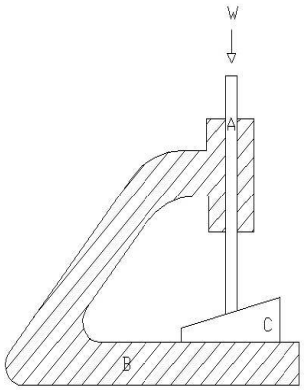
Machine

It is a combination of resistant bodies with successfully constrained motion which is used to transmit or transform motion to do some useful work. E.g.: Lathe, Shaper, Steam Engine, etc.

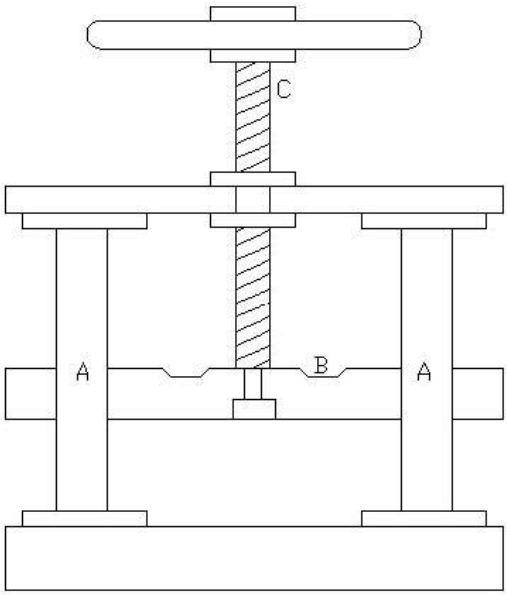
- ***Kinematic chain with three lower pairs***

It is impossible to have a kinematic chain consisting of three turning pairs only. But it is possible to have a chain which consists of three sliding pairs or which consists of a turning, sliding and a screw pair.

The figure shows a kinematic chain with three sliding pairs. It consists of a frame B, wedge C and a sliding rod A. So the three sliding pairs are, one between the wedge C and the frame B, second between wedge C and sliding rod A and the frame B.



This figure shows the mechanism of a fly press. The element B forms a sliding with A and turning pair with screw rod C which in turn forms a screw pair with A. When link A is fixed, the required fly press mechanism is obtained.



2. Kutzbach criterion, Grashoff's law

Kutzbach criterion:

- **Fundamental Equation for 2-D Mechanisms:** $M = 3(L - 1) - 2J_1 - J_2$
  Can we intuitively derive Kutzbach's modification of Grubler's equation? Consider a rigid link constrained to move in a plane. How many degrees of freedom does the link have? (3: translation in x and y directions, rotation about z-axis)
- If you pin one end of the link to the plane, how many degrees of freedom does it now have?
- Add a second link to the picture so that you have one link pinned to the plane and one free to move in the plane. How many degrees of freedom exist between the two links? (4 is the correct answer)
- Pin the second link to the free end of the first link. How many degrees of freedom do you now have?
- How many degrees of freedom do you have each time you introduce a moving link? How many degrees of freedom do you take away when you add a simple joint? How many degrees of freedom would you take away by adding a half joint? Do the different terms in equation make sense in light of this knowledge?

Grashoff's law:

- **Grashoff 4-bar linkage:** A linkage that contains one or more links capable of undergoing a full rotation. A linkage is Grashoff if: $S + L < P + Q$ (where: S = shortest link length, L = longest, P, Q = intermediate length links). Both joints of the shortest link are capable of 360 degrees of rotation in a Grashoff linkages. This gives us 4 possible linkages: crank-rocker (input rotates 360), rocker-crank-rocker (coupler rotates 360), rocker-crank (follower); double crank (all links rotate 360). Note that these mechanisms are simply the possible inversions (section 2.11, Figure 2-16) of a Grashoff mechanism.
- **Non Grashoff 4 bar:** No link can rotate 360 if: $S + L > P + Q$

Let's examine why the Grashoff condition works:

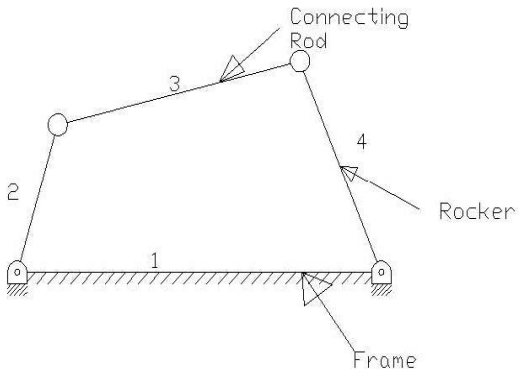
- Consider a linkage with the shortest and longest sides joined together. Examine the linkage when the shortest side is parallel to the longest side (2 positions possible, folded over on the long side and extended away from the long side). How long do P and Q have to be to allow the linkage to achieve these positions?
- Consider a linkage where the long and short sides are not joined. Can you figure out the required lengths for P and Q in this type of mechanism

3. Kinematic Inversions of 4-bar chain and slider crank chains:

- ***Types of Kinematic Chain:*** 1) Four bar chain 2) Single slider chain 3) Double Slider chain

- **Four bar Chain:**

The chain has four links and it looks like a cycle frame and hence it is also called *quadric cycle chain*. It is shown in the figure. In this type of chain all four pairs will be turning pairs.



- **Inversions:**

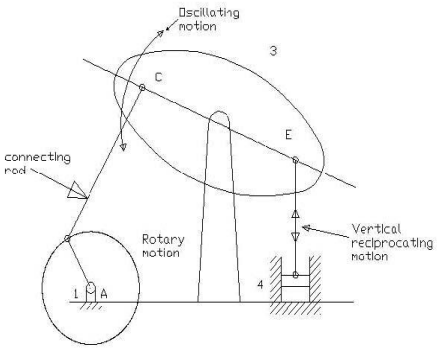
By fixing each link at a time we get as many mechanisms as the number of links, then each mechanism is called 'Inversion' of the original Kinematic Chain.

Inversions of four bar chain mechanism:

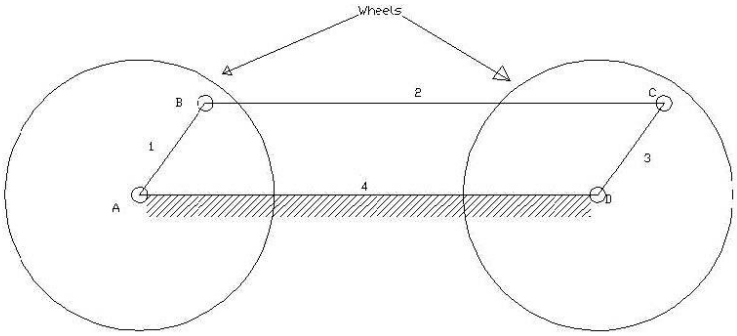
There are three inversions: 1) Beam Engine or Crank and lever mechanism. 2) Coupling rod of locomotive or double crank mechanism. 3) Watt's straight line mechanism or double lever mechanism.

- **Beam Engine:**

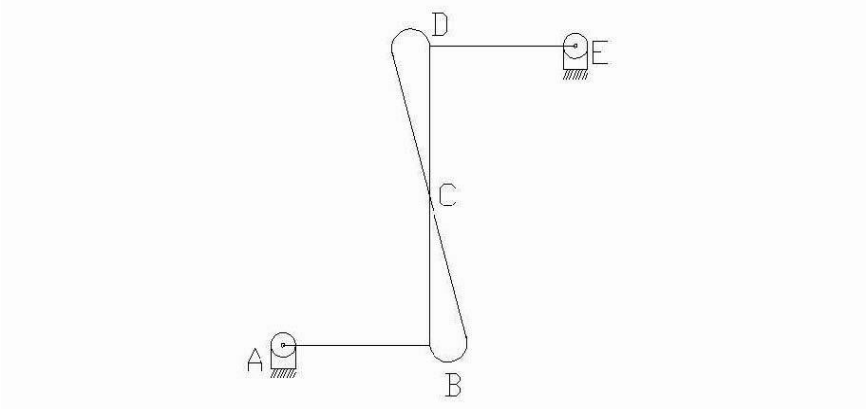
When the crank AB rotates about A, the link CE pivoted at D makes vertical reciprocating motion at end E. This is used to convert rotary motion to reciprocating motion and vice versa. It is also known as Crank and lever mechanism. This mechanism is shown in the figure below.



- **2. Coupling rod of locomotive:** In this mechanism the length of link AD = length of link C. Also length of link AB = length of link CD. When AB rotates about A, the crank DC rotates about D. this mechanism is used for coupling locomotive wheels. Since links AB and CD work as cranks, this mechanism is also known as double crank mechanism. This is shown in the figure below.



- 3. **Watt's straight line mechanism or Double lever mechanism:** In this mechanism, the links AB & DE act as levers at the ends A & E of these levers are fixed. The AB & DE are parallel in the mean position of the mechanism and coupling rod BD is perpendicular to the levers AB & DE. On any small displacement of the mechanism the tracing point 'C' traces the shape of number '8', a portion of which will be approximately straight. Hence this is also an example for the approximate straight line mechanism. This mechanism is shown below.



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