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arabic summary

الملخص العربى

منذ بداية العصر الحديث ولم يظهر أى إختراع تقنى له تأثيرة فى القطاع الهندسى أكثر مما قدمة الكمبيوتر من تقنيات فائقة التصوير ، والذى سمح للمستخدم الواحد أن ينتج أكثر مما يتوقع إنتاجة من مجموعة بأكمالها كما أنة جدير بالذكر أن هناك العديد من الأبحاث المتقدمة لولا وجود الكمبيوتر لما سمعنا عنها على الإطلاق. من المعروف أن قطاع التصميم يشمل على الكثير من الأعمال ، وهى ليست فقط بالأعمال المرهقة التى تتطلب حسابات طويلة ، ولكن الحلول نفسها لمعظم الأجزاء لايمكن تنفيذها إلا من خلال محاولات عديدة ومعقدة . إن هندسة الإنتاج الحديثة تتطلب الكثير والكثير لتحسين المنتجات ودرجة دقتها من أبعاد وتسامحات ... إلخ ، بالإضافة إلى الإنتاجية المرتفعة .

وبالنسبة لتصميم بعض أجزاء ماكينات العدد مثل الكامات يكون من الصعب – إلى درجة كبيرة تصميم طقم كامات لإنتاج منتج معين . ***فعادة يتم توريد أقراص الكامات من الشركة المصنعة للماكينة مع تجهيزها (مثل رسم الأشعة عليها) وإرسال طقم ضبعات معها للمساعدة فى عملية رسم الكامة*** ، وحيث أنه لا توجد قواعد خاصة وثابتة لتغطية جميع البينات الخاصة بتصميم كامات ماكينات العدد (حيث أنها تعتمد أساسا على متطلبات كل منتج على حدة) ، **لذلك كان الغرض الرئيسى لهذه الرسالة هو تصميم وإعداد نظام للمحاكاة Interactive Dialogue System للقيام بتصميم وتصنيع هذه الكامات أتوماتيكيا مائة فى المائة ودون تدخل أى عامل بشرى.**

وبإستخدام مثل هذا النظام فإن الحسابات والرسومات والتصميمات (والتى كانت تعد يدويا معتمدة كما سبق القول على الخبرة) يمكن إجراؤها فى يسر وسهولة تامة وبسرعة فائقة التصور (كما هو مذكور فى الرسالة) أيضا سوف يقل الوقت الكلى اللازم للحسابات والتصميم والرسم كما أن هناك وفر عظيم فى الجهد ، ومنع الأختلافات المتعددة الغير مرغوبة من مهندسى التصميم . لذلك فمن المنطقى التصور والأعتقاد تماما بأنه سوف نحصل على تصميم ذات جودة عالية. ومن خلال العديد من العمليات يقدم نظام الـ CAD/CAM الدقة الفائقة الجودة والسرعة لتنفيذ التصميمات ومن الأمثلة التى أجريت باستخدام هذا النظام تم الحصول على أعظم النتائج . **أكثر من ٩٧,٥٪ وفر فى الوقت والذى يعتبر إلى حد كبير إنجاز رائع بكل المقاييس** ، كما تم إعداد وتنفيذ البرامج الخاصة لكل كامة لتنفيذها وتشغيلها على الماكينات الرقمية (NC M/C Tools) أوتوماتيكيا

بعد إتمام حساب وتصميم ورسم الكامة يقوم البرنامج بإرسال معلومات عن بروفيل الكامه إلى software مساعد لإعداد البرنامج الخاص للتشغيل ، وبذلك يكون هناك ضمان عالى الدقة لتشغيل بروفيلات الكامات والذى بدورة ينعكس على إنتاج المنتج المستخدم فى تصميمه طقم الكامات وهذا بدورة يقودنا إلى جودة ١٠٠ ٪ .

يتضح أخيرا لقطاع هندسة الإنتاج أن تقديم مثل هذه البرامج إلى الصناعة سوف يعود عليها بفوائد عديدة وللمصنع المستخدم الحرية المطلقة فى بناء قاعدة معلومات قوية تضاف إلى الأنظمة الأخرى لنصل إلى نظام متكامل لقطاع الإنتاج .

والرسالة تحتوى على ستة فصول ، **الفصل الأول :** يمثل مقدمة عن كامات ماكينات الورش موضحاً أنواعها بالنسبه لحركة التابع وشكل الكامة ، وأيضاً معلومات ملخصة عن أهم البيانات الخاصة بالكامات بصور عامة. **الفصل الثانى :** يعتبر دراسة شاملة عن ما سبق كتابته ونشره فى هذا الموضوع وكذلك يتضمن تقرير شامل عن المشكلة. **الفصل الثالث :** يحتوى على خطوات التصميم لكامات ماكينات الورش وخاصة كامات الديسك بالطرق التقليديه ، الشائعة والمتعارف عليها. **الفصل الرابع :** يوضح مفهوم أنظمة إستخدام الحاسب الآلى فى التصميم والتصنيع. **الفصل الخامس :** يتضمن منهجية نظم الخبرة. وأخيرا **الفصل السادس :** وهو يوضح الإستنتاجات الأساسيه ومبررات وقناعة النظام ، والدراسة المقارنة والتوصيات الناتجة بناء على تطبيق هذا النظام . **الملحق الأول :** ويحتوى خطوات عمل البرنامج ، ثم **المراجع** وأخيراً **الملخص العربى**.

ABSTRACT

Since the beginning of modern history , *perhaps no technological innovation has influenced engineering more than the electronic digital computer , which assumed to be very important role in logic design & manufacturing system.* Mechanical design , *involves a lot of routine work not only tiresome and lengthy calculations have to be done , but the solutions for most part can only be achieved through complicated iteration.*

Tool design is a vital component *of mechanical design , at the same time it is a specialized phase of tool engineering. Also , its functions may be performed by a tool engineer in addition to his other duties in manufacturing , or they may be performed by tools-design specialist who devotes his entire working time to tool design.* **Tool designer** *must be able to visualize exactly how the work piece is to be made , he should be competent to judge the merits of different methods.*

Up today our designer engineers , *work through the conventional way of design which it is in reality differs from one to another depending on the experience and data available in hand, it is also time consuming and involved duplication of effort by design and manufacturing personal, which being completely differs with the main aim of designer engineers, such as improved of work piece accuracy both in terms of dimensional and profile tolerances, this combined with the requirement for higher output .*

Thus, the objective of this thesis is to design an interactive dialogue system for production engineers in manufacturing fields, particularly in the field of design and manufacturing of machine tool cams (disk cams) to assist the engineers / users to draw, calculate, design and manufacture through a well developed system. *By using such system, the conventional calculations and design may be performed quickly and simply, because there is no fixed rules cover all points in cam design, as so much depends upon the requirements of each component.* **This system provides** a *tremendous saving in drawing/ calculations/design time and effort, and help to prevent a variety of unnecessarily differences. Also saving a great amount of money due to a great reduction of material wastage.*

Therefore, it is reasonable to believe that a better design will result from a CAD / CAM system, *it is a working tool and communications methodology which today represents the fasts , most accurate and consistent way to progress designs through various processes. Excellent results have been obtained from the system justification* , **i.e. 97.5 % time saving which considered to be a tremendous achievement.**

The thesis consists of six chapters . **Chapter One** presents an introduction to machine tool cams, cam definition terminology, geometry of cams and followers and their classification etc. **Chapter Two** illustrates the more relevant work as a literature survey and the statement of the problem. **Chapter Three** presents in detail the manual procedure for Disc Cam Design and Drawing through a comprehensive literature and calculations for several examples to assist the production engineer in understanding the process starting from the required product to the final design of the cam set. **Chapter Four** introduces the concept of CAD/CAM/DB system and the related advantages, the CAD/CAM programs and the drawings for any set of cams through the developed system. **Chapter Five** explains through a short illustration the role of expert system methodology in establishing software tool for future work. **Chapter Six** illustrates the fundamental conclusions , the system satisfaction and justification , comparative study , and the recommendations. **One Appendix** has been provided in this thesis illustrating list of the program. Then **References** will be listed , and finally the **Arabic Summary**.

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CONTENTS

CHAPTER FOUR:

The concept of CAD/CAM & DB Systems

CHAPTER FIVE:

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MANSOURA UNIVERSITY
FACULTY OF ENGINEERING
INDUSTRIAL PRODUCTION ENGINEERING DEPARTMENT

CAD / CAM SYSTEM FOR MACHINE TOOL CAMS AND THE ROLE OF EXPERT SYSTEMS METHODOLOGY

By

ENG. MANAL ABD EL-AZIZ ALI MEKAWY

B. Sc. (Prod. Eng.) , Affiliate Member ASME

A Thesis

Submitted In Partial Fulfillment For The Degree Of

Master Of Science

In Production Engineering

١٩٩٧

SUPERVISOR

Thesis Title

CAD/CAM SYSTEM FOR MACHINE TOOL CAMS
AND
THE ROLE OF EXPERT SYSTEMS METHODOLOGY

Researcher Name

Eng. Manal Abd El - Aziz Ali Mekawy

Supervisor

Name	Position	Signature
Prof. Dr. Tawfik T. El-Midany	*Prof. and Head of Ind. Prod. Eng. Dept.* *Mansoura University*	

DEDICATION

To My Family .... Specially

To My Lovely " PARENTS "

For thier sincere ..... warm feeling .....

great support ..... encouragement .....

and thier unlimited care .....

GOD bless them for ever and ever

&

To My dear professor

MANAL

1997

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*Also , I express my deepest thanks to my Boss **Eng. Mohamed Hassn** General Inspector of Talkha Power Station for hardly support and help.*

Manal Mekawy

1997

NOMENCLATURE

D - R - D	Dwell - Rise - Dwell
D - R - R - D	Dwell - Rise - Return - Dwell
R - R - R	Rise - Return - Rise
THED	Three hundredth and sixty equal divisions
R	Rays or arcs radii
R1	Maximum cam diameter radius
R.P.M (r.p.m)	Revolutions per minute
V	Surface speed m / min.
Db	Bar diameter or (diameter of material)
f	feed rate
LOCS	Laying out cams sheet
SP calculated	Calculated spindle revolutions per minute r.p.m
SP actual	Actual spindle revolutions per minute r.p.m
V actual	Actual cutting speed
BL	Bar Length
PL	Product length
CTW	Cutting Tool width
N1	Maximum Turning speed
N2	Maximum Drilling speed
N3	Maximum Threading speed
SL	Strock length
ID	Idle Degree
TID	Total Idle degree
TPD	Total productive degree
n_o	Basic number of revolutions for every productive operation
np	Total Productive revolutions for the product
Sp_{oc}	Number of spindle revolutions required for one component
CP	Cam path
TP	Tool path

LR	Lever Ratio
RFR	Rises and Falls ratio
CDR	Coefficient of the number of degree per revolution
PDR	Productive degree per revolution
TP	Productive Time
CT	Actual cycle time
TN	Actual (Net) machining time
D	Diameter of the arm circle
D1	Diameter of the arm circle
Do	Maximum cam diameter
Dm	Mean cam diameter
R	Arm length
B	Minimum cam diameter
D	Diameter of camshaft
O	Opening hole
S	Cam thickness
D1	Diameter of fixation hole
C	Distance between cam center & fixation hole
TR	Transmission paths
ES	Expert system
ESAE	Expert system Aided Engineering
ESAD	Expert system Aided Design
ESAM	Expert system Aided Manufacturing
ESAD/ESAM	Expert system Aided Design/Expert system Aided Manufacturing
AI	Artificial Intelligence
KE	Knowledge Engineering
IE	Inference Engine
WDB	Working Date Base

CONTENTS

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LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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1 Introduction to Machine Tool Cams

1-1 Introduction

The production of turned components *on machines developed from the lathes but designed with a system of automatic movements , has been going on for many years and the term " automatic " has become generally accepted as applying to such machines. Over the years considerable progress has been made in the development of such machines , but the fundamental principles of their operation have shown little change from their reliance on cams and other well-known mechanical devices for producing the movements necessary [1].*

Fully automatic machine tools are machines *in which, once the machine is setup , all the movements related to the manufacturing cycle and also the loading of blanks and the unloading of machined parts are performed without the operator's participation [2,3,4,5,6]. Automatic machining methods have been in use for a long time. Until quite recently most of the automatic systems have been controlled mechanically.*

Controlling the ignition of fuel *in each of the cylinders in your car - four, six or eight - is a small cam attached to the distributor shaft. With as many lobes as the engine has cylinders , the cam actuates the ignition at an astounding rate of forty or fifty times a second.*

Opening and closing the intake *and exhaust valves-again on your car-is a shaft aligned with cams, two for each cylinder , that open and close the intake and exhaust valves through a linkage system called the valve train. You awake in the morning by an alarm, tripped by a cam or an eccentrics. Typewriters, sewing machines, can openers, and spacecraft all contain cams and eccentrics of one sort or another-cams that either transform one type of motion into another or that transform force into torque or torque into force.*

1-2 Cam Definition

☞ ***A cam is** a mechanical element of a machine which is used to drive another element, called the follower , through a specified movement by direct contact.*

☞ **The cam and follower** constitute one of the simplest as well as one of the most versatile mechanisms found in modern machinery today, Fig. 1-1 , illustrates a plate cam with oscillating follower as used in many machines.

☞ **In action** the cam rotates, usually at constant angular velocity, and drives the follower in an oscillating motion whose characteristics are dependent upon the shape of the cam.

☞ **The versatility of the cam** lies in the fact that a change in the cam curve will result in a change in the characteristics of the follower motion.

☞ **For this reason** the number of follower motions available is limited only by the ingenuity of the designer [4,7].

But though a cam can be designed to impart nearly any motion to its follower certain motions produce extreme velocity and acceleration effects resulting in high stresses and vibration in the associated components. Unless the designer selects materials and components to satisfactorily resist these high stresses either wear or fatigue failure will result in a relatively short life for the parts. *So the principal problem in the kinematics design of cams is to compromise upon a follower motion which will have relatively mild values of velocity and acceleration.*

1-3 Cam Terminology

Some of the important terms used in laying out the cam profiles are explained in the following paragraphs :

1. **The cam profile:** it is the actual working counter or the working curve of the cam. It is the surface in contact with the knife edge, roller surface. The cam profile may be of any shape; it may be external, single, or multi-lobe. Figure 1-2 , shows a cam profile of a single - lobe radial cam.
2. **The base circle:** It is the smallest circle drawn to the cam profile from the center of rotation of a radial cam. Cam size will depend upon the size of the base circle.

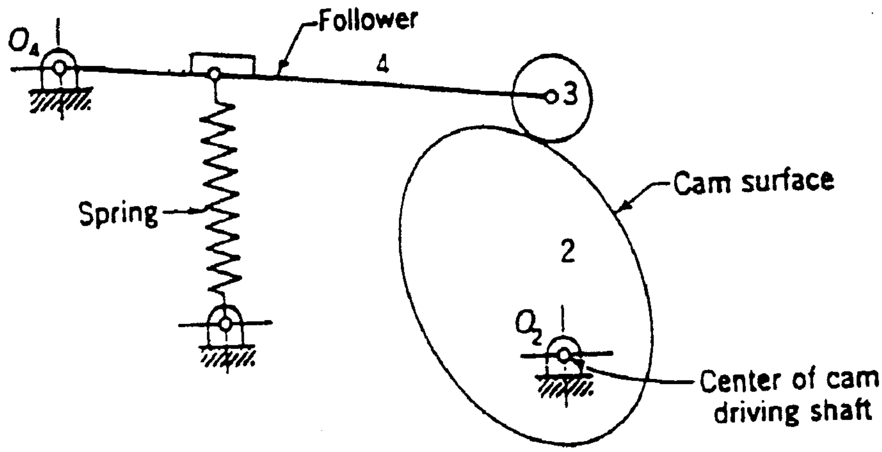

Fig. 1-1 A Schematic drawing of a cam and follower

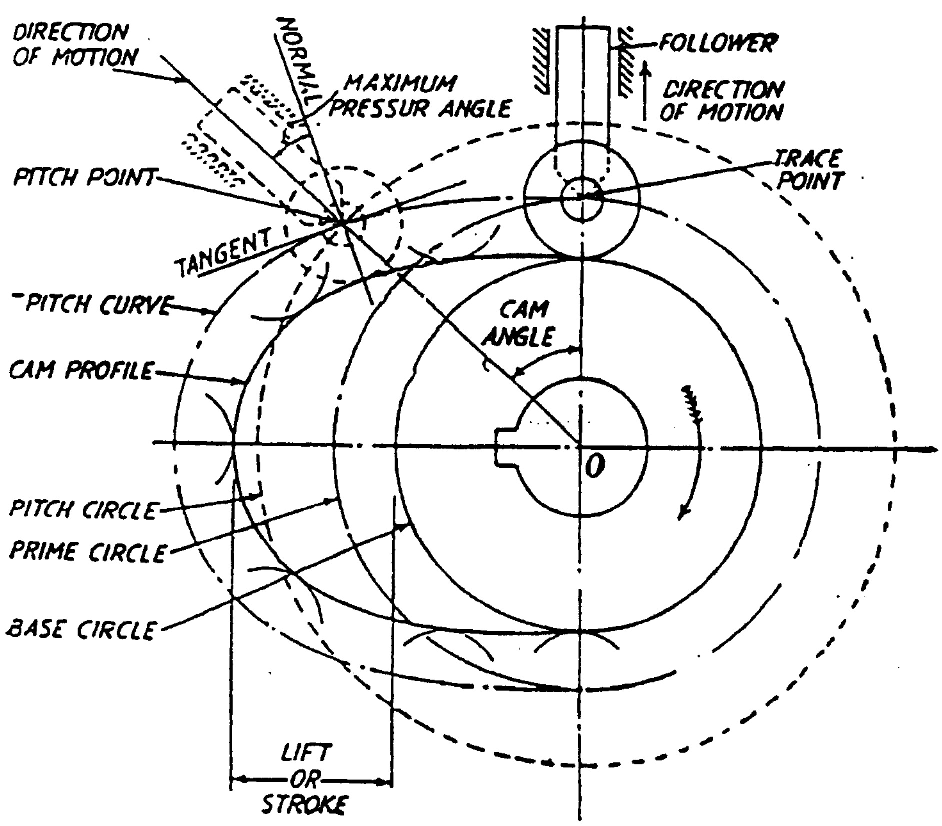

Fig. 1-2 Cam profile of a single-lobe radial cam

3. **The trace point:** It is the point on the follower located at the knife edge in knife edge follower and center of the roller in roller follower, or center of the spherical face in mushroom spherical follower. It is a reference point on the follower for the purpose of tracing the cam profile.
4. **The pitch curve:** It is the path of the trace point. For the purpose of laying out the cam profiles it is assumed that the cam is fixed and the follower rotates around it. Thus the knife edge, or the roller center etc. will trace a curve if assumed to be rotating round the cam. This curve is called the pitch curve.
5. **The prime circle:** It is the smallest circle drawn to the pitch curve from the center of rotation of the cam.
6. **The pressure angle:** It is the angle at any point on the pitch curve, included between the normal to that point on the curve and line of motion of the follower at that instant. This angle is very important in cam design as it represents steepeness of the cam profile.
7. **The cam angle:** It is the angle of rotation of the cam for a definite displacement of the follower.
8. **The pitch point:** It is the point on the cam pitch curve having the maximum pressure angle.
9. **The lift or stroke:** It is maximum displacement of the follower from the base circle of the cam. It is also sometimes called the throw of the cam.
10. **The pitch circle:** Is a circle with center as the center of the cam axis and radius such that is passes through the pitch point.

1-4 The Geometry of cams and followers

1-4-1 Types of cams

Cams may be classified through the following three ways: **Follower motion**, e.g., dwell-rise-dwell **(D-R-D)**; dwell-rise-return -dwell **(D-R-R-D). Cam shape**, e.g., wedge, radial, globoidal, cylindrical, conical, spherical. And **manner of constraint of the follower**. Constraint may be obtained either by spring loading to keep the follower in contact with the cam surface, or by positive drive.

A-1 Classification based on follower motion

1. **Dwell-Rise-Dwell Cam (D-R-D)** ; the zero displacement part of the cam is called dwell. There is zero displacement followed by a rise contour to another dwell period. It is used very frequently in machinery. In this case rise is followed by a fall or it may be dwell -rise -dwell return, see Fig.1-3
2. **Dwell-Rise-Return-Dwell Cam (D-R-R-D);** in this type the rise and return are preceded and followed by dwells as shown in Fig.1-4.
3. **Rise-Return-Rise Cam (R-R-R-);** this has no dwells. Its application is limited. An eccentric mechanism is suggested in place of such a contour cam see Fig.1-5.

B-1 Classification based on the shape of the cam

1. **The Translation:** Wedge or flat cam, see Fig. 1-6 , this is the simplest type of cam. The plate cam moves back and forth imparting a translatory motion to the follower. In Fig.1-6 the follower could be held in the groove and thus has a positive motion. The follower could be held by a spring and the plate cut to give a desired motion without any groove cut. The follower will in that case move on the surface of the plate.
2. **The Radial or Disc Cam :** The cams shown in Figs.1-1,1-14,1-15 and 1-16 belong to this class. The position of the follower is determined by the radial distance from the cam axis. The follower is held in contact by spring, or gravity. The cams shown in Figs.1-7, 1-8 also belong to this class. The difference is only of constraint. In Figs.1-7,1-8 , the follower has positive constraint. The radial type of cams are the most popular because of their simplicity and compactness. The cam shown in Fig.1-7 is also called the yoke cam. The cam shown in Fig.1-8, is conjugate supplementary or double disc cam. In this type, one roller is reloaded against the other. A particular type of radial plate cam used in automobiles, has its contour of radii of circles. The spiral cam shown in Fig.1-9, is a form of face cam having a spiral groove cut in it. Pin gear follower is driven by teeth in the groove; the follower velocity is a function of the radial distance of the groove from the axis of the cam. This cam is used in computers.

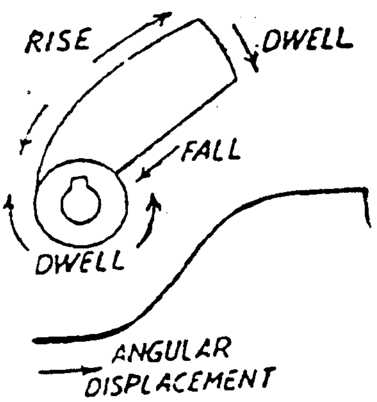

Fig. 1-3 Dwell-rise-dwell cam

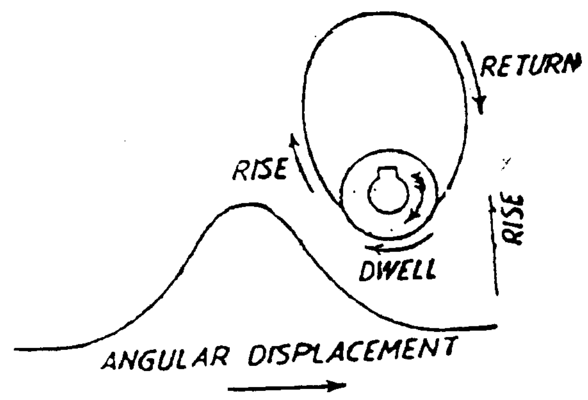

Fig. 1-4 Dwell-rise-return-dwell cam

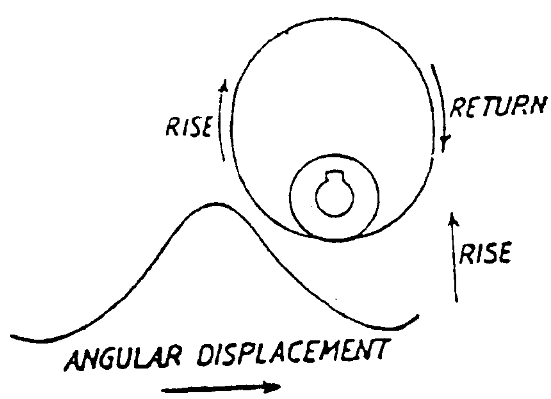

Fig.1-5 Rise-return-rise cam

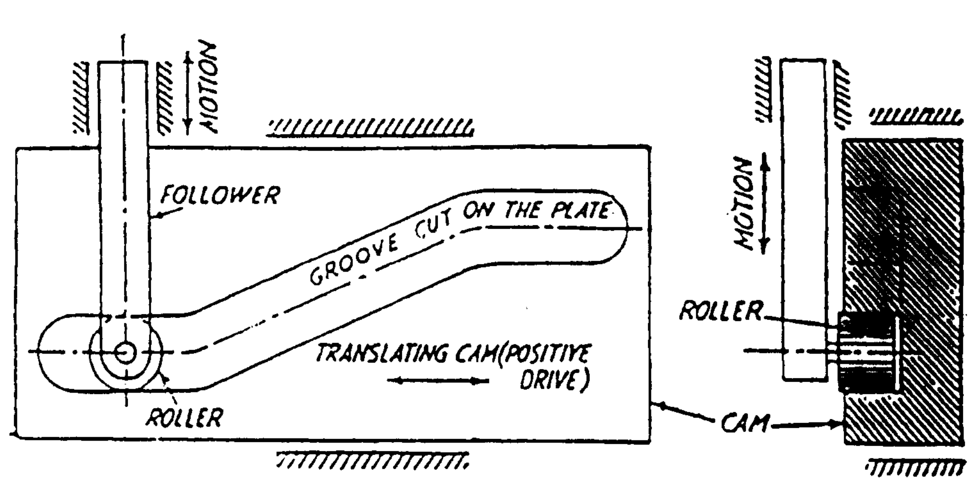

Fig.1-6 Translation wedge or flat cam

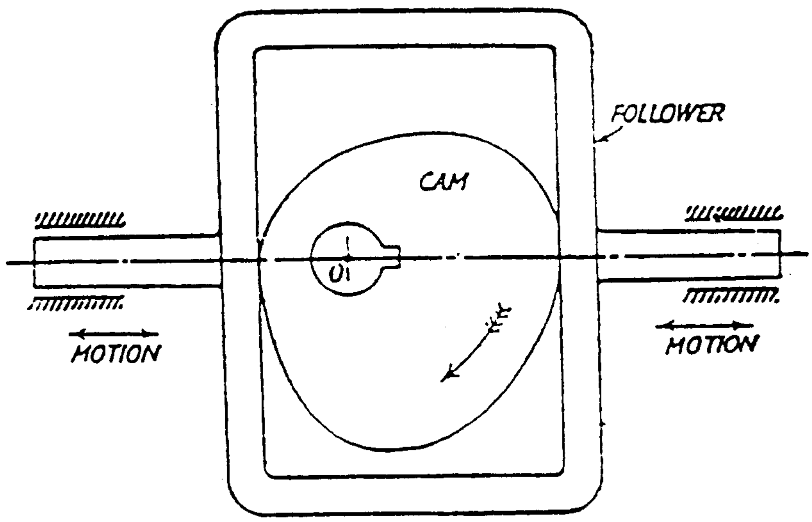

Fig.1-7 Radial or disc cam

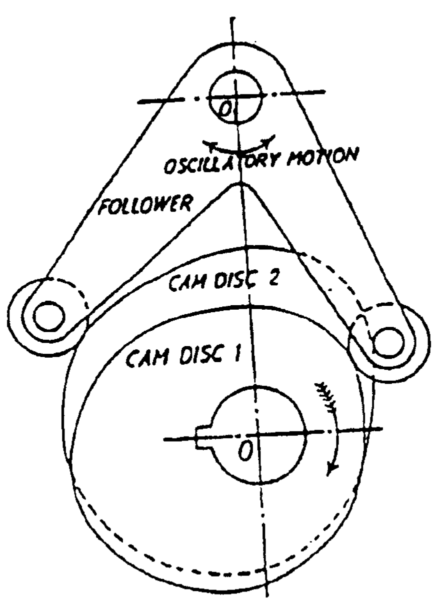

Fig. 1-8 Radial or disc cam with follower has positive constraint

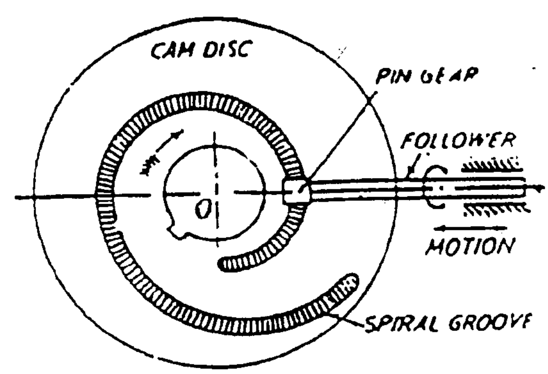

Fig. 1-9 Spiral cam with follower has an oscillatory motion

3. **The Cylindrical, or Drum Cam:** It has a circumferential contour cut in the surface of the cylinder which rotates about its axis. The follower may translate or oscillate in the direction of this axis. Two types of cylindrical cams, one in which the groove is cut on the surface and roller has constrained positive motion; and the other in which the end of the cylinder is the working surface, are shown in Figs. 1-10, 1-11 .
   The follower in Fig.1-10 is having an oscillatory motion and in Fig.1-11 it is having translatory motion.
4. **The Globoidal Cam:** It is similar to the cylindrical cam convex or concave globoids, as shown in Figs.1-12,1-13 replace the cylinder. These cams though of much academic interest have not been popular. These cams are used for indexing and other such purposes.

C-1 Classification based on constraint

1. **Spring Loaded or Pre-Loaded:** In the radial cams of the types shown in Fig.1-14 the follower is to be held by an external force provided by pre-compression of the spring or hydraulic load or gravity. The cylindrical cam shown in Fig.1-11 is also a case of successful constraint.
2. **The Cylindrical Cam:** Shown in Fig.1-11, the globoidal cams shown in Figs.1-12,1-13, the yoke cam are all cases of positive constraint. No external force is required to keep the cam surface in contact.

1-4-2 Types of Followers

The surface of a follower in contact with a cam may have a knife edge, or it may be flat -faced, spherical -faced, or be a roller.

The knife-edge follower is not a practical one because the contact stresses would be infinite; this classification is used only for its theoretical value.

The flat-and spherical-faced followers have similar purposes and are used for relatively steep cam curves and where space is limited.

Rollers for followers are made in standard sizes by many anti friction-bearing manufacturers. These types of followers are illustrated in Fig.1-14.

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MANSOURA UNIVERSITY
FACULTY OF ENGINEERING
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By

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