Youssself	2
Design Office	5
Gift	2
Educational Aid	7

13. Most of the people suggested that the links are big and flexible. They should be of smaller size and should be rigid.

Taking into consideration the feed back from the users ~~and~~ after testing of the aid some modifications are recommended. The links should be of smaller size and should be more rigid. So aluminium is recommended as ~~a~~ the material of links. The ~~a~~ smaller size of links reduces the size of pack and at the same time will reduce the cost of the system.

11. COST ANALYSIS

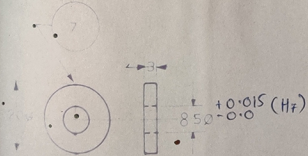
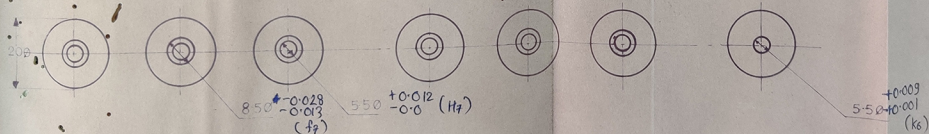
Links (Aluminium/Weight 1000 gms.)	
Material Cost	Rs. 20
Labour Cost	Rs. 5
Pins (Polypropylene/P.V.C. Injection moulded. Weight 100 gms.)	Rs. 8
Package (Made up of thick P.V.C. Guage 12).	Rs. 10
Board (Made up of thin grain size Thermocole and card board).	Rs. 10
	Rs. 53

If rexine pack is used the pack cost will be Rs. 20/- .

If a package with Thermocole bottom and Acrylic top is used the cost of package will be Rs. 25/-.

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J. Denavit
Mechanisms by Joseph S. Beggs.
4. Introduction to the Basic Mechanisms by Roy E. Hampton.



7	WASHERS
6	PIN MALE
5	PIN FEMALE THREE TYPES
4	FIXING PIN THREE TYPES
3	LINK FOR BELL CRANK LEVER
2	SLIDER LINK
1	BASIC LINK FIVE TYPES
N.	DESCRIPTION

MANGESH BHALERAO
 SCALE.1:1
 LINKIT SYSTEM.
 I. D. C. (BOMBAY)