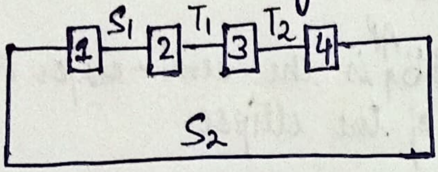
①. Inversion of Double Slider Crank Chain –

→ A Kinematic chain consisting of 4 links and 4 pairs:.
- •) Two turning pairs
- •) Two sliding pairs.

It forms of a closed loop mechanism that can provide complex motion conversions.

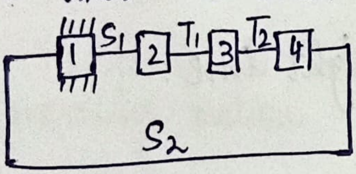
Links in the chain –

Link 1 : Frame (fixed link in first inversion).
Link 2 & 4 : Sliders.
Link 3 : Connecting links.

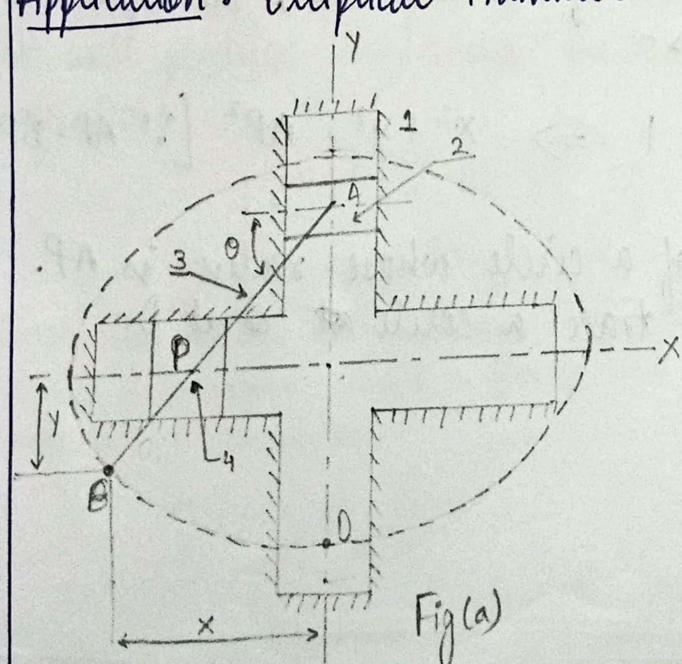


① First Inversion –

It is obtained by fixing link 1.
In this, the two adjacent pairs 2-3 & 3-4 are turning pairs and the other two pairs 1-2 & 1-4 are sliding pairs.



Application : Elliptical Trammel.



Fig(a)

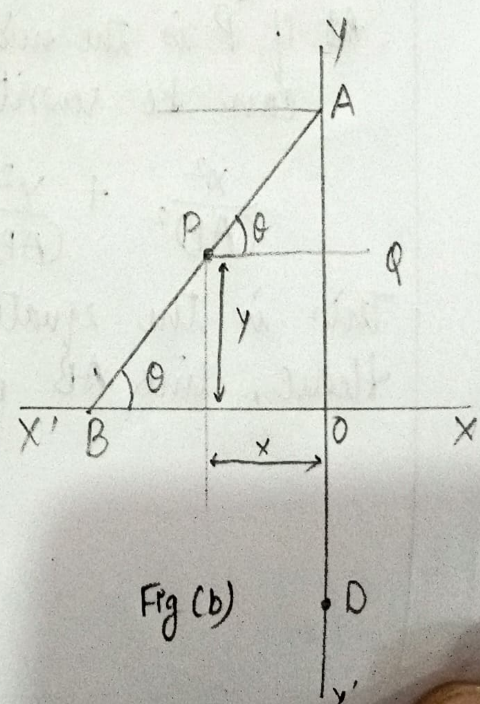


Fig (b)

To prove: The mechanism traces an elliptical path.

As shown in fig (b)

$x = PQ = AP\cos\theta$

$y = PR = BP\sin\theta$

$\Rightarrow \cos\theta = \frac{x}{\cancel{AB}AP}$ & $\sin\theta = \frac{y}{BP}$.

Squaring both sides and adding it –

$$\cos^2\theta + \sin^2\theta = \frac{x^2}{AP^2} + \frac{y^2}{BP^2}.$$

$$\Rightarrow \frac{x^2}{AP^2} + \frac{y^2}{BP^2} = 1. \quad \text{—— (1)}$$

∴ This gives the equation of ellipse.

The above expression proves that ~~AB~~ AP, is the semi-major axis and BP is the semi-major axis of the ellipse

Also,

For A, $x = 0$

$y = AB\sin\theta$

For B, $y = 0$

$x = AB\cos\theta$

Hence, at A and B, it follows a straight line.

Similarly,

If P is the mid-point of the link AB, The equation (1) can be rewritten as –

$$\frac{x^2}{(AP)^2} + \frac{y^2}{(AP)^2} = 1 \Rightarrow x^2 + y^2 = AP^2 \quad [\because AP = BP].$$

This is the equation of a circle whose radius is AP.

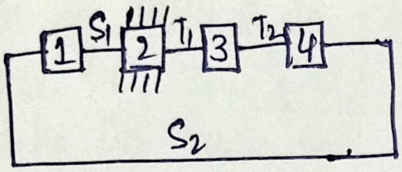
Hence, link AB will trace a circle. ~~at~~ at D.

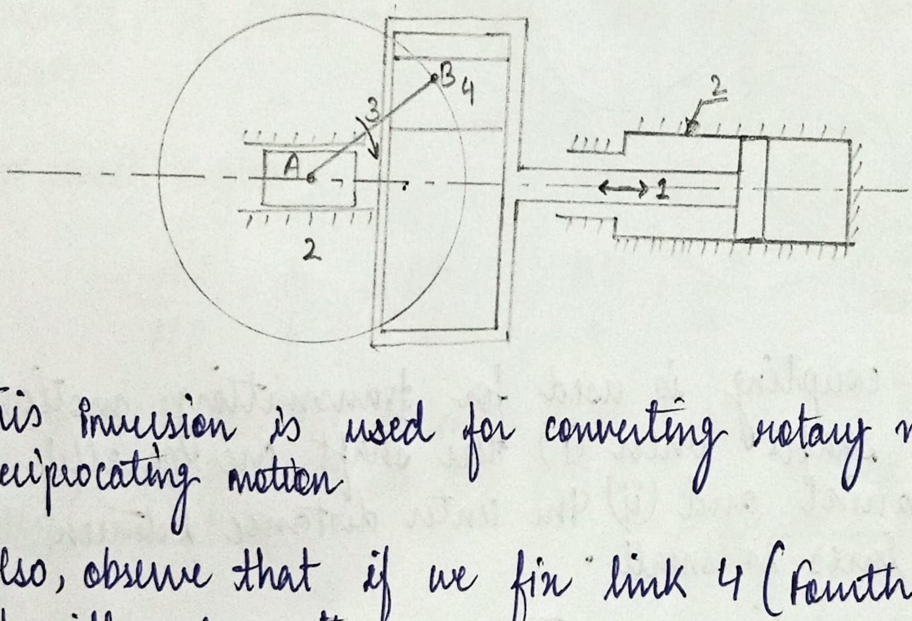
2) Second inversion:

→ Second inversion is obtained by fixing any one of the slider blocks of the first inversion.

→ When link 4 is fixed, end B of crank 3 rotates about A and link 1 reciprocates in the horizontal direction.

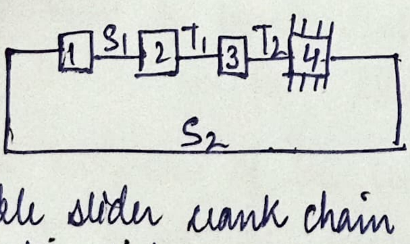
Application: ~~So~~ Scotch Yoke Mechanism.





→ This inversion is used for converting rotary motion into reciprocating motion

Also, observe that if we fix link 4 (fourth inversion), it will produce the same mechanism as discussed ~~bef~~ above.

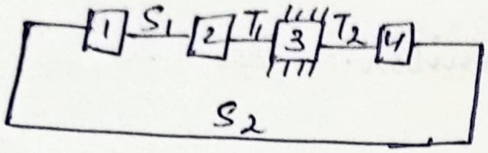


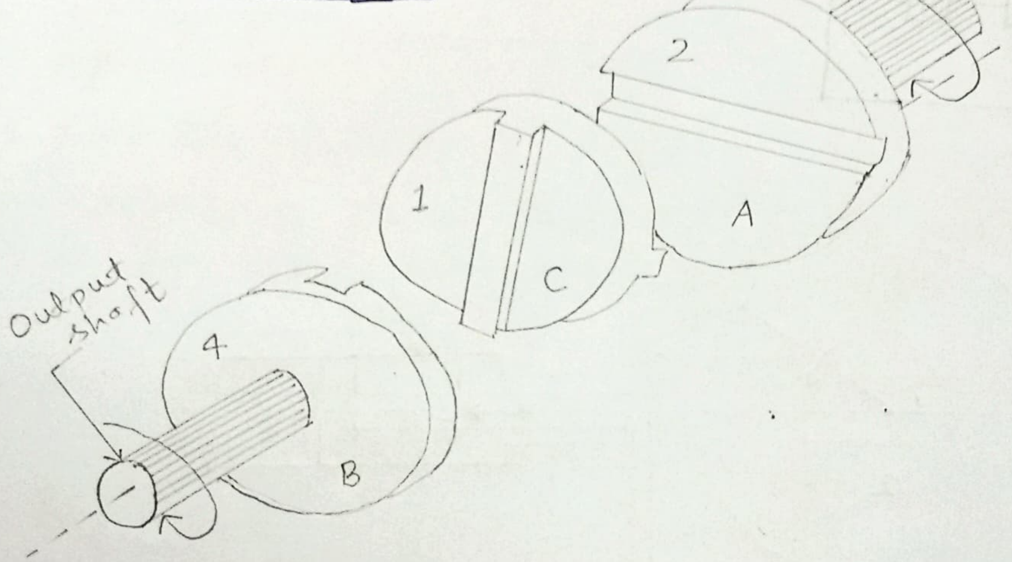
Since, the double slider crank chain is symmetric with respect to its 2 prismatic links, fixing link 1 and link 4 yields congruent mechanism.

(3) <u>Third Inversion</u> -

→ It is obtained by fixing link 3.
→ When link 3 is fixed, link 1 rotates and link 2 and 4 reciprocates

<u>Application</u>: Oldham's Coupling





•) The Oldham's coupling is used for transmitting motion between two shafts when (i) the shaft are parallel but not coaxial and (ii) the center distance between their center lines is small.
The maximum sliding velocity of each tongue along its slot is given by

$$\boxed{V_s = r\omega}$$

) Discuss in detail three approximate straight line motion mechanism.

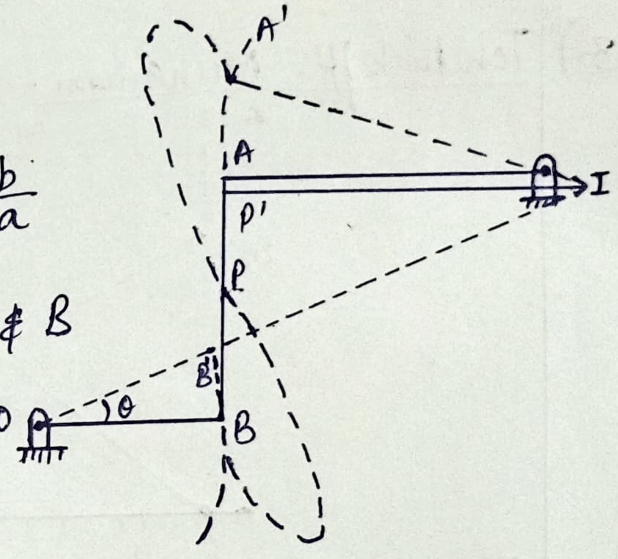
→ Approximate straight line motion mechanisms are linkages that generates a path nearly straight for a certain range of motions without using actual sliding pairs.

→ Three approximate straight line motion mechanism are—

·) Watt's Linkage —

In fig, OBAO is a crossed four bar chain in which O and O_1 are fixed. In the mean position of the mechanisms, links OB and O_1A are parallel and the coupling rod AB is perpendicular to O_1A and OB. The tracing point P traces out an approximate straight line over certain positions of its movement, if $PB/PA = O_1A/OB$. This may be proved as follows—

For small angles—



$$\frac{A'P'}{B'P'} = \frac{\theta}{\phi} = \frac{AA'}{a} = \frac{BB'}{b} = \frac{b}{a}$$

where a, b are the distance from A & B to P, and AA', BB' are the arc displacement.

→ Watt's Mechanism consist of —

·) Two long links of equal length.

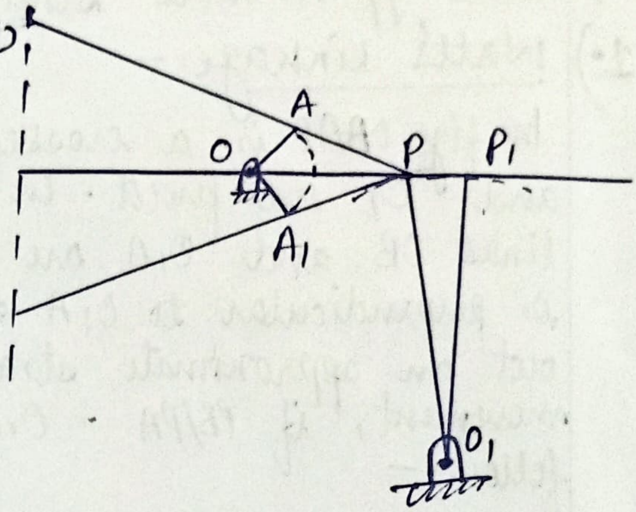
·) A shorter link connecting them (coupler)

~~It traces~~ The midpoint of the coupler is the tracing point whose locus is a special curve known as Watt's curve— a lemniscate ~~of~~ or figure 8 curve.

Grasshopper mechanism —

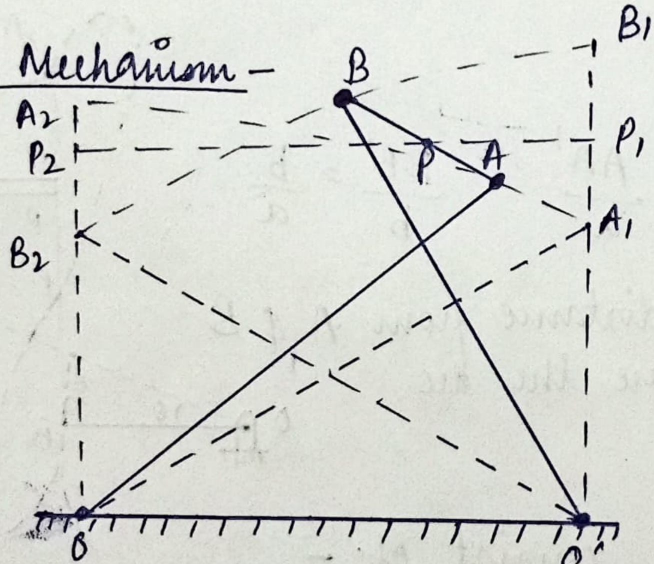
It is a four bar mechanism and all the pairs are turning pairs as shown. In this mechanism, the centers O and O_1 are fixed. The link OA oscillates about O through an angle AOA_1, which causes the pin P to move along a circular arc with O_1 as center and O_1P as radius. For small angular displacements of OP on each side of the horizontal, the point Q on the extension of the link PA traces out an approximately a straight path QQ', if the lengths are such that

$$OA = \frac{(AP)^2}{AQ}.$$



→ Used to guide mechanisms where a long approximate linear motion is required, such as steam engine piston rods. It strengthen its simplicity, making it suitable for practical guides when moderate straightness suffices.

3.) <u>Tchebicheff's Mechanism</u> –



It is a four bar mechanism in which the crossed links OA and O_1B are of equal length. The point P, which is the mid-point of AB traces out an approximately straight line parallel to OO_1. The proportions of the links are, usually, such that point P is exactly above O or O_1 in the extreme positions of the mechanism i.e. when BA lies along OA or when BA lies along ~~BA~~ BO_1. It may be noted that the point P will lie on a straight line parallel to OO_1, in the two extreme positions and in the mid position, if the lengths of the links are in proportions $AB : OO_1 : OA = 1 : 2 : 2.5$!