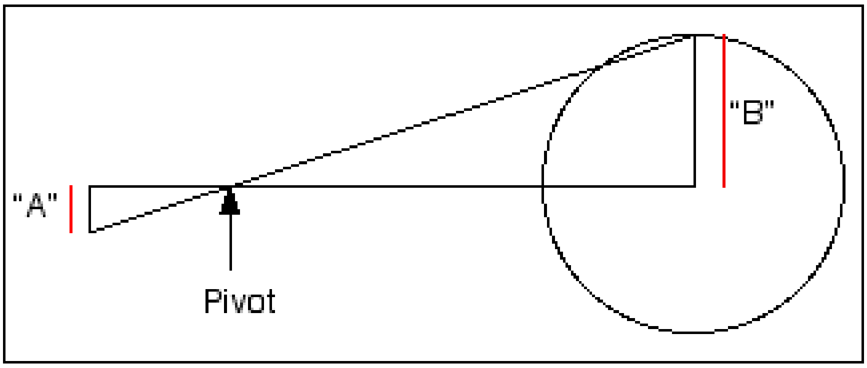
The DIY Oscillator locomotive engine

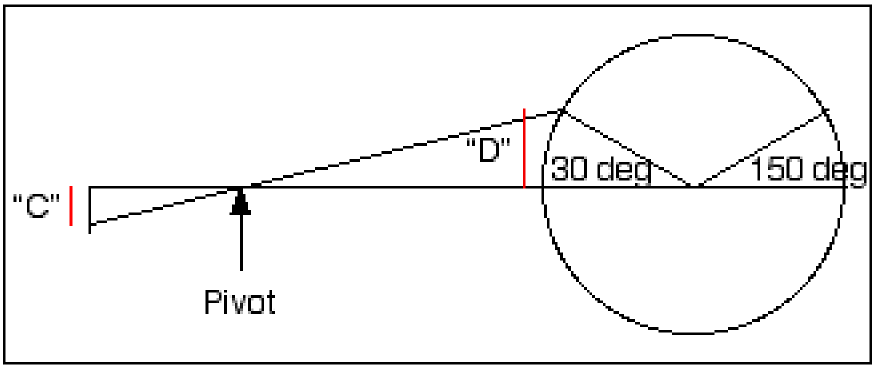
In this worked example we will go through; The Maths Required ,The Design Constraints, to produce, A Design -for a locomotive engine.

Part 1 -The Maths Required.

In an oscillator engine the opening and closing of the ports is determined by the ANGLE that the cylinder is to the crankshaft. This means that the maximum separation of any port can be determined by calculation or scale drawing. The length of the throw of crankshaft and the distance from the pivot to the centre of the crank define **2** of the **3** sides of a right angle triangle...



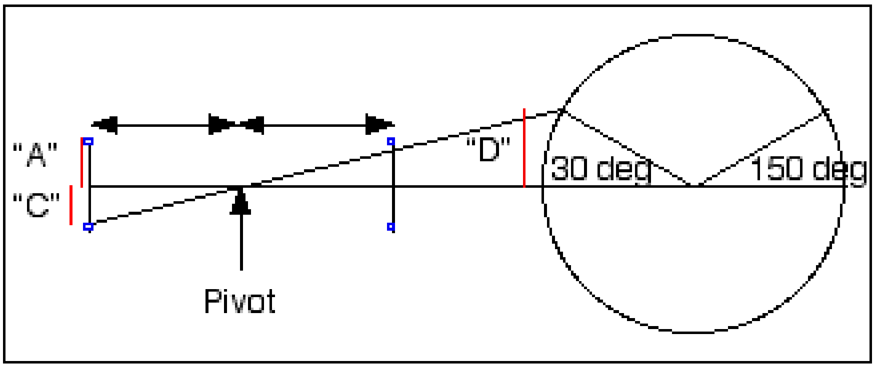
In the drawing above the distance “A” is directly proportional to the throw of the crankshaft “B”. Therefore the OUTSIDE edge of the port can be no further than “A” from the centre line. The cylinder has to fill and exhaust once per revolution. This does of course mean that there has to be a “blank spot” between the inlet port on the face of the mounting block. The size of this “blank spot” determines the maximum size of the ports for the cylinder -as it is the movement of the cylinder across the mounting block that causes the opening and closing the ports.



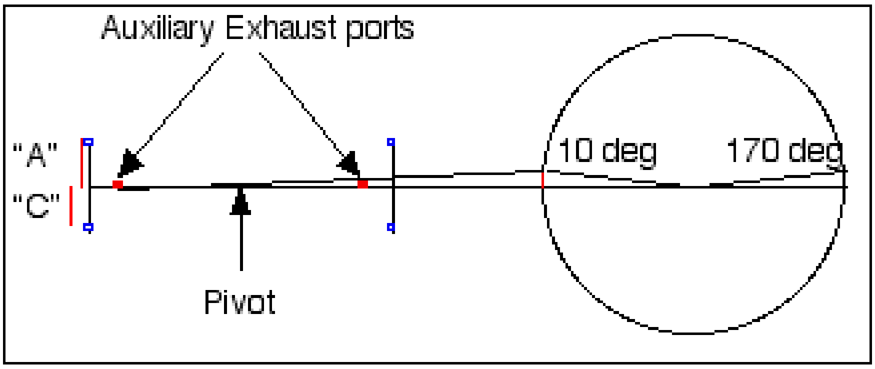
Since it would be impossible to have 180 deg of admission and exhaust it has become the standard to set admission at between 30 degrees and 150 degrees -thus giving 120 degrees of admission. As above the distance “C” is directly proportional to “D”. Thus “C” gives the INSIDE edge of the port.

The difference between “A” and “C” gives you the maximum port size for your cylinder.

Ideally the cylinder should be “double acting”. This means that whilst the admission of steam is occurring on one side of the piston exhaust of steam is occurring on the other. By taking the dimensions already drawn the locations of the 4 ports can be worked out by simple reflection of the distances from the pivot.



Although it is not possible to achieve 180 degrees of exhaust with a simple two port system -it **is** possible to achieve l**onger periods of exhaust** using an **third** auxiliary exhaust port operating between the closing of the inlet port and the opening of the exhaust port proper. This must be located in a position far enough from the stroke of the piston so that the piston does not block it at full reach and close enough to the two other ports for ease of access. The position and size of them can be drawn or calculated in the manner above. They should be open during the period of 0 degrees to10 degrees.



Thus the complete cycle is as follows and this is classed as a **Semi-Uniflow** operation.

0 to 10	auxiliary exhaust port vents
10	auxiliary exhaust port closes
10 to 30	all ports sealed
30	admission port opens
30 to 150	admission port vents
150	admission port closes
150 to 170	all ports sealed
170	auxiliary exhaust port opens
170 to 190	auxiliary exhaust port vents
190	auxiliary exhaust port closes
190 to 210	all ports sealed
210 to 330	exhaust port open
330	exhaust port closes
330 to 350	all ports sealed
350	auxiliary exhaust port opens
350 to 360	auxiliary exhaust port vents

Part 2 -The Design Constraints.

The **P**rimary **D**esign **C**onstraints (PDC) may listed as follows:

A: Length of stroke.
B: Bore of cylinder.
C: Pressure of steam.
D: Space between chassis rails and axles

Target application for this motor would be driving the centre axle of an 0-6-0 or similar loco.

Analysis

A: Breaking it down still further -a survey of available driving wheels shows that a normal stroke would be around 25mm. Longer then this would not be useful.

B: A wider bore cylinder would compensate for the short stroke. From a design aspect a “square” engine (i.e. bore+stroke are equal) would provide a better compromise at the expense of using more steam. However a wide bore cylinder requires more steadying -and the size of a rigid pivot will limit this.

C: High pressure steam means thicker pipe work and boiler work. It would therefore be better to design an engine to use lower pressure steam with pipe work and boiler work that could be easily fabricated from common commercial sizes. Since 1.6mm copper is a very common thickness the maximum working pressure of a boiler made with it would be 4 Bar. So, the usable pressure would be lower and it would be reasonable if we take 3 Bar as the maximum pressure fed to our cylinder.

D: This can be defined as an area 50mm wide and 155mm long -assuming an axle separation of 80mm. Into this space we have to squeeze; two double acting cylinders, a central crank shaft -and a bed plate to mount it all on...

The **S**econdary **D**esign **C**onstraints (SDC) may be listed as follows:

A: Suitable materials.
B: Ease of sourcing.
C: Manufacture.
D: Additional tooling required.

Analysis

A: The common materials used are steel and brass. The problem with brass and steel is water... Normal brass with suffer “De-Zincification” in the presence of ionic water as the zinc dissolves into it. Steel of course rusts... However steam is not an ionic solvent and thus De-Zincification will not occur -thus we **could** use brass for our cylinder. Bronze would be better -but would be more expensive.

Stainless steel does not rust -but is somewhat difficult to work with. This would have to be used for the piston rods -however we could use mild steel for the rest of the construction.

The piston rings and gland seals traditionally would have been made of graphited hemp cord. If we fit a displacement lubricator to the steam supply then we could use modern Flouro Silicone Rubber “O” rings.

Given the ease of use there is no reason why the engine should not be fitted with ball races -this will save on bushes and reaming.

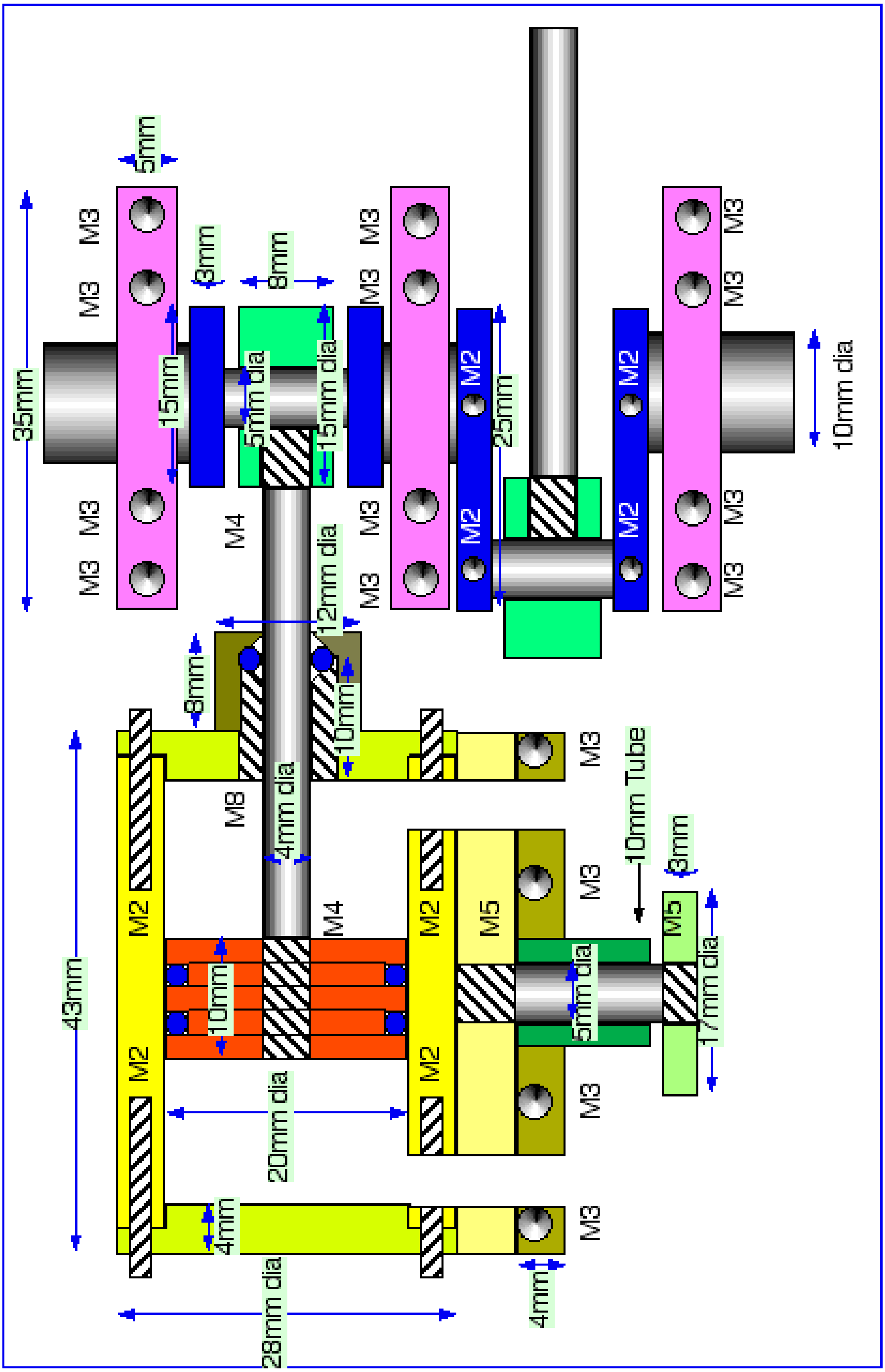
B: From the results of the PDC(B) and the fact that we intend to have a braced pivot means that we can go to fairly large bores, but the available sizes of bar to make the cylinder and piston from -limit this. 28mm is a std size of both brass and bronze bar and 20mm is as well. This would give us a 4mm thick cylinder wall, ample for the job, and it can be drilled for M2 studs to take the end plates of the cylinder. 4mm stainless steel rod is cheap and a commonly held size, 5mm and 10mm mild steel bar will provide the cranks and journal webs. 6mm thick slab steel will provide the bed plate and the pillow blocks for the crank bearings.

C: The engine would require the use of a lathe, a milling machine and rotary table.

D: Boring bars, M2 taps/dies, M4 taps/dies, M5 taps/dies, M8 taps/dies etc!

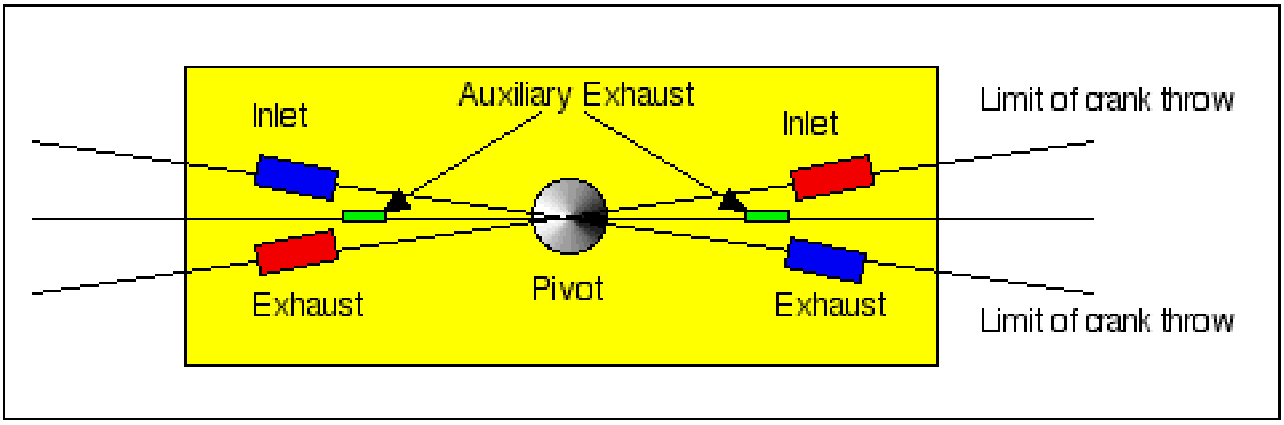
Part 3 -A Design.

A typical design would have two cylinders offset from each other and “quartered” for optimum starting.

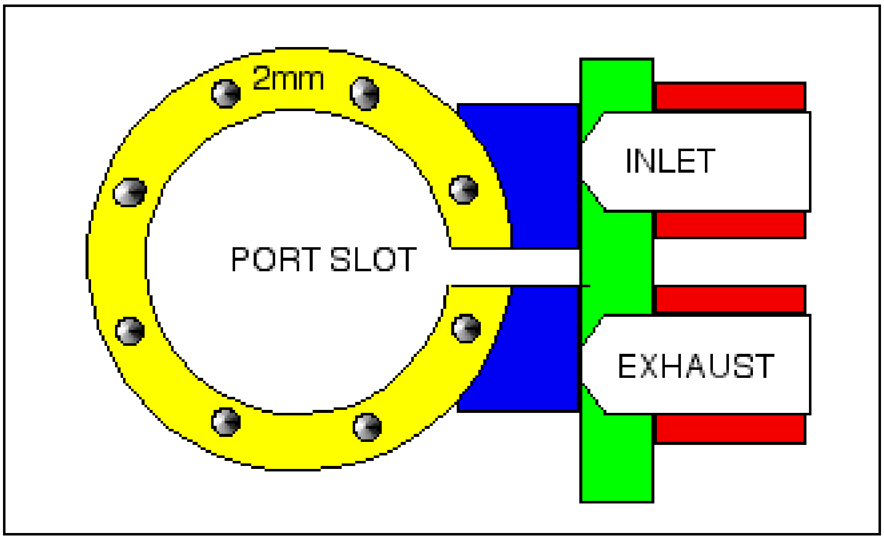


Only one half of the design is shown here for reasons of space.

The pillow blocks are secured to the base plate with M3 studs. The crankshaft is made from 3mm thick mild steel and is “pinned” with 2mm steel studs. The piston has 2 “O” rings and is 10mm thick. It screws onto the piston rod before being silver soldered there. The ports for the cylinder are in fact slots. Ideally they should be angled to align with the angle of oscillation...



Some thought should be given to the shape of the rear of the ports in the mounting block. These should be wider at the joint of the pipework to allow faster inlet and egress of steam.



When “springing” the face plate of the cylinder to the mounting block only sufficient tension should be used to seat the surfaces together -any more will induce frictional losses.