

Hello all you F-body listers. Welcome.

Er, that's enough small talk - on with the show.

Suspension Linkages for Solid (Rear) Axles.

This is a quick and dirty bit of HTML to illustrate some solid axle linkages that have been buzzing around my head for a while now.

For anyone who has seen a 'Locost', the owner has probably told you (in great detail) how he built it from plans in a Haynes book called "Build your own sports car for £250 (and race it!)" by Ron Champion. It's a top book. I may well do it myself one day, as I own the book too.

At the rear-end of the 'as-specified' Locost is a European Ford Escort Mk I/II solid back axle. This is modified with three brackets attached to it, two for parallel trailing links, and one for a Panhard rod.

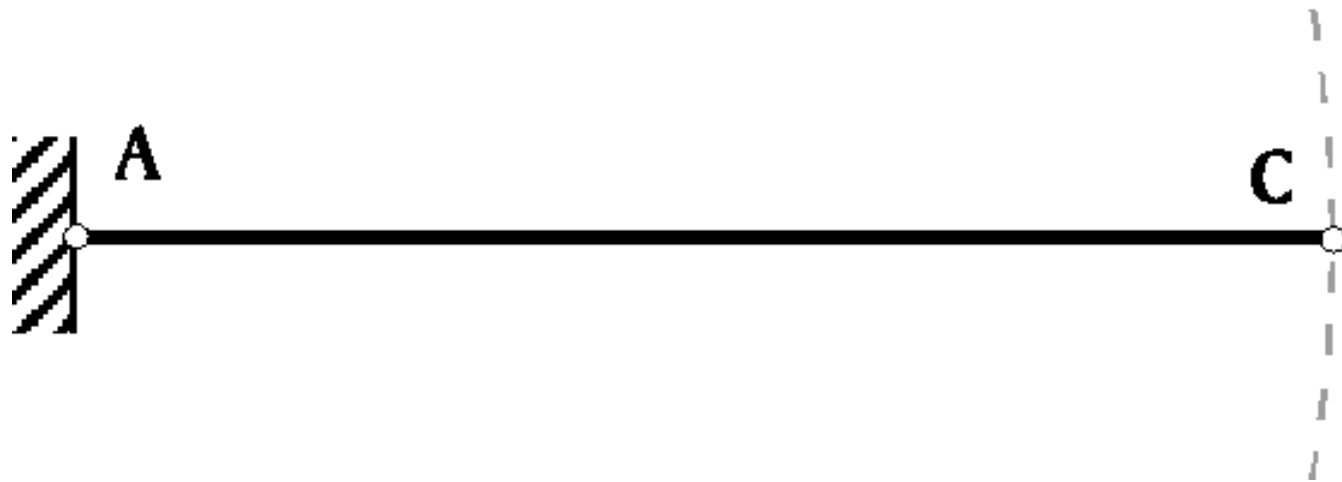


Figure 1: The Panhard Rod.

Doesn't look much, does it. **A** is a location point on your chassis frame. **C** is a location point on the axle, and they are usually as far apart as possible on a Panhard rod.

Okay. So what does it do? The idea is that you want to locate your rear axle in a lateral plane by constraining it to a vertical line of motion (i.e. stop it from moving from side to side). For all you F-body owners out there, your leaf springs actually fully locate the suspension without one - in theory. In practice, putting the huge twist from a V8 through the axle, it winds up all sorts of things and you get nasties like axle tramp - stuff that car designers cringe at and try to brush under the carpet mats. The Panhard rod is one way of better locating that wayward rear end and as you know was used on the higher performance SS and Z/28 cars.

"Hang on a moment," I hear you say. "That grey dotted line isn't straight, so as the axle moves up and down, it actually does move laterally somewhat."

"Yes, it does," replies the car designer, "but it's a very small amount if the rod is long [actually, the path error can be calculated, for vertical travel 'h', the error is $L(1-\cos T)$ where $\sin T = h/2L$. This approximates to $h^2/8L$ meaning the

error grows with the square of the suspension movement, and also inversely with length - it shrinks as rod length increases.]"

Phew.

What that crap in square brackets means is that is definately ain't a true vertical motion, but will do for small amounts of suspension travel. The car designer then plays his trump card: "Indeed; **and it's cheap, too.**"

So, can we achieve a better constrained vertical motion? Yes, we can.

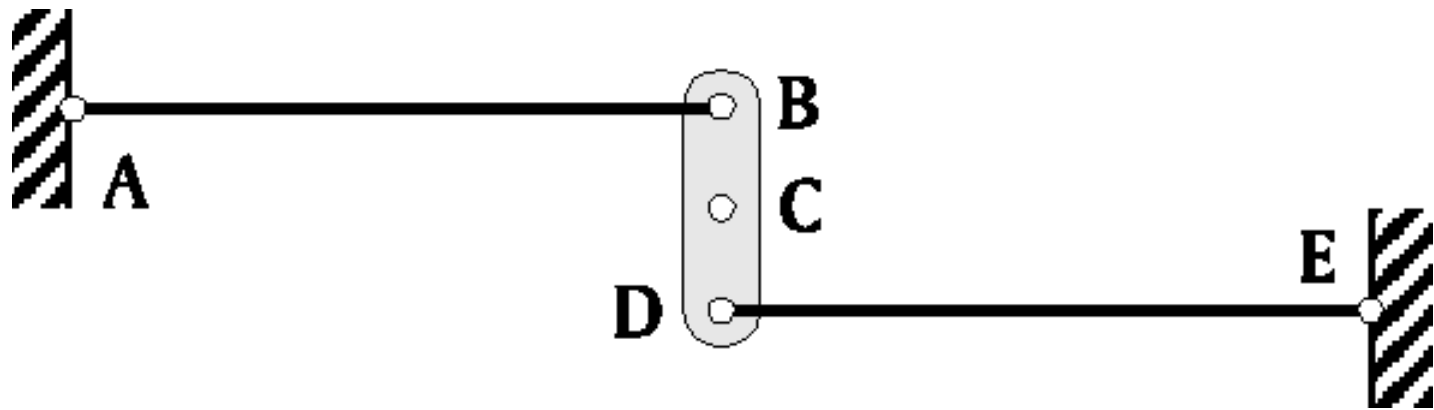


Figure 2: The Watt Linkage.

So here we have a simple geometric linkage. A and E are usually fixed to the chassis, C again is the location point on the axle. These can be (and often are) reversed with the same effect. Whichever way they are connected, C will become the roll centre of the axle. Usually (not always) it is attached to the nominal roll centre of the solid axle alone, which is where the car lateral centreline crosses the axle's axis. (Plot hint: Remember this - it's very important later!)

BCD is a link, which rotates as point C moves up and down with respect to A and E. The clever part is, it moves in a very close approximation to a straight line. You'll have to take my word for this - in fact, if you have Lego Technic or Meccano hanging around (or some bits of wood and screws, or thick card and bifurcated rivets) then go and try it out. Pin A and E to your kitchen table, and use a marker pen in C to trace the line. Your significant other will want to kill you, but you'll understand how clever this linkage is.

Great, so we have a better way of laterally locating our rear axle than a Panhard rod. Whoopee. Indeed, for three times as many rods or links, we haven't really improved the dynamics of our car from a driver's seat-of-the-pants point-of-view.

Hang on, because the ride becomes a little twisty.

The Watt linkage can be modified, within a certain mathematical rule. The arms AB and DE do not necessarily have to be the same length or on the same side. However:

Point C on the link must be nearer to the longest arm where lengths: $BC/CD = DE/AB$.

Hmmm... so that would look like...

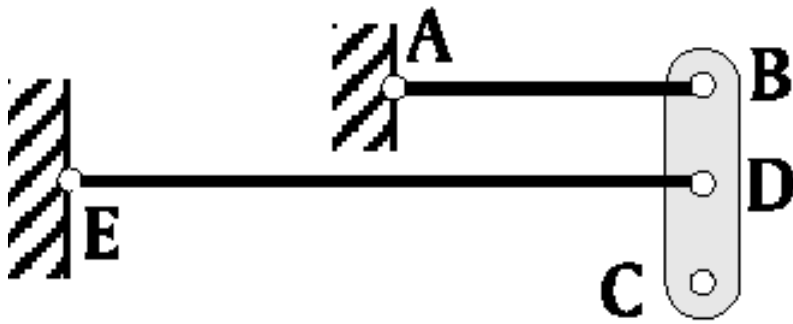


Figure 3: The modified Watt Linkage or WOBLink.

The diagram shows the same convention, A & E are on the chassis, C is on the Axle.

Great, what does this do? Exactly the same as the Watt linkage - geometrically, the motion produced at C is identical.

So what? Ah. This is where the physical location of the rear axle in the car is important. Notice C hangs down, and A and E are high up. So you can physically put C below the axle line without too much of a problem. Extend a location bracket down underneath the axle and you can pivot the axle on C... which is still the roll centre. Ta-da. You've lowered the roll centre.

Wonderful, what does that do? Well, it's kind of outside the scope of this document (so it will be in the next one I write) but it goes something like this: a lower roll centre allows better lateral weight transfer. This means your tyres will work better because they will tend to scrub more sideways that want to be roll and load the outside tyre. This goal is achieved also (less elegantly) by an anti-roll or sway bar. However, they are additional.

Great! No catches? Well yes. The roll centre of a normal solid axle is basically the radius of your tyre - about 14 inches, say. The ride height of an everyday car is maybe 7 or 8 inches, so that you can run over bricks and debris in the road without having it take off your exhaust. So, by sticking a bracket underneath your solid rear axle and locating it from that, anything you do run over has a good chance of ripping your rear axle off. On a racetrack, that's not an issue, really - you run maybe 2 to 3 inches ground clearance, and if there is debris on the track, you cheer because that's one less competitor in your way. But if you've ever had to sit by the side of the road waiting for the AAA to pick you up, I think you'll agree - it's not too hot for a road car.

So, what now?

Well, I found this little beast. I don't know if it is at all practical for a road car - I think it is, but I haven't tried it yet. You won't see it on a production car because it is fairly complex, and that makes every automotive account manager look for a way to eliminate it...

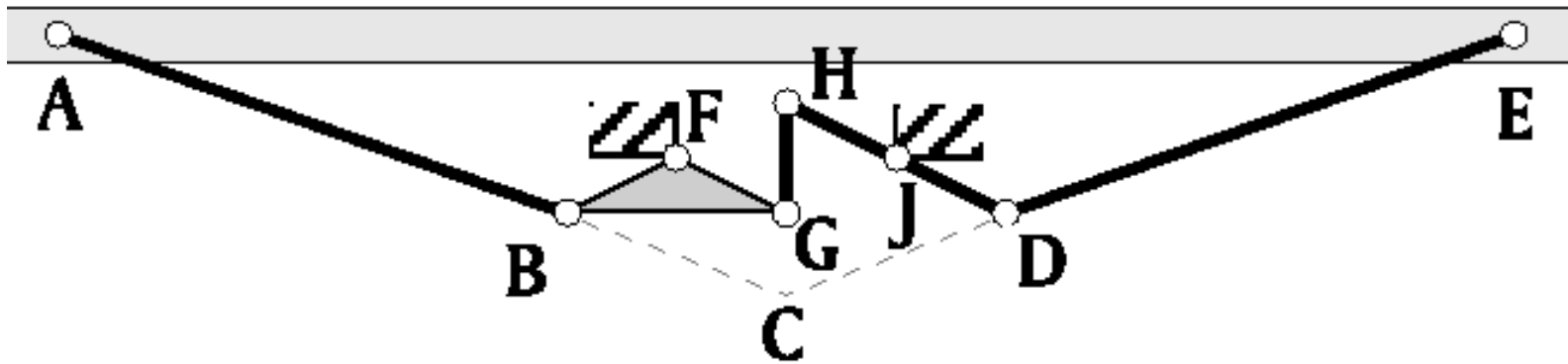


Figure 4: The Mumford Linkage.

This scary looking contraption is a Mumford Linkage. A and E are shown attached to the axle, this time, and points F and J are pivots on the chassis.

AB, DE, DJH and GH are straight links. BFG is effectively a bell crank.

A photograph of the complex part of this can be found here: <http://www.billzilla.org/mallock11.JPG>

There it is attached to a Mallock Mk31 race car, belonging to a very enthusiastic fellow by the name of Bill Sherwood.

The beauty of this thing is that the virtual point C is your roll centre. The astute will quickly recognise that if you shorten the distance AE, the roll centre rapidly disappears into the ground and below... and you've kept a fair chunk of your ride height too. Actually, putting the roll centre below ground is a bad idea for a number of reasons, but it is feasible to lower it as much as you like as long as it is higher than the front roll centre, which feasibly can go to the ground or a little below. How much you want to play depends on all sorts of things like your effective spring weights, overall weight and weight distribution of the car, ride height, tyre widths and so on and so on.

I think this linkage is fab - and if I don't put it straight onto a Camaro, I'll be building a Locost and comparing one or two setups. I haven't a clue how much difference it will make from the driver's seat. All I can say is I can't wait to find out.

Mark Fox.

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