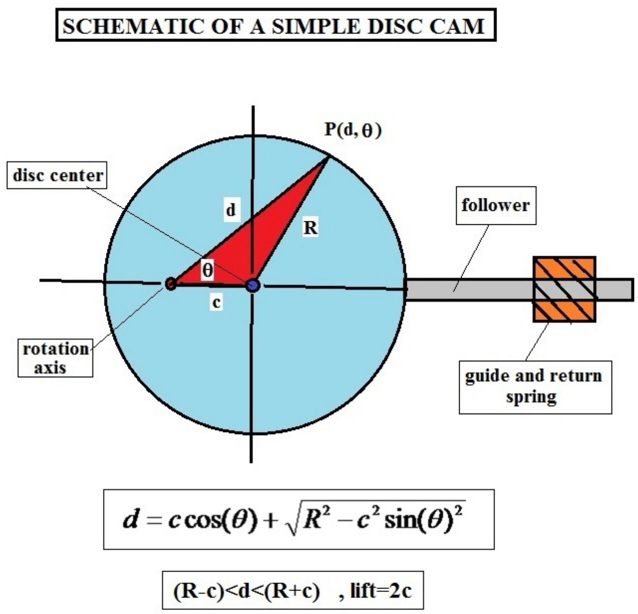
PROPERTIES OF CAMS

A cam is a mechanical device which is capable of converting circular motion into a periodic linear axial motion. It forms an integral part of any automobile engine. Our purpose here is to discuss some of its properties including the concept of dwell, rise and return.

As a starting point we consider one of the simplest of all cams, namely, a solid circular disc rotating about a fixed off-center axis and driving a follower (lifter). Here is a diagram of the device-



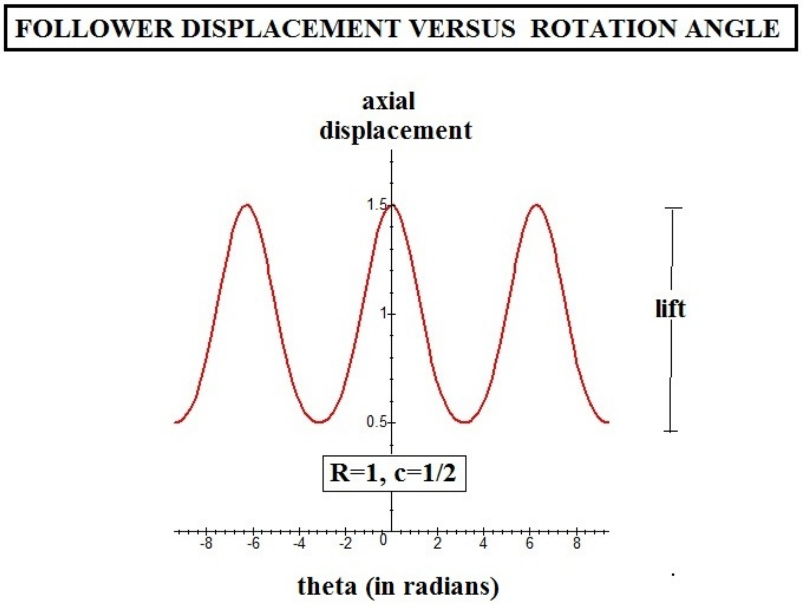
The disc rotates at constant angular velocity about a rotation axis which is locatred at distance c from the disc center. Applying the Law of Cosines one finds that-

$$c^2 = d^2 + R^2 - 2dR\cos(\theta)$$

, where d is the distance from the rotation axis to a point P on the edge of the disc, R is the disc radius, and θ the angle d makes with respect to a line passing through the disc center and the rotation axis. Solving for d one finds-

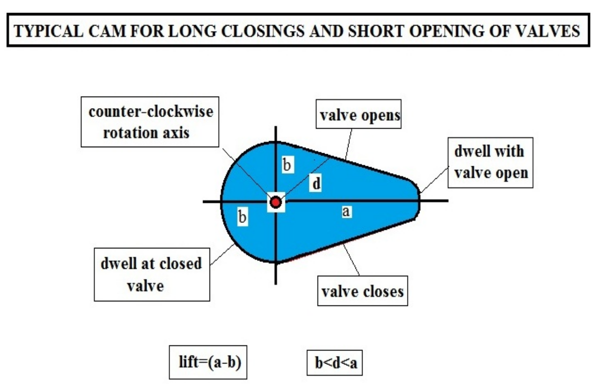
$$d = c\cos(\theta) + \sqrt{R^2 - c^2\sin(\theta)^2}$$

This shows that the follower which hugs the disc periphery via a return spring has a periodic excursion maximum of R+c at θ=0 and an excursion minimum of R-c at θ=π. The lift of the cam thus becomes (R+c)-(R-c)=2c. Plotting d versus θ produces the periodic curve-



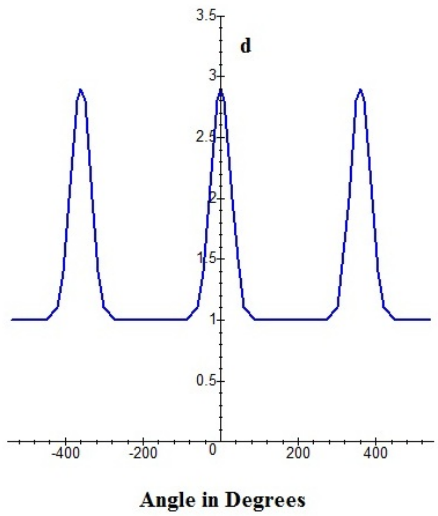
Notice that the follower displacement does not follow a simple SHM motion but rather has thinner maxima and wider minima.

For more realistic cams, suitable for lifting and closing of intake and exit valves in automobile engines, one needs to reshape the cam cross-section so as to have a relatively short rise and fall times followed by a short dwell time while the valve is open and longer dwell time when the valve remains shut. This may be accomplished by elliptical shaped cams having a circular shape at its opposite ends. A typical cam capable of having a follower and valve lifter act like this follows-



We can construct the follower response for this cross–section cam by measuring the distance d from the rotation axis of the cam surface at various angles. The measured displacement pattern over three 360 deg cycles looks like this-

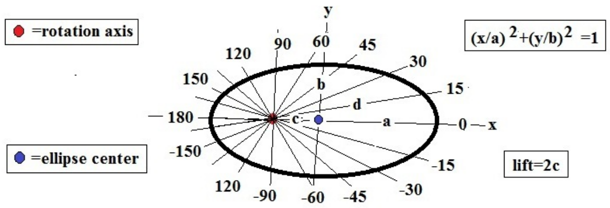
AXIAL DISPLACEMENT OF THE FOLLOWER FOR THE ABOVE CAM



Note the long closing times when the valve is shut and the quick opening followed by a quick closing. The gasoline spray enters the intake valve to the combustion chamber and exhaust gases are removed by a timed second exhaust valve. Except for fuel injection, nothing has really changed in this regard in four cycle engine design in well over one hundred years since the time of Otto. It suggests that engineers might spend some time coming up with an electronic triggered means to remove burnt gases from combustion chambers rather than the use of archaic mechanical cams.

As a final consideration let us look at how one can construct pretty much any desired follower displacement and hence valve opening and closing in a periodic process such as occurs in internal combustion engines. One starts with a cam shape approximating the desired displacement. This can be the shape of an ellipse as the first approximation. One chooses the desired lift 2c and places the rotation axis accordingly. Next one measures the distance d from the rotation axis to the cam periphery for different angles. I show this in the following figure-

GRAPHICAL CONSTRUCTION OF THE FOLLOWER MOVEMENT GENERATEDE BY AN ELLIPTIC CAM



theta in degrees	0	15	30	45	60	90	120	150	180
displacement , d	50	47	38	28	19	15	14	16	19

When these measurements are graphed as θ versus d one has a clear picture of what periodic displacements the elliptic cam is producing. For those sections of the cycle where one wants no change in axial displacement (dwell) , one replacers that part of the ellipse by constant radius circles centered on the rotation axis. Once this is done one smoothes out the transition points between the elliptic and circle portions of the cam to produce the desired result. Automobile engineers have perfected this technique to very high precision.

August 26, 2016