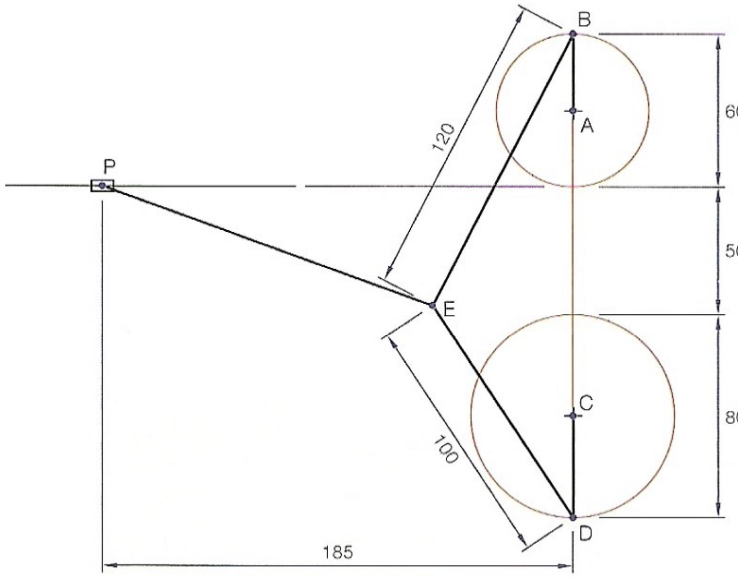


Fig. 17.109

Q10. Fig. 17.109 shows two cranks, AB and CD. AB rotates clockwise and rotates twice for every one revolution of CD, which rotates anti-clockwise. B, D and E are pivot joints and P is a sliding link. Plot the locus of E for one revolution of CD (two revolutions of AB). Draw a displacement diagram for P for the full movement.

Cams

A cam is a shaped component generally used to change rotary movement into linear movement. Cams are used regularly in engine parts and mechanisms. The most usual types are **radial plate cams**. A shaft rotating at uniform speed carries a disk, usually of irregular shape, called the cam. A **follower** presses against the curved surface of the cam, Fig. 17.110. Rotation of the cam causes the follower to move according to the shape of the cam profile. The follower is kept in constant contact with the cam by gravity, or by using a spring. The follower shown in the diagram is a **knife-edge follower**. There are other types of followers which we will look at later on in the chapter. A knife-edge follower can follow very complicated cam shapes but wears rapidly.

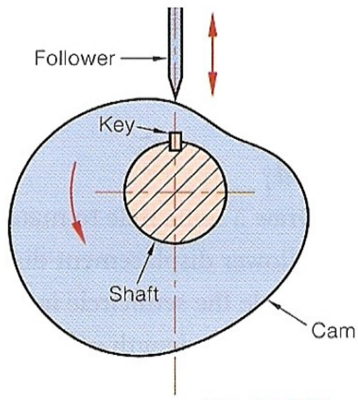


Fig. 17.110

Displacement Diagrams

The movement of the follower is an important consideration in cam design. Its rate of movement and position varies hugely according to the cam profile. A displacement diagram is a means of planning this follower movement before the cam is constructed. It is a graph plotting the movement of the follower for one full revolution of the cam.

Uniform Velocity

The follower rises or falls at a constant speed. The movement will plot as a straight line on a graph.

Uniform velocity gives constant follower speed but produces abrupt changes which may cause the follower to jump. It should be noted that

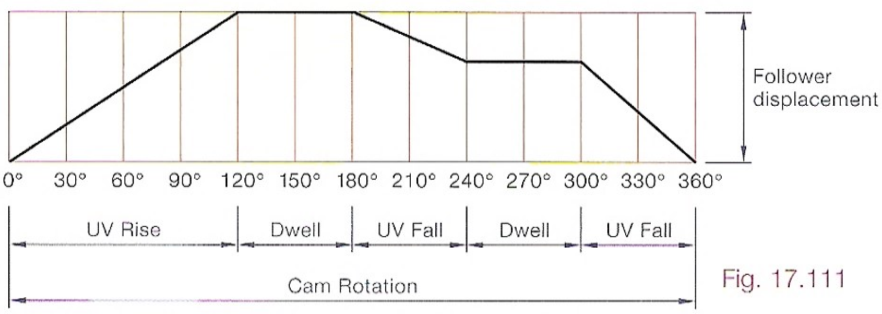


Fig. 17.111

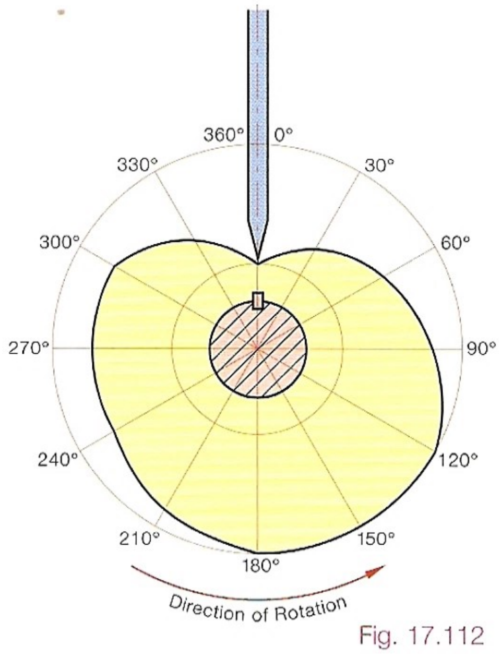


Fig. 17.112

those portions of the cam that give uniform rise or fall to the follower will be portions of Archimedian spirals. When the follower dwells, the cam profile will be a portion of a circle having the same centre as the cam.

Simple Harmonic Motion (SHM)

Simple harmonic motion produces a very gentle transition from one movement to the next. The speed of the follower is not constant. The construction is based on a circle and produces a sine curve on the follower displacement diagram.

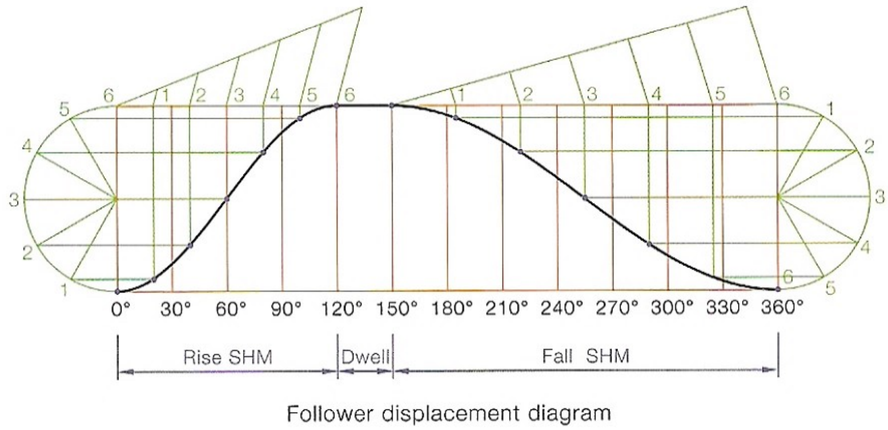


Fig. 17.113

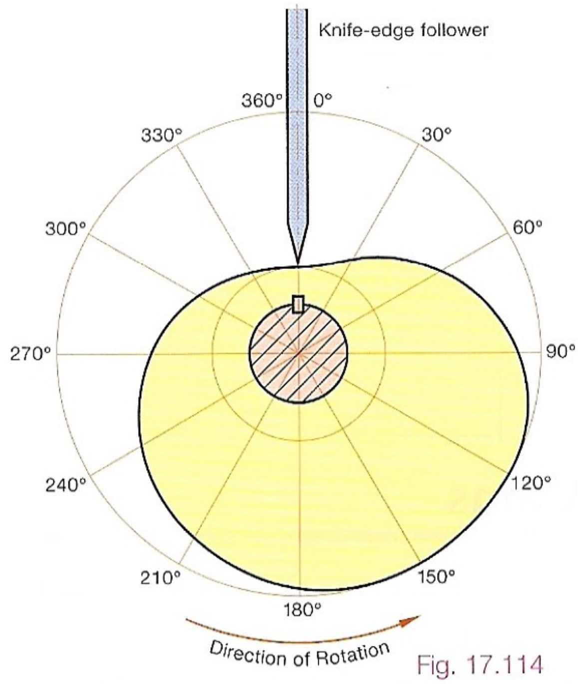


Fig. 17.114

Method

(1) Draw a semicircle to match the rise that is required for the follower. This semicircle is usually placed at the end of the follower displacement diagram.
(2) Divide the semicircle into equal segments, usually six.
(3) Divide the length of rotation it takes for the full movement into the same number of equal parts.
(4) Plot the points as shown in Fig. 17.113.

Uniform Acceleration and Retardation (UAR)

As the name suggests, the follower accelerates smoothly and decelerates smoothly at the start and the end of this movement.

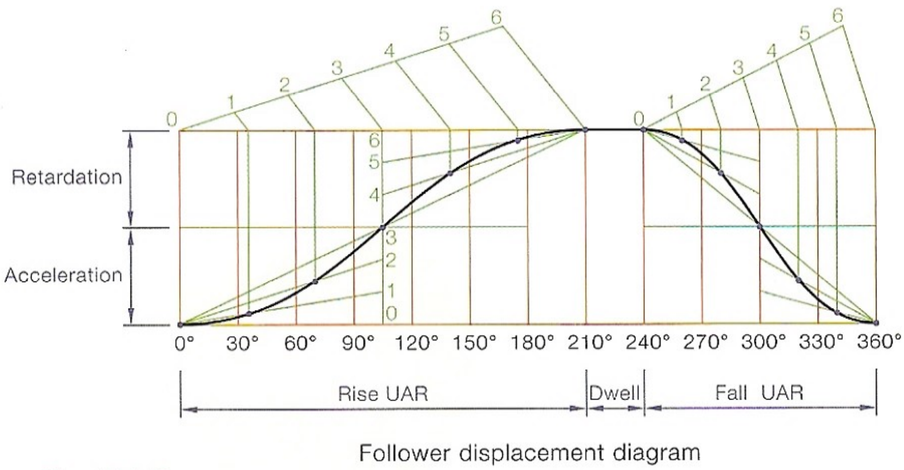


Fig. 17.115

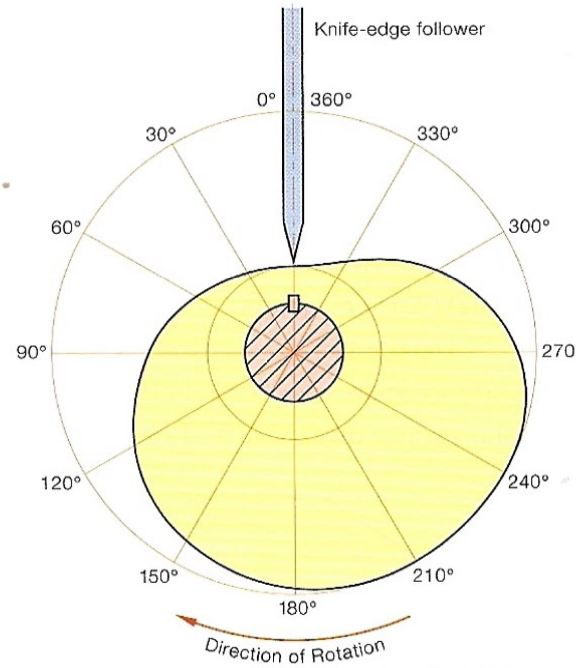


Fig. 17.116

Method

The construction is based on two half parabolas. We use the rectangle method as shown in Fig. 17.115.

Draw the profile of a clockwise cam to give the following displacement to an in-line knife-edge follower:
0° to 120° a UV rise of 36 mm,
120° to 330° a SHM fall of 36 mm,
330° to 360° dwell.
The centre of the cam is 18 mm below the nearest approach of the follower.

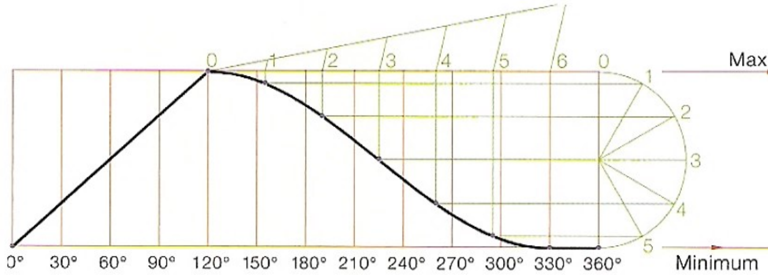
(1) Start by drawing the follower displacement diagram. The height of the graph will be 36 mm. The length of the diagram does not matter but should be easily divisible by twelve.

(2) Project across the top and bottom of the follower displacement diagram. The centre of the cam will be 18 mm below the minimum line.

(3) Draw the maximum and minimum circles and divide them into twelve equal segments.

(4) Index these divisions. Since the cam rotates clockwise the divisions on the circles will be indexed anti-clockwise.

(5) Project each point on a degree line on the follower displacement diagram across to the vertical axis of the cam.



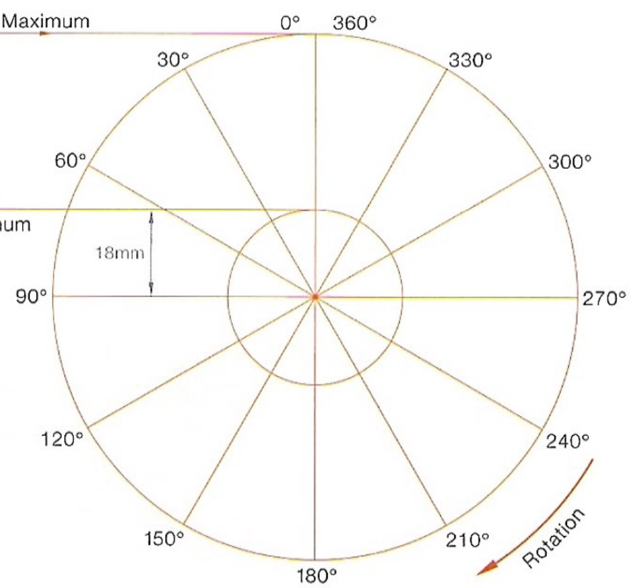
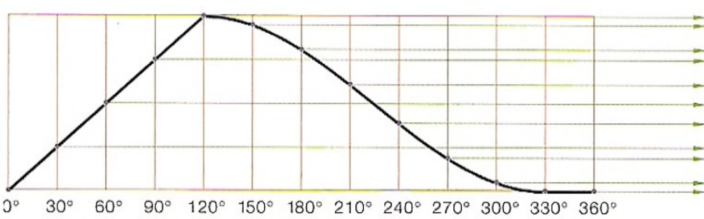


Fig. 17.117

(6) With centre 0, swing each around to the appropriate division on the circle.

(7) Once each point has been found the cam profile is drawn freehand.

(8) Draw in the follower, the shaft and the keyway.



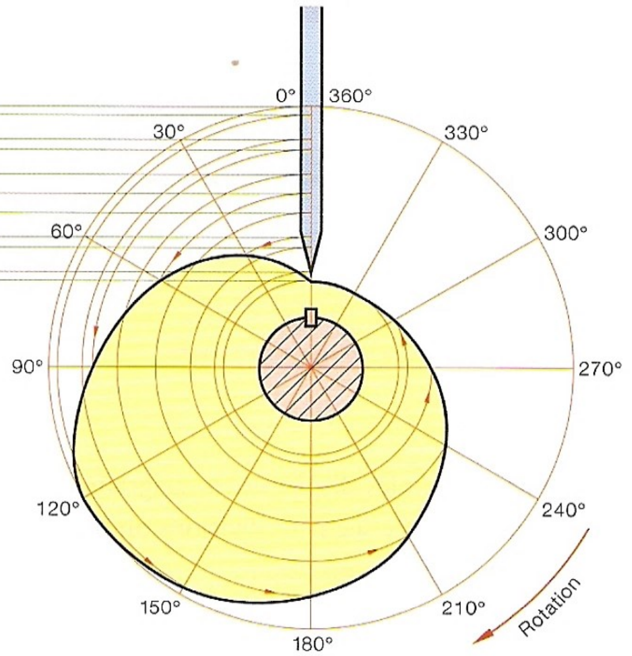


Fig. 17.118

(9) The direction of rotation must be shown.

(10) Divisions can be made smaller than 30° to increase accuracy if required.

Draw the profile of an anti-clockwise cam to give the following displacement to an in-line, knife-edge follower:
0° to 120° simple harmonic rise of 30 mm,
120° to 180° uniform velocity rise of 10 mm,
180° to 330° uniform acceleration and retardation fall of 40 mm,
330° to 360° dwell.
Cam centre 16 mm below nearest approach of the follower.

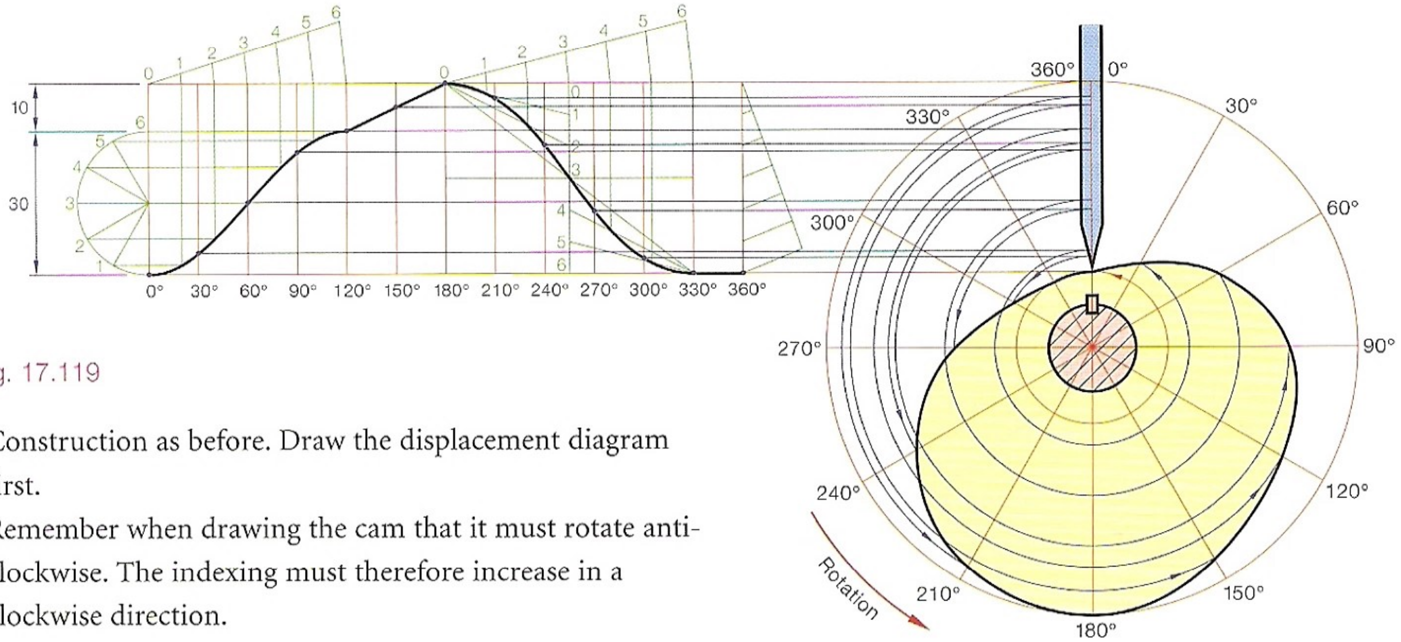


Fig. 17.119

(1) Construction as before. Draw the displacement diagram first.
(2) Remember when drawing the cam that it must rotate anti-clockwise. The indexing must therefore increase in a clockwise direction.

Draw the profile of a clockwise cam to give the following displacement to an in-line, knife-edge follower:
0° to 30° dwell,
30° to 150° uniform acceleration and retardation rise of 30 mm,
150° to 210° uniform velocity fall of 10 mm,
210° to 270° simple harmonic rise of 22 mm,
270° to 360° uniform acceleration and retardation fall of 42 mm.
Cam centre 18 mm below nearest approach of the follower.

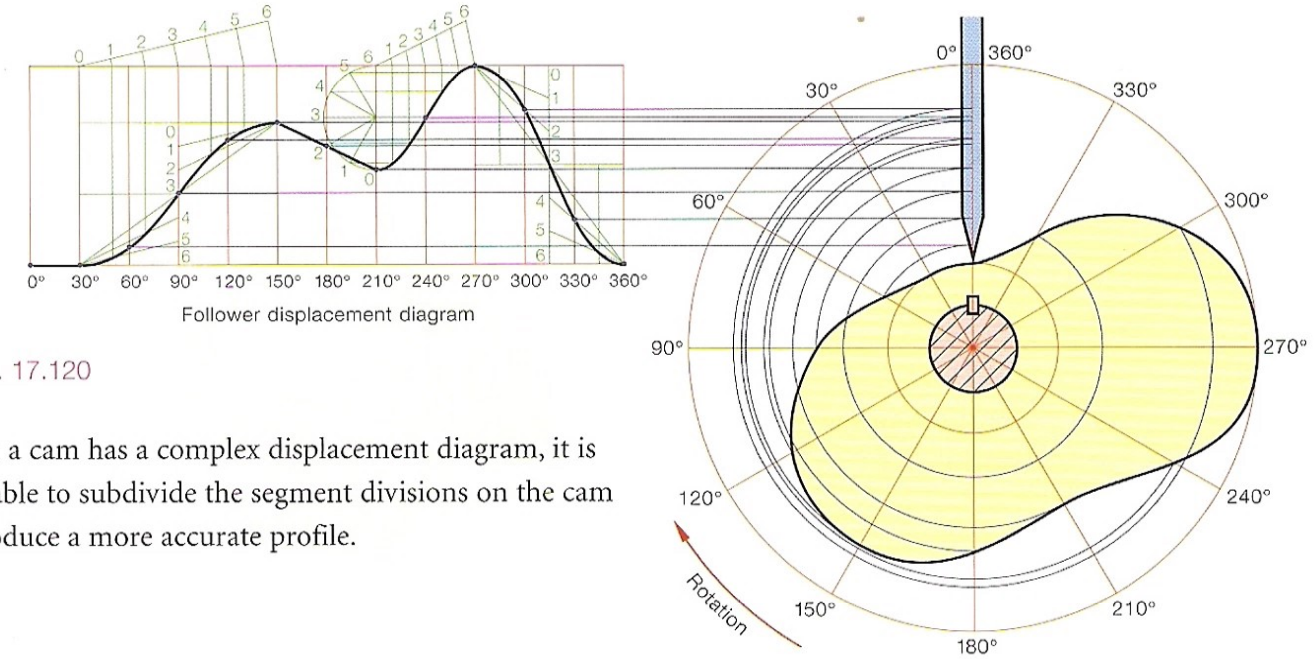


Fig. 17.120

When a cam has a complex displacement diagram, it is advisable to subdivide the segment divisions on the cam to produce a more accurate profile.

Plot the follower displacement diagram for an in-line, knife-edge follower in contact with the cam profile shown in Fig. 17.121.

(1) Draw the cam.
(2) With centre C draw the maximum and minimum displacement circles.
(3) Divide the cam into segments and index.

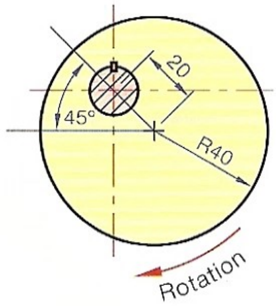


Fig. 17.121

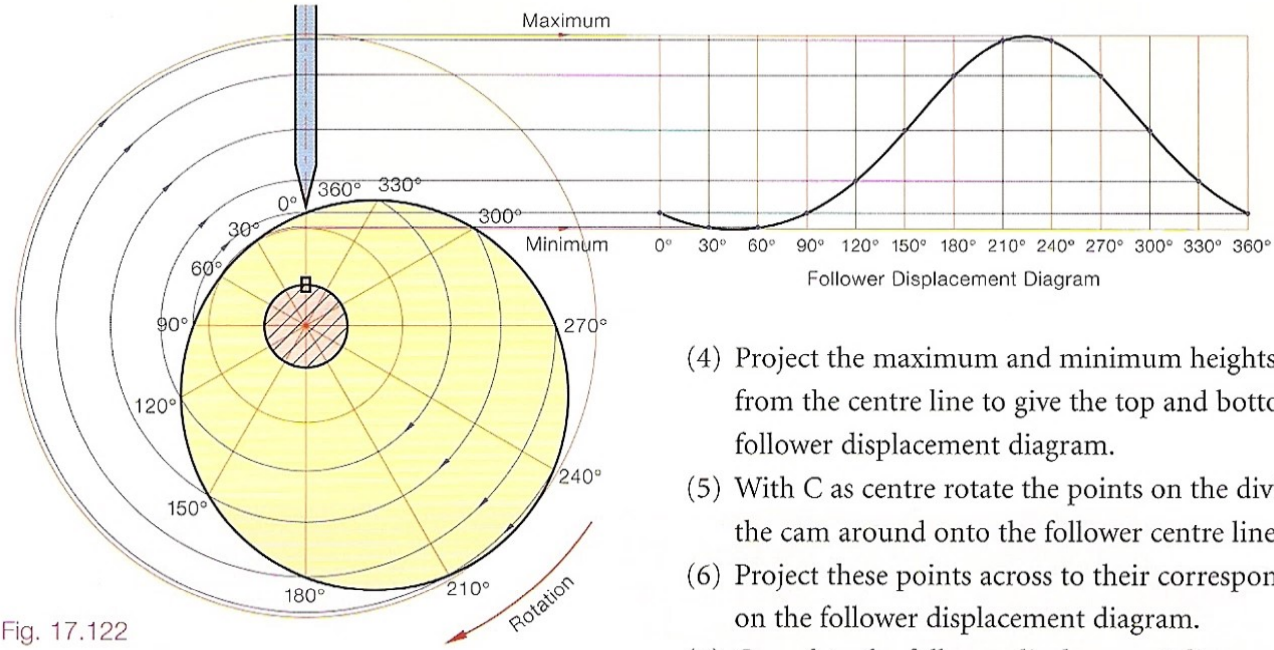


Fig. 17.122

(4) Project the maximum and minimum heights of the follower from the centre line to give the top and bottom lines of the follower displacement diagram.
(5) With C as centre rotate the points on the division lines on the cam around onto the follower centre line.
(6) Project these points across to their corresponding positions on the follower displacement diagram.
(7) Complete the follower displacement diagram by drawing a smooth curve through the points.

Plot the follower displacement diagram for an in-line, knife-edge follower in contact with the cam profile shown in Fig. 17.123.

(1) Draw the cam.
(2) Draw the maximum and minimum circles.

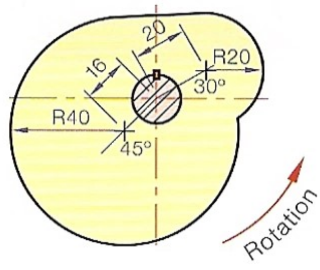


Fig. 17.123

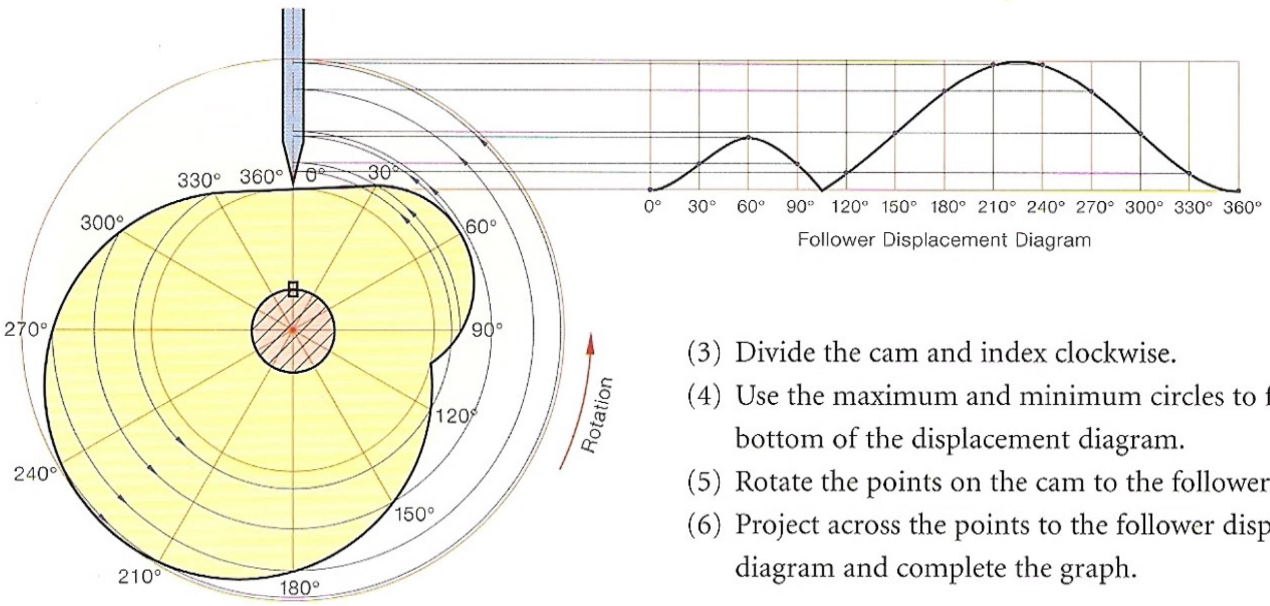


Fig. 17.124

(3) Divide the cam and index clockwise.
(4) Use the maximum and minimum circles to find the top and bottom of the displacement diagram.
(5) Rotate the points on the cam to the follower centre line.
(6) Project across the points to the follower displacement diagram and complete the graph.

HIGHER LEVEL

Other follower types

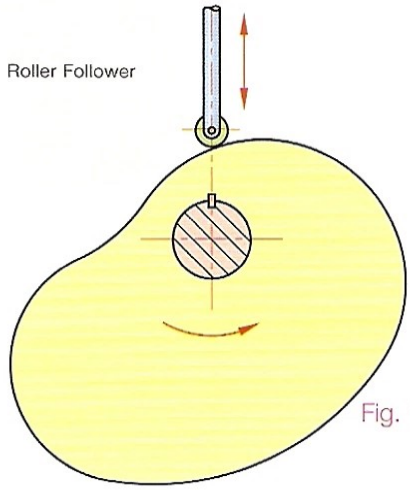


Fig. 17.125

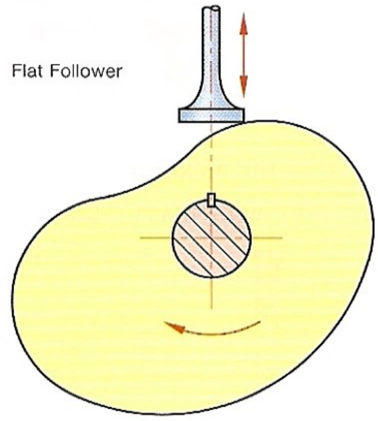
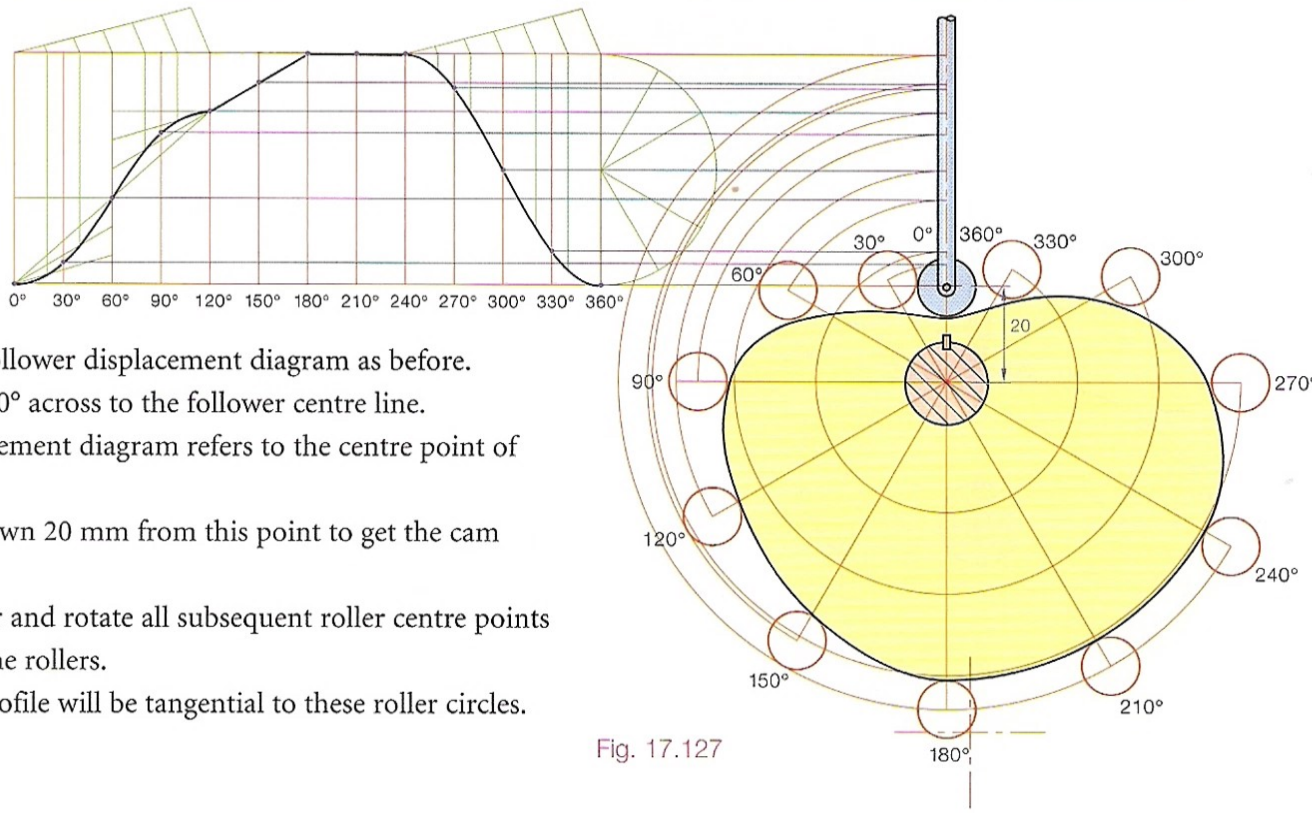


Fig. 17.126

The roller follower wears less quickly than a knife-edge follower.
It is smoother at high speeds.
It cannot follow intricate shapes.

The flat follower wears better than a knife-edge follower.
It can bridge over hollows.

Given the follower displacement data:
0° to 120° uniform acceleration and retardation rise of 36 mm,
120° to 180° uniform velocity rise of 12 mm,
180° to 240° dwell,
240° to 360° simple harmonic motion fall of 48 mm.
The roller follower is in-line and 12 mm in diameter. Rotation of cam is clockwise. The nearest approach of the roller centre to the cam centre is 20 mm.



(1) Draw the follower displacement diagram as before.
(2) Project the 0° across to the follower centre line.
(3) The displacement diagram refers to the centre point of the roller.
(4) Measure down 20 mm from this point to get the cam centre.
(5) Project over and rotate all subsequent roller centre points and draw the rollers.
(6) The cam profile will be tangential to these roller circles.

Fig. 17.127

Given the follower displacement data:
0° to 60° dwell,
60° to 180° SHM rise of 30 mm,
180° to 240° UV rise of 18 mm,
240° to 360° UAR fall of 48 mm.
wer is in-line and flat and extends 6 mm to either side of the centre line. The centre of the cam is 16 m below the nearest approach of the follower. The cam rotates anti-clockwise.

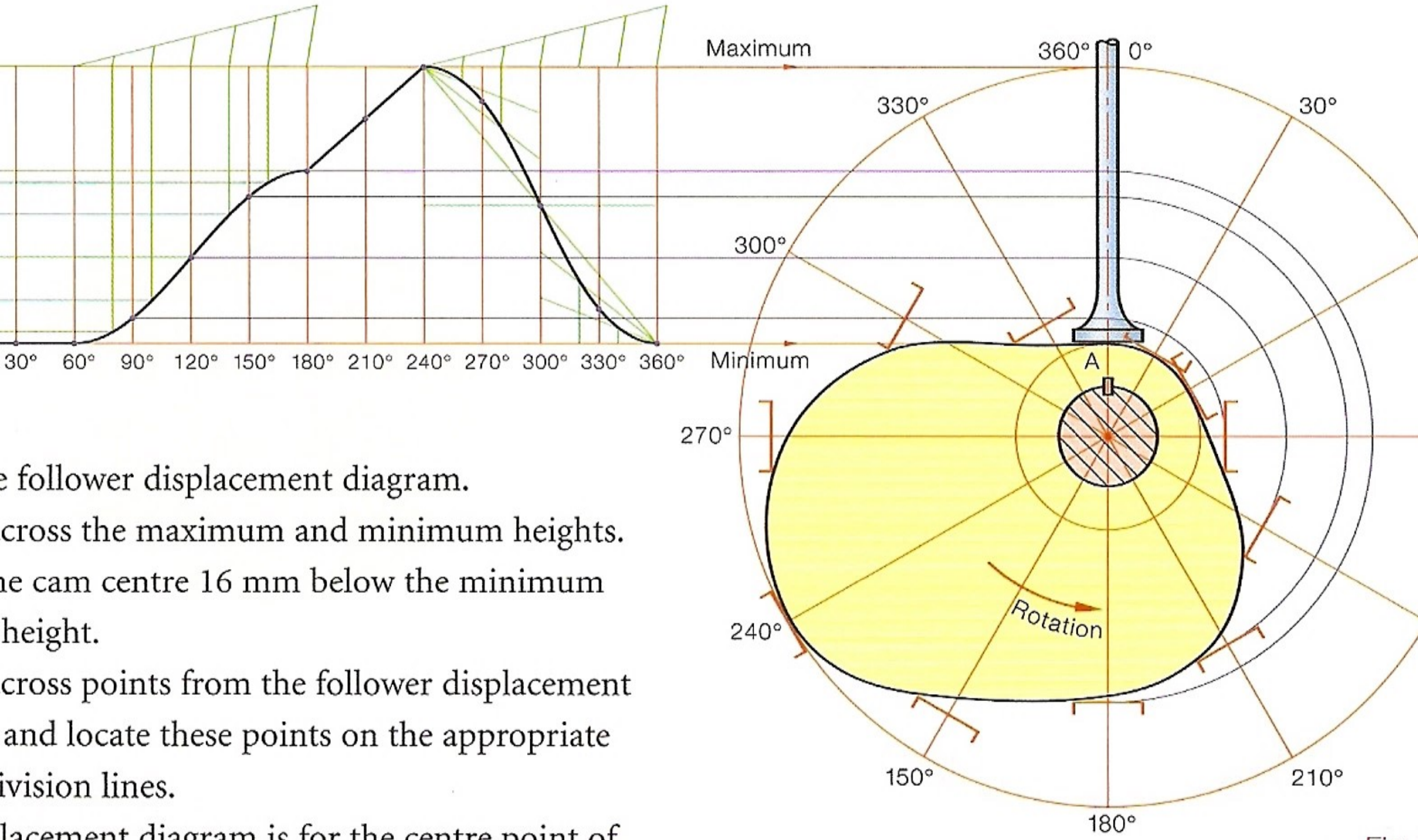


Fig.

e follower displacement diagram.
cross the maximum and minimum heights.
he cam centre 16 mm below the minimum height.
cross points from the follower displacement and locate these points on the appropriate ivision lines.
lacement diagram is for the centre point of of the follower, point A. At each point round the circle draw the follower base as

e cam profile so that the follower touches it ocation.

Given the follower displacement data:
0° to 120° SHM rise of 30 mm,
120° to 180° UV rise of 6 mm,
130° to 360° UAR fall of 36 mm.
In-line roller follower of 12 mm diameter. Cam rotation anti-clockwise. Cam centre 25 mm below the nearest approach of the roller centre. Draw the cam profile.

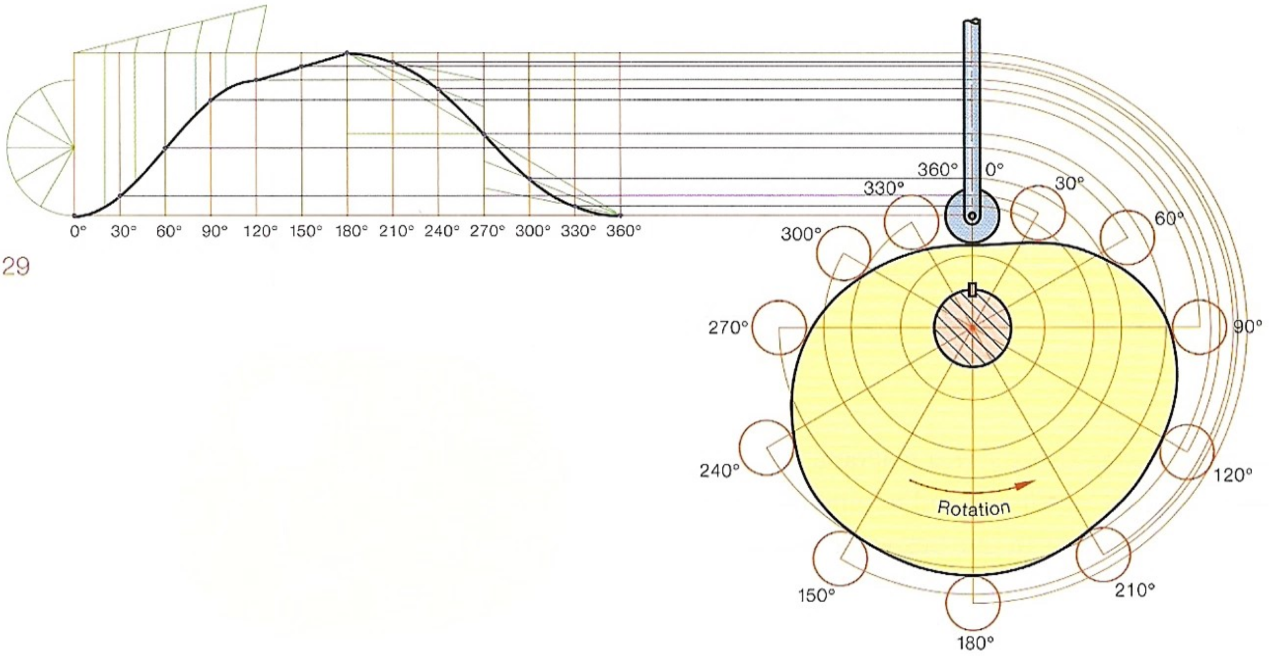


Fig. 17.129

Given the follower displacement diagram as in the previous example.
The follower is in-line, flat and extends 6 mm each side of the centre line.
Cam rotates anti-clockwise.
Cam centre 25 mm below the nearest approach of the follower.
Draw the cam profile.

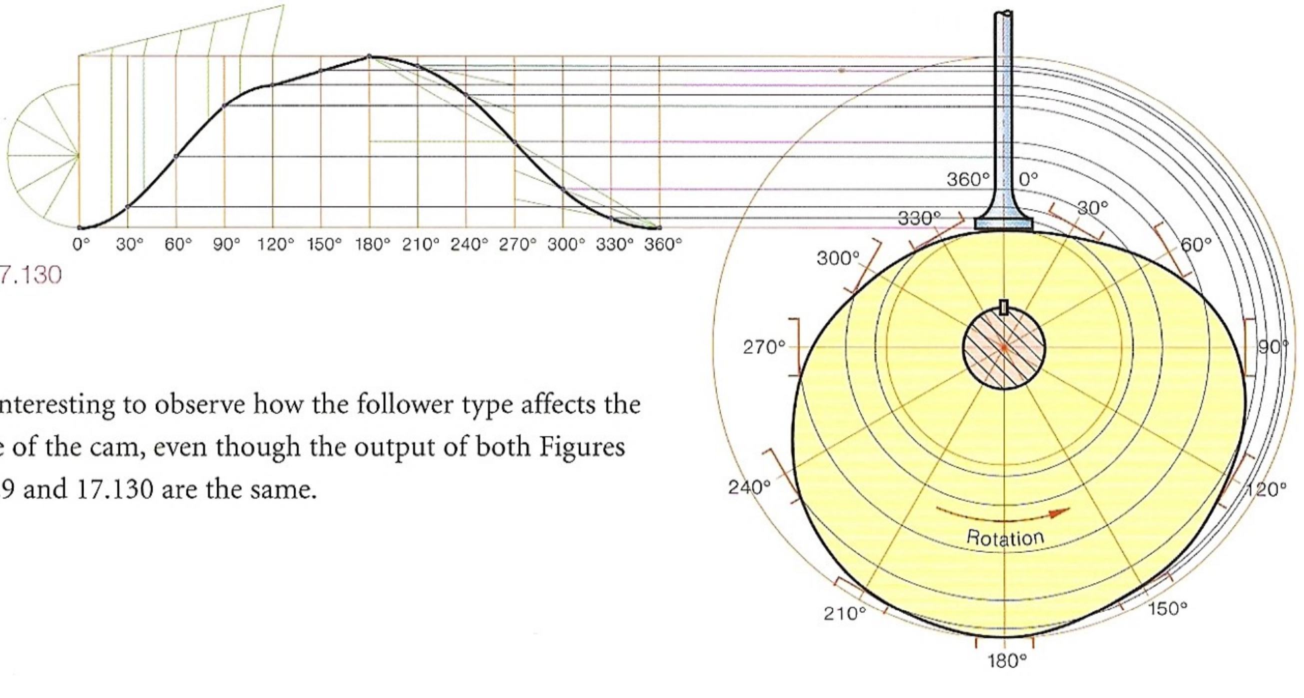


Fig. 17.130

It is interesting to observe how the follower type affects the shape of the cam, even though the output of both Figures 17.129 and 17.130 are the same.

Given the cam profile in Fig. 17.131, construct the follower displacement diagram.
The follower is an in-line roller follower of 16 mm diameter.

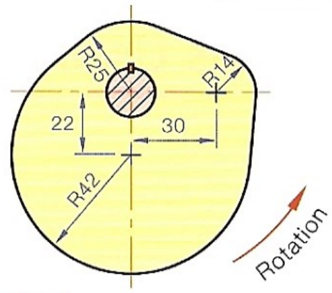


Fig. 17.131

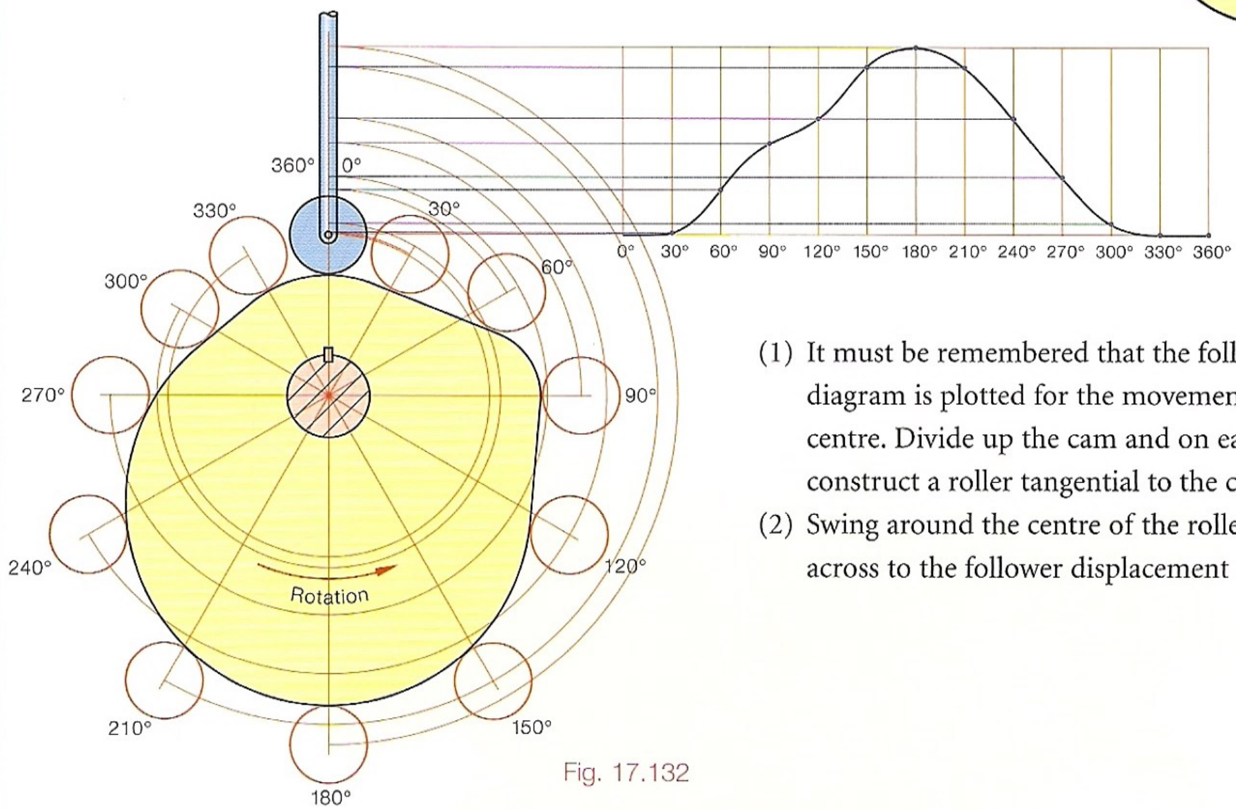


Fig. 17.132

(1) It must be remembered that the follower displacement diagram is plotted for the movement of the roller centre. Divide up the cam and on each division construct a roller tangential to the cam.

(2) Swing around the centre of the roller and project it across to the follower displacement diagram.

Given the cam profile in Fig. 17.132, construct the follower displacement diagram.
The follower is an in-line, flat follower and extends 8 mm each side of the centre line.

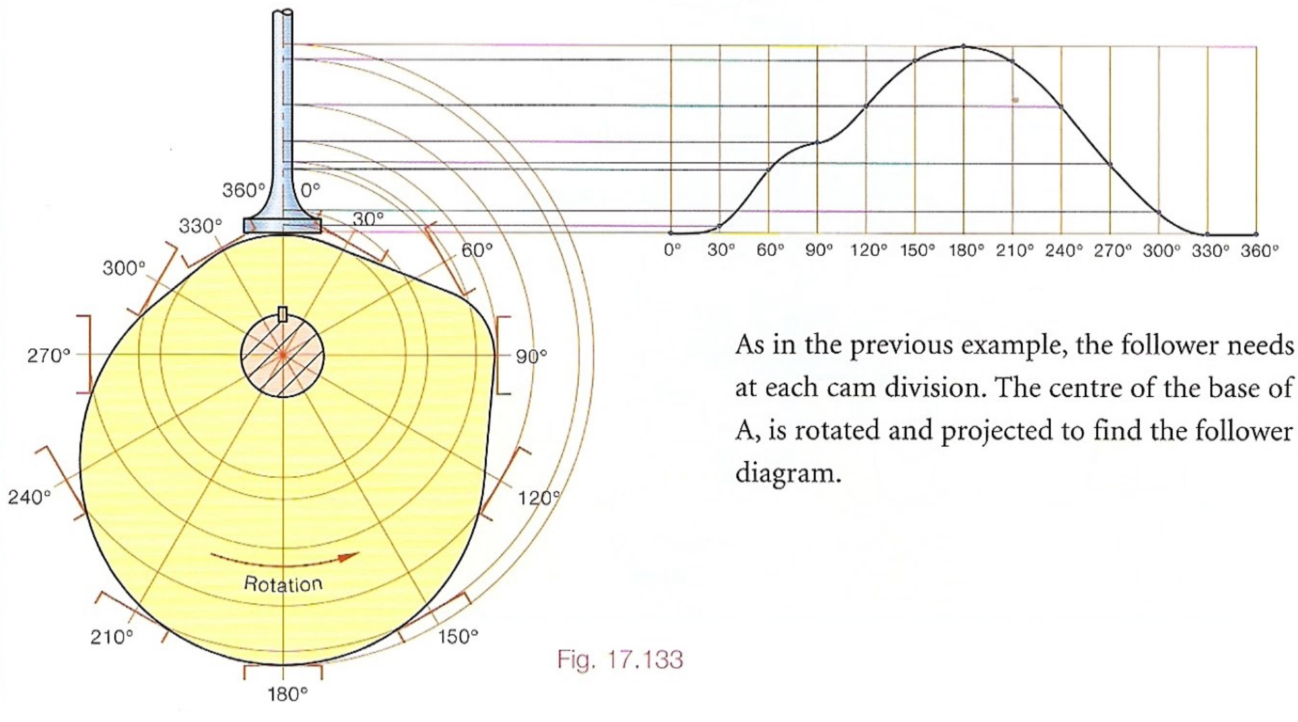


Fig. 17.133

As in the previous example, the follower needs to be drawn at each cam division. The centre of the base of the follower, A, is rotated and projected to find the follower displacement diagram.