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Motorcycle News for Positive People

## Yamaha R1 Aluminum Girder Front Suspension from SuspensionSmith of Australia

by Paul Crowe - "The Kneeslider" on 10/17/2011

in [Motorcycle Builders](#)



Yamaha R1 with aluminum girder front suspension from SuspensionSmith of Australia

Laurence Smith runs SuspensionSmith, a suspension business in Australia. Working on motorcycle forks, shocks and swingarms all day, it shouldn't be surprising he has a few of his own ideas about what comes between the wheels and frame and when he started thinking about why girder front suspensions weren't

often found on sport bikes, he decided to look into it. Of course, Laurie was in a better position than most of us to work out answers to his questions and the result is the bike you see here, a 2004 Yamaha R1 with his very own aluminum girder front suspension. He's pretty pleased with the result and thought readers of The Kneeslider might want to have a look. Laurie sent me some photos and explained how it all came about.

*Here's what Laurie had to say:*

The project began in late 2009. I was wondering why girder forks aren't seen on any sports and race bikes,... usually just on very old stuff like Vincents, Ridges, etc. and on modern bikes it's usually restricted to custom bikes and cruisers, low dynamic performance stuff. Why is this so when girders have all the advantages of link type systems with antidive characteristics, low stiction etc.?

I began by using Tony Foale's FFE suspension software to investigate the working dynamics of how girders function. I then built a rough prototype to test some ideas on geometry and construction, the bike I used was an FZR400 frame with a 98 CBR 919 motor for extra go that I had built some time ago.



First girder prototype on FZR400 with Honda CBR 919 engine

This prototype taught me a lot of what I needed to know for the next step. Having mucked around with the FFE software I realized what the problem with girders was. The advantage a link type design offers is the ability to tailor the wheel path and control the amount of prodrive/antidive you want to use, which, in

this case, means a more vertical wheel path. The girder's big weakness with this wheel path is massive trail loss when braking or when the suspension moves in general.

The reason is the wheel on a girder moves independently of the steering axis with a more vertical wheel path, this leads to an increase in steering offset which leads to trail loss and all the problems associated with very low trail.

On teleforks the wheel moves in parallel with the steering axis and offset is fixed and so doesn't change, so trail doesn't change except with variations in rake angle. Other designs like Hossack, center hub, etc., the steering axis moves with the wheel/suspension and again offset is fixed so trail remains more constant.

So how do I fix this? Very simply, steepen the rake angle so that the rake angle closely follows the wheel path and offset and trail remains more constant, it's not perfect but miles better than what has been before.

I chose a 16 degree steering rake angle and I was very confident of doing this because Tony Foale has long put forward the advantages of steep rake angles and these kinds of angles are commonplace in bicycles, from mountain bikes to road bikes, and to do this I needed to modify an existing frame to achieve this angle. I found the 04 R1 to be the best candidate for this type of modification, which was just a matter of cutting out the standard steering head and welding in a custom longer one.



Longer steering head welded on R1 Frame

With that done I now designed and made the link setup with rearwards offset link pivots, the advantage of



this design is it allows the use of very long links but still keeps the design very compact for good steering clearances and a very low steering inertia. Another advantage is the natural balance the steering now has, a telescopic fork has most of its steered mass in front of the steering axis so its natural balance is to fall away from center, my girder fork has its steered mass behind the steering axis so its natural balance is to return to center and stay centered, that's gotta be good for stability and feel.

A very important feel, one of the biggest advantages of a telefork is the direct feel it gives to the rider and as riders that's what we are used to. My girder retains that kind of feel with benefits. So I did a first prototype in wood.



First R1 girder prototype in wood

Then made the final design in 6061 aluminium and a TTX30 front shock from a quad bike.



Final R1 girder design in 6061 aluminum

Wasn't long before the bike was ready for its first road test.



First road test of the R1 girder

Overall it feels brilliant, it has exceeded my expectations. The steering isn't twitchy or sensitive, its uber stable and ultra precise, the suspension works very well over very rough surfaces and braking is a



revelation, I have dialed in some amount of initial brake dive but it is very controlled and confidence inspiring.



Yamaha R1 with aluminum girder front suspension

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Thanks, Laurie. Well guys, that's how you do it. You get curious and then you get busy, you answer the "I wonder" with action. The Yamaha R1 seems to be a good candidate for this conversion, but there may be some other possibilities, too. How long before we see more of these? Great work Laurie.

**Link:** [SuspensionSmith](#)

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phil [October 17, 2011 at 11:53 am](#)

It's always nice to see expertise put to good use. The only 'problem' I see is that the rake gives the disconcerting appearance of having contacted a sturdy wall at speed. 😊

Great work though.

[Reply](#)

Paul Crowe - "The Kneeslider" [October 17, 2011 at 12:00 pm](#)

Lots of new and very effective technology can look odd when you first see it simply because you're not used to it. If all sportbikes used girders, "normal" forks like we use today might look like a stretched out chopper in comparison. It's all perception.

[Reply](#)

Ola [October 17, 2011 at 12:49 pm](#)

Very interesting, I love it when people do stuff that hasn't been tried before, just because they're

curious, instead of rehashing the same old, conservative concepts!

It seems that unsprung weight would increase quite a bit with this design though, but maybe the difference between this aluminium structure might not be so big, compared to steel inner fork legs?

[Reply](#)

[Viv Collins](#) [October 17, 2011 at 12:53 pm](#)

Ok took me a few moments to realize exactly where the bottom link was located in relation to the top link on his final version and work out the angles and benefits.

I have to say my first reaction was to back away slowly while keeping an eye on it just in case it did some thing unexpected 😊

[Reply](#)

[QrazyQat](#) [October 17, 2011 at 1:21 pm](#)

“Lots of new and very effective technology can look odd when you first see it simply because you’re not used to it. If all sportbikes used girders, “normal” forks like we use today might look like a stretched out chopper in comparison. It’s all perception.”

If you look at a standard older bike from when I started in the late 60s and a sport bike today, the rake is way out there.

Back when mag wheels just came to be on bikes, we put a set on a Honda belonging to the son of the shop’s owner. It sat around for a week waiting for his buddy’s identical Honda to show up to be shipped overseas with our race cars (they were going on a trip after Le Mans). When the other bike showed up those wire wheels looked so weird, so old fashioned. A week before they’d looked pretty normal to me. 😊

[Reply](#)

[kim](#) [October 17, 2011 at 2:34 pm](#)

While I’m sure this system works very well, and probably better than the bike’s stock front end, he’s up against two problems: The bying public’s conservatism, and the fact that the tube type fork still seems to have development potential. BMW’s introduction of the telelever didn’t keep even that large company from using traditional forks on their smaller bikes, or reverting to them on their really fast sports and race bikes.

As for the looks, I think there will still be some out there who find the more aggressive stance desirable – the prototype with the carbon fibre girder type front end from Confederate Motorcycles had a bit of that too.

[Reply](#)

Paul Crowe - "The Kneeslider" [October 17, 2011 at 3:12 pm](#)

You’re right, we’ve talked before about the conservative nature of motorcycle buyers in general, but within that group is a smaller group who would be happy to try something like this on their own bike, it’s not a mass market application. Once you ignore the idea that you have to sell a million of something to be successful, you can try a lot of new ideas that could work really well.

[Reply](#)



Bob [October 18, 2011 at 12:42 am](#)

I've been fascinated by funny front ends from the first time I saw the Elf bike in Cycle magazine. I have clippings from Motocyclist for Parker's RADD prototype bike, various mags for the Bimota Tesi, the Yamaha GTS1000, the Motod Saxon, BMW telelever and paralever, the White Power single side linear bearing suspension, etc, etc. I have a first edition of Tony Foale and Vic Willoughby's book on motorcycle chassis design. I think the biggest impediment to alternate forms of suspension is the economics of production and how well conventional suspension work. Many of the advantages of the alternative suspension in reduced stiction, anti-dive, etc are only realized when you push the limits of the existing suspension. Most riders don't go there and consequently don't demand higher limits. In the racing arena, RADD, Fior, Hossack, Elf, Bimota, Britten, Foale haven't been able to demonstrate a clear advantage over conventional suspensions. I have lots of magazine articles with Alan Cathcart waxing on about the superiority of a funny front end, but, in the top levels of racing a top shelf Ohlins suspension with an Ohlins technician to dial it in is difficult to compete with.

[Reply](#)

Eric [October 18, 2011 at 12:24 am](#)

I've been following a couple of this guy's projects and by the looks of them, these bikes are for his enjoyment and he isn't very concerned with the view of the "buying public".

[Reply](#)

B\*A\*M\*F [October 17, 2011 at 2:40 pm](#)

This really makes me want to adapt the Hossack/Fior suspension to a bike of some kind. How cool is this?

[Reply](#)

Tin Man [October 17, 2011 at 3:13 pm](#)

I also find the look unpleasant, Its not just because its different, it just does not flow with the lines of a bike. There is such a thing as Beauty, The Human eye can detect beauty even when we can't describe beauty. Look at buildings from the 60s, they looked trendy at the time but have not aged well, then look at a nice Red Brick pillored building built 100 or 300 years ago, still looks "right", good taste never goes out of style. This concept holds true for Fashion (Narue Jacket) , Auto design (Aztec) or of course Motorcycles.

[Reply](#)

GM [October 17, 2011 at 4:29 pm](#)

Totally agree with you. But give this version some slack, it is mostly a proof of concept. Any version of this suspension that makes it to production is likely to have its aesthetics refined. Especially if the bike is designed from the beginning with this in mind.

[Reply](#)

david [October 20, 2011 at 9:33 pm](#)

Keep in mind the bodywork and frame and everything about this bike was not designed with the look of a foreshortened girder fork in mind... I'm sure Yamaha designers would take that into consideration before mass producing something like this...

[Reply](#)

Claymore [October 17, 2011 at 3:52 pm](#)

With the weight balanced closer to the center of the wheel, it just seems like it would be more prone to 'catch' on a pothole or something.

[Reply](#)

hoyt [October 17, 2011 at 4:50 pm](#)

Cool project & great execution. It's nice to see someone in the business of suspension systems trying alternatives.

Aesthetically, you probably have to see it in person before commenting negatively. The vertical appearance would be offset by the shock's angle if you run it naked

Isn't the unsprung weight on this design only from the bottom "scissor" pivot point down?

[Reply](#)

Ola [October 17, 2011 at 6:01 pm](#)

The unsprung weight would be at least the entire "fork leg" structure, and possibly also parts of the pivot arms, since all that would be moving as unit. I'm guessing also the bottom end of the shock, no?

[Reply](#)

Rob [October 17, 2011 at 6:34 pm](#)

Paint that girder in one or both of the two tones of grey like the bike and Bob's your uncle. It's just a bit shiny compared to the rest of the bike. Maybe some plastic on the girder to make it look more aerodynamic and incorporate a front mud guard.

[Reply](#)

BoxerFanatic [October 17, 2011 at 6:50 pm](#)

This few tells me very little other than rake is pretty steep, and trail is probably near zero.

But without seeing the acting members of the suspension, which are likely behind the fairing, it is hard to actually evaluate.

most previous "girder" suspensions have not solved the dis-association of the suspension forces from the braking forces.

Hossack/Fior/Duolever does that.

RADD also does, with a lower center of gravity, but more complexity.

I am not sure if this one does, or if it is just a steered damper atop some rigid legs.

[Reply](#)

BoxerFanatic [October 17, 2011 at 6:51 pm](#)

Web page didn't load the additional pics until after I refreshed... now I see the additional

photos.

[Reply](#)

Mike [October 17, 2011 at 7:14 pm](#)

. . . or maybe a full carbon fibre confection like the Confederate Motorcycles B120 Wraith?

[Reply](#)

Rich [October 17, 2011 at 8:10 pm](#)

I am rather certain the trail is of a conventional nature. If you visit Tony Foale's website you can read his tests of unconventional rake angles and the bikes actually have positive handling attributes as a result. Trail can be at conventinal numbers by changing offset.

I would have done a Hossack as opposed to a girder to reduce steered inertia but it is a beautiful bit of work.

[Reply](#)

laurie [October 17, 2011 at 11:32 pm](#)

Rich you are spot on

In this case steering geometry is 16 degree rake and 102mm trail and uses 15mm of negative offset to acheive that,as you get into steeper rakes then offsets need to become negative.ie. the wheel is mounted 15mm behind the steering axis,hence the better steering balance I mentioned and steering inertia is minimal due to its compact nature.

I have measured unsprung weight and surprisingly its only a couple hundred grams more than the telefork it replaces.

Agreed the hossack etc types are good but I feel they have a drawback of using a linkage to connect the bars too the uprights and so may suffer from some loss of feel and extra complexity.

Time will tell.

[Reply](#)

Rich [October 18, 2011 at 1:15 am](#)

I know several Hossack and FFE builders on the chassis list and the only complaint about lack of feel seems to stem from the use of bearings that lack rolling elements. The plain spherical bearings have a great deal of friction which inhibits front end movement over the gritty bits as the tire moves across the road surface. Steering linkage has never been an issue that I've heard of. Nice work...

[Reply](#)

todd [October 18, 2011 at 1:26 am](#)

I really think it's a shame he put the fairing back on.

-todd

[Reply](#)

Stan [October 19, 2011 at 10:18 pm](#)

+1



[Reply](#)

[Tony Foale](#) [October 18, 2011 at 3:40 am](#)

Laurie,

Great job.

I see benefits in using zero offset geometry. That is, set the rake to give the desired trail with zero offset, but you are close to that.

What amount of dive do you have dialled in? I usually aim for around 1/4 to 1/3 of that which one would get with teles.

Good luck with it and enjoy.

Tony Foale.

[Reply](#)

[laurie](#) [October 18, 2011 at 5:48 am](#)

Hiya tony

Thanks mate

So for a zero offset with the trail I am using means a rake angle of around 19 degrees...certainly would make the design easier to package,drawback with what I have is the length of the steering head/frame required to achieve 16 degrees.

I have an adjustable pivot point for the top link so I can alter prodive/antidive over a small range but its about 22% prodive in the midstroke to around 10% antidive at full bump

And good work with your software,its very useful,is there any chance you may upgrade the FFE analysis too a similar level as your setup analysis,incorporating suspension unit data, force data etc

Laurie

Laurie

[Reply](#)

[Tom Lyons](#) [October 18, 2011 at 9:19 am](#)

Pretty cool!

[Reply](#)

[jim](#) [October 18, 2011 at 9:33 am](#)

Reminds me of the fork from RMD Billet

<http://www.r1engineering.com/thegirder.htm>

[Reply](#)

Paul Crowe - "The Kneeslider" [October 18, 2011 at 9:50 am](#)

Check that "related" link at the end of the article above.

[Reply](#)

[Nortley](#) [October 18, 2011 at 10:57 am](#)

Old is new again. Save for the top shock mount location, that's a Vincent girddraulic, which is not a

bad thing at all. If the legs were contoured and polished like the Vincent fork blades, they could get away with being beefier for strength and also be lightened from the inner faces. Replacing the steam age bridge girder fork with something sleek would better match the majority of the bike which pushes it up the road.

[Reply](#)

B50 Jim [October 18, 2011 at 12:42 pm](#)

I appreciate the components having been milled from aluminum billet. I assume Laurie wrote CNC programs to whittle the parts quickly and accurately. I like the concept of girder front ends because of their adjustability and ease of experimentation as well as the vintage vibe. However, the market seems to like the simplicity of tube-type suspensions and chrome forks, and will need a lot of education to accept something completely different. How about Earles forks? Natural anti-dive, adjustability and solidly stable, plus they work great with a sidecar.

[Reply](#)

Victor [October 18, 2011 at 12:54 pm](#)

Good work about the technical aspect. About the aesthetic values the CNC components are required to be tuned. But it's obvious, since this suspension is a prototype. I guess the next Laurie's step will be carbon. About the aesthetic values, is that fork look fine? Is it ugly? How much the aesthetic vs. technical values are important choosing a bike today? Like the airplanes pilots tell, if an airplane is fine it flies good. Personally I think the same for motorcycles. But of course it's not true for all and so we're just witnessing an umpteenth sort of cell division in the motorcyclists wishes. Motorcyclists tribes and supporters break into fragments of styles (and drive the marketing guys crazy)...

[Reply](#)

Ken [October 18, 2011 at 2:50 pm](#)

How cool would it be to have one of the new Indians to have a suspension like this??? Make it look retro a la Vincent but with a better performing bike package (motor, chasis, breaks). How killer would that be?

[Reply](#)

Les [October 19, 2011 at 9:59 am](#)

From watching the video it looks odd. It doesn't seem to require countersteering. You are turning it like a car. Or do I need more coffee this morning?

[Reply](#)

todd [October 20, 2011 at 11:00 pm](#)

all motorcycles (and bicycles) steer the direction you are going. "Countersteering" is just the term used for initial reverse-steering rider input (to initiate lean) and subsequent pressure on the inside bar (to resist it from tucking in) as the front steers into the turn.

-todd

[Reply](#)

Phoebe [October 19, 2011 at 10:59 am](#)

Totally awesome! I'm aware of the issues regarding trail and girder type suspensions, which is why they're not really used very often. Very cool to see someone figured out a way to tame that!

[Reply](#)

Henry3 [October 19, 2011 at 10:31 pm](#)

John Britten built and used a carbon fiber girder fork on his V1000 and look how successful he was with that setup. That was back in the early to mid 90's and he was beating factory works bikes so that must say something.

[Reply](#)

laurie [October 20, 2011 at 2:14 am](#)

Henry3

yes the Britten is a totally awesome machine and accomplishment by the man

But I need to point out that the Britten doesn't use a Girder type fork

It uses a Hossack/Fior type design, which is very different in the way it is steered etc

I predict we will be seeing a lot of FFE designs coming into being very soon...Moto2 being one venue...and it's about time 😊

Laurie

[Reply](#)

[Doug S. October 20, 2011 at 11:23 am](#)

Good work and thanks for the write-up!

Speaking of Moto2, do you know if Martin Wimmer has used his front-end on his Moto2 bike, yet?

[Reply](#)

laurie [October 21, 2011 at 6:07 pm](#)

Have not heard anything, can only be a matter of time

Laurie

[Reply](#)

[Doug S. October 20, 2011 at 11:39 am](#)

btw...the top video is fantastic. Gives new meaning to rider feedback 😊

[Reply](#)

Gary [October 22, 2011 at 6:51 pm](#)

Ventilate that fork and match it up with a Ducati trellis frame; add one of those new 26 or 30 inch custom front wheels for the potholes, garnish to taste and wow...

[Reply](#)

petr [October 22, 2011 at 10:02 pm](#)

Isn't that almost exactly the same system BMW uses on their K1300? They call it the duolever.

[Reply](#)

laurie [October 23, 2011 at 5:15 am](#)

Nope...very different in the way its steered,the Duo lever is a copy of the Hossack system.

[Reply](#)

Joe [October 23, 2011 at 3:27 pm](#)

Laurie,

Great job! Just a question about the upper link clearance from the mounting bracket; it looks quite close . Isn't there some concern that lateral leverage created while cornering could cause one or the other link to contact the mounting bracket? Is the assembly so rigid laterally that this is not a problem? If so,how is this possible especially in light of the fact that it appears that all of the links are independent and not a unit as on the Confederate Wraith or the RMD Billet R1. By the way, the look is tremendous! I love it.

[Reply](#)

laurie [October 24, 2011 at 4:16 am](#)

Thats a good question Joe

This is my Lateral flex system I am also working on.

If you look really close in the Vid of the upper link you can see the tops of two bearings that are bolted too the front face of that mounting bracket.

These bearings run against the inner faces of the link and are adjustable so that I can vary the running clearance.

The Idea eventually is to experiment with the lateral flex of the upper link and torsional flex of the lower link....those bearings being in a position to control the amount of flex and run a Damper system to control that lateral flex.

The clearance between the link and mounting bracket will be widened once the need is identified.

In the Vid the clearance is set at zero so no lateral flex is being allowed.

[Reply](#)

Joe [December 6, 2011 at 7:53 pm](#)

Hey Laurie,

Hope all is well with you. How's the progress on the suspension? Does the adjustable lateral flex work as you hoped?

[Reply](#)

laurie [December 9, 2011 at 5:05 pm](#)

Going very very well

Recently had Australian Motorcycle News test the bike...Alex Cudlin rode it and was Impressed...he noted a few things that need work so I am using his feedback to make some minor tweeks.

The bike is in the current Dec issue Australian Motorcycle news and its a good writeup.

Have not done any work on the lateral flex yet...still tweeking the basic design.

Just fitted a 06/R1 swingarm which gives me a longer swinger and so puts more weight on the front....I am coming up against the usual FFE problem of the front tyre not being worked hard enough and so not generating enough heat and grip...the suspension is just too compliant



for its own good.

Needs front tyres made specifically for FFE

That's the reason why the Moto2 Vyrus hasn't been raced yet ... can't get the front tyre to work properly.

[Reply](#)

[Joe January 3, 2012 at 9:18 pm](#)

Laurie,

Happy New Year! Hope you are well. I wonder if you can share some of your recent findings in your efforts toward refining the girder. Have you been able to improve the working action of the front tire? I have a few thoughts that may be relevant toward that end, but your own first hand experience would, of course, be the most informative.

[Reply](#)

[laurie January 7, 2012 at 6:45 pm](#)

Hi joe

Yes had some forward progress getting the tyre to work.

Had the bike at Eastern creek recently with some Pirelli slicks

The swingarm change putting more weight on the front helped immensely as well revalving the front shock to increase comp damping so as to take away some compliance.

Also dialing in more prodive to help the bike steer better on corner entry

The result was much better overall feel and great steering and the tyre was getting plenty hot enough although tyre wear was still minimal but felt great, at least at the pace I was doing.

More to come

[Reply](#)

[Joe January 9, 2012 at 6:24 pm](#)

Laurie,

That's good news! I wondered if a softer compound tire than you first used would be one step in the right direction. Are the Pirelli slicks a bit softer? Also, increasing compression damping as you've done has worked to keep better contact with the asphalt. Would fitting a slightly stiffer spring help as well?

You said that unsprung weight is very close to the stock forks. It seems to me that is another important consideration in helping the suspension do its job of keeping the tire in contact with the track, especially as speeds increase. The carbon rims you have go a long way toward that end. Is this an area that you think needs improving at all?

Thank you for letting us know how you're doing. I think a lot of people, like myself, are curious and like to see a little departure from the status quo. Joe

[Reply](#)

[laurie January 17, 2012 at 4:53 pm](#)

Yeah been using a soft front and actually been going softer on front springs and dialing in more prodive which is helping the bike to steer

I don't think there's much to be gained with less unsprung in terms of suspension behavior but certainly lots to be gained with less rotating inertia.

[Reply](#)

Tom Moke [February 12, 2012 at 7:47 pm](#)

I love the concept and the look! but I see trail variation being one of the biggest issues with this concept. What trail variation in bump did you achieve and do you notice the effects while riding?

[Reply](#)

laurie [February 16, 2012 at 4:23 pm](#)

I seem to have trail variation under control so far by matching wheelpath too a steeper rake angle.

When riding the bike very hard a lack of trail would show up as a lack of feel and feedback and a tendency to tuck the front when pushing into a slide.

The front has great feel and doesn't tuck uncontrollably

I have a vid on you tube showing me initiating a front slide...I was intentionally pushing the front and anticipated the slide so when it happened I picked the front up with the throttle and a little wiggle of the bars was the result.

Also the front doesn't show any signs of chatter

Very happy

slide is at 12 on the time counter

<http://youtu.be/ASw3J78EyaU>

[Reply](#)

Joe [April 5, 2012 at 10:54 am](#)

Laurie, Just read the write-up about the bike in Performance Bikes magazine. Overall it was positive. I suppose by this time Mr. Scaysbrook will have already ridden and evaluated version2 at Eastern Creek. Just a question; how long are your upper and lower links and why did you decide on those lengths? I'm also designing a link suspension which is only in the concept stage at this point. Your input would be helpful for comparison. Looking forward to hearing about your progress. Joe

[Reply](#)

laurie [April 7, 2012 at 12:33 am](#)

Hey Joe!

Yeah length but also angles of links are crucial.

It all comes down to the wheelpath that the combination gives.

Wheelpath is all important as it determines characteristics of prodrive, wheelbase, rake and trail and how these effect weight bias, weight transfer, grip, steering feel/response etc.

My email is: [suspensionsmith@gmail.com](mailto:suspensionsmith@gmail.com) contact me and I will give you some direction

cheers

Laurie

[Reply](#)

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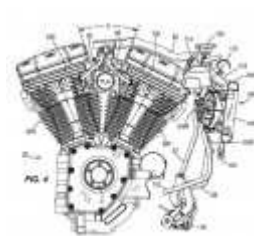
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