

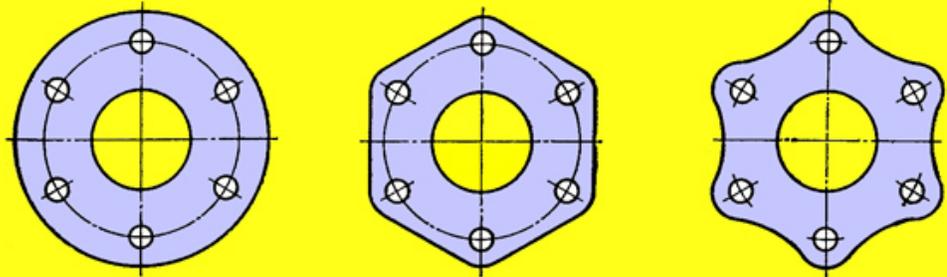
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# Lightening Parts



Issue: 655

Section: DIY Tech Features

3 September, 2013

## Lightening Parts

Some techniques for making your custom constructions lighter

by [Julian Edgar](#)

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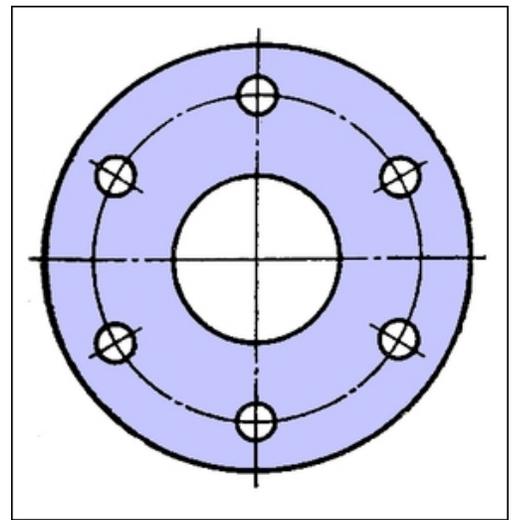
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*This article was first published in 2010.*

In any vehicle, weight is of critical importance. Reduce weight and the vehicle will have better performance (in both acceleration and braking) and improved fuel economy. All else being equal, it will also go around corners better. But very few engineering or other reference books cover design techniques for minimum weight.

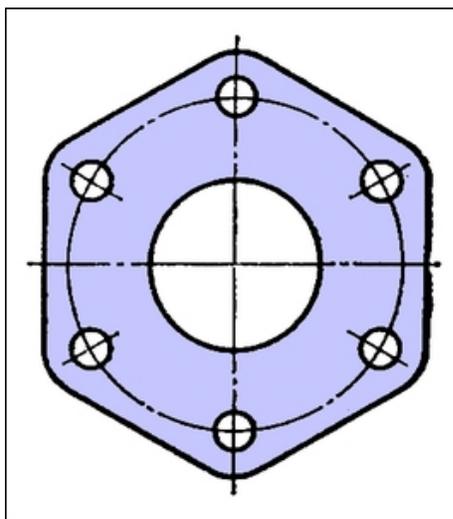
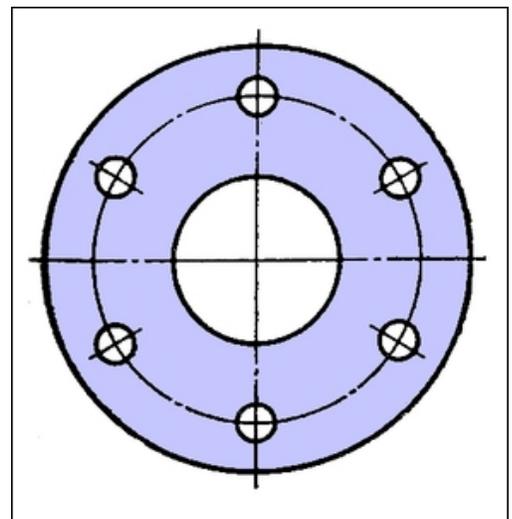
In [Lightweight Design](#) we looked at some of the fundamental design decisions that will result in low weight, but what about the nitty gritty of individual parts design? That's what we're going to look at in this article. Much of the content is drawn from *Fundamentals of Machine Design, Vol 1*, first published in Moscow in 1976.



## Flanges

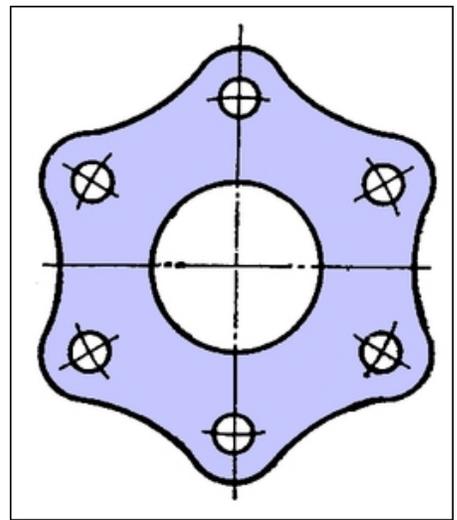
Keeping rotating flanges low in weight is important because it not only reduces the total weight of the vehicle, but it also reduces the inertial mass that needs to be accelerated. This is analogous to lightening an engine flywheel – the engine will spin-up more quickly because there is less mass to be accelerated.

Here is a typical flange.



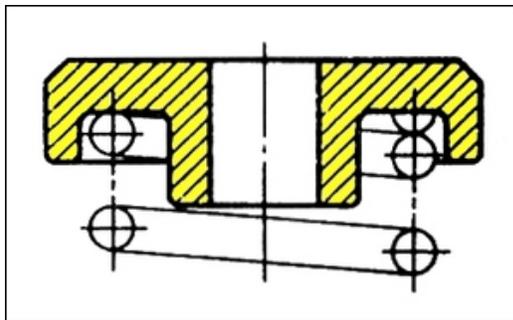
By trimming the un-needed metal around the outside, the mass is reduced to being 84 per cent of the original.

By further metal removal, the mass is reduced to being just 76 per cent of the original!



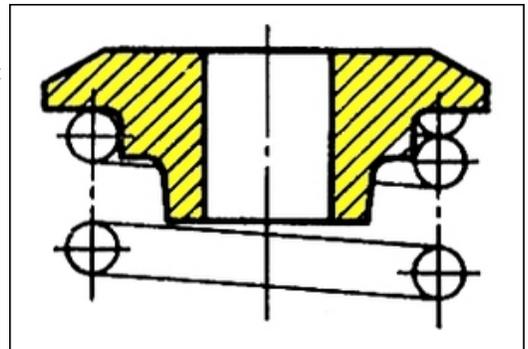
### Internal vs External Locating

If a part can be centred by either internal or external means, internal centring will save weight – simply because the part will be smaller.



This diagram shows a spring centred by an external cap...

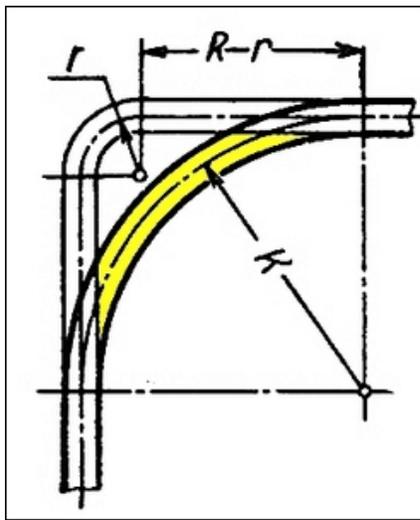
...and this shows an internal locating device. As can be seen from the shaded area, the internal approach is lighter – and it looks like with some height reduction, it could be lighter still.



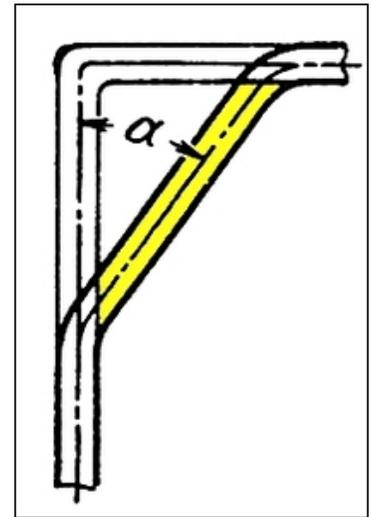
### Short-Cuts

Where material can be saved by directly joining stressed parts of the structure, this approach should be taken. That might seem rather obvious, but in many cases (especially in castings and designs made from sheet materials), additional and unnecessary material is often used.

Here the more direct path (and also one that will be less of a stress raiser) saves about 20 per cent in weight over the right-angled bend.

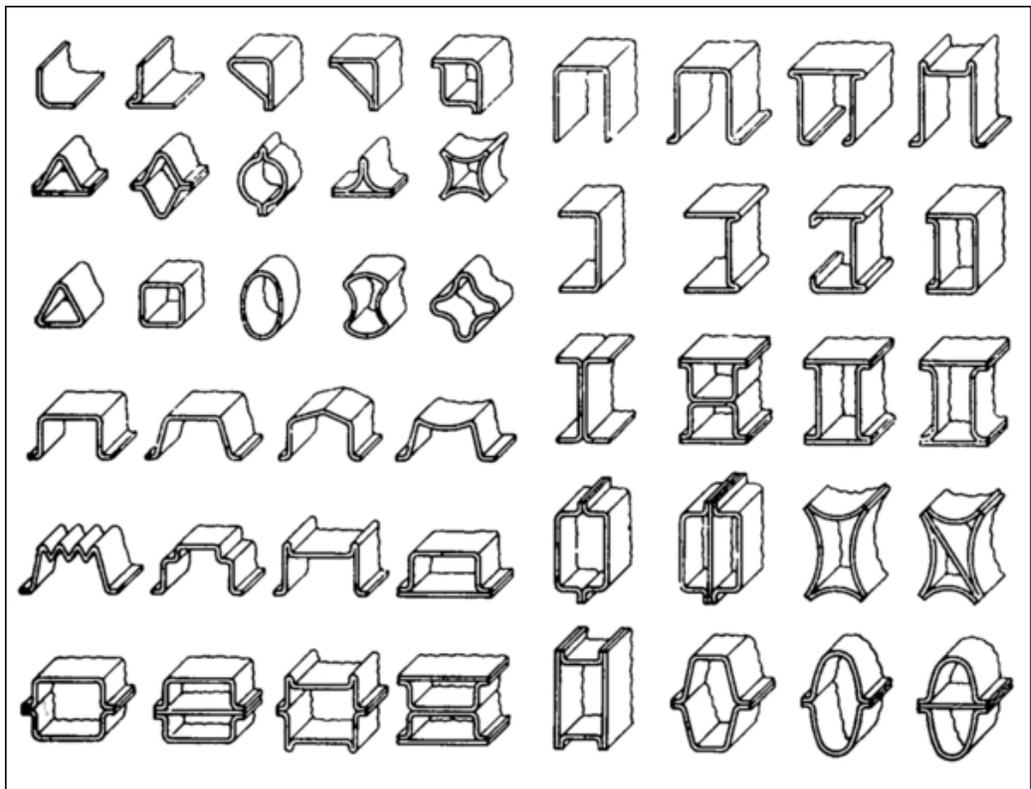


The weight saving here is 30 per cent.



### Sheet Profiles

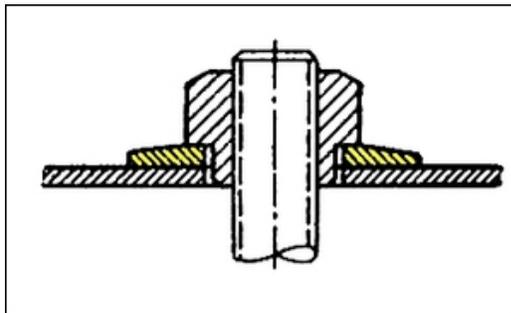
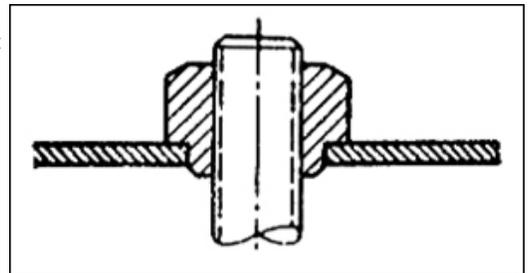
Light gauge materials can gain considerable strength if formed into the correct shapes. Anyone who has ever cut up a car will be familiar with the range of sections used in rocker panels, windscreen pillars and the like. Here is a brilliant smorgasbord of different profiles able to be rolled, folded and/or welded together.



### Fastening to Thin-Wall Sections

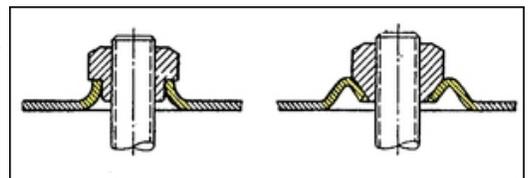
Thin-wall sections of the sort shown in the above diagram provide high strength with low weight. But when making attachments to them, care needs to be taken that the forces are appropriately distributed into the walls and that localised bending of the thin sheet does not occur.

Here a bolt passes through the thin wall. Note that a bush has been used to centre the bolt in the sheet metal hole.

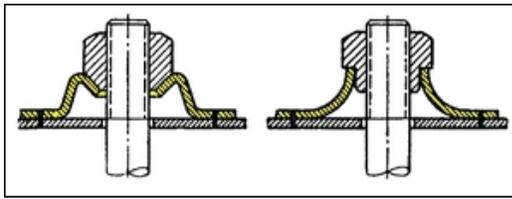


A large diameter washer has been used here to spread the load. (Incidentally, note the varying thickness of the washer – it's thickest where it needs to be strongest. More weight saving.)

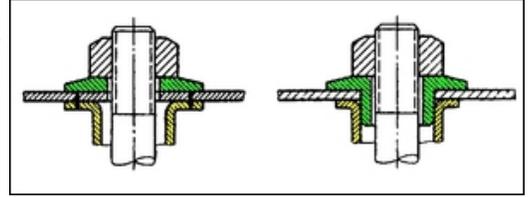
The walls of the hole have been flanged to provide greater strength. Note how the shape of the bush has been altered to match the flanging.



Here additional sheet metal stiffening elements have been added. Again, the shape of the bush has been altered to match the opening.

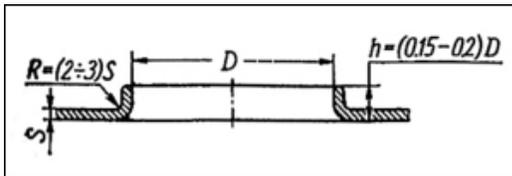


However the best approach is to use an internal column subjected to compression as the bolt is tightened. Here both external washers (green) and internal struts (yellow) have been used. (Click on the diagram to enlarge it.)



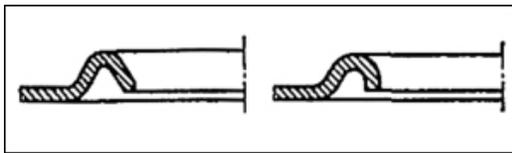
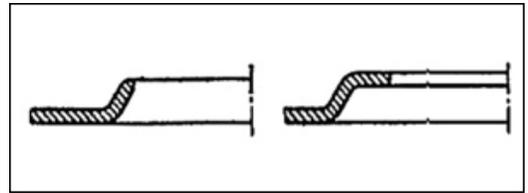
## Reinforcing Lightening Holes

The use of lightening holes in sheet metal is a common way of reducing weight. However, to increase local rigidity, reduce stress concentrations and enhance fatigue resistance, the holes should be reinforced. This can be achieved by pressing a flange or adding material.



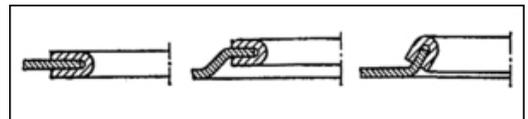
When a hole is flanged the flange height (h) should be in the range 0.15 – 0.25 of the hole diameter. The radius of the flange bend should be 2/3rds the thickness of the sheet.

Here are two alternative hole flanging approaches.



Flanging can also use half- and fully-curved edges, achievable through multiple flanging operations.

Reinforcing straps can also be added.



## Conclusion

This story contains just 17 simple and easily understood diagrams. However, the more I look at each, the more 'food for thought' I gain. From doing something as simple as bolting a bracket to the sheet metal inside the engine bay to building a full car, there's plenty here to consider...

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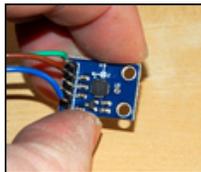
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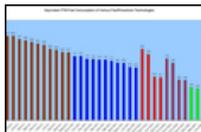
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