

Racing Car Suspension

by Major Arthur Mallock

London Special Builders' Group
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Reported by John Pitchers

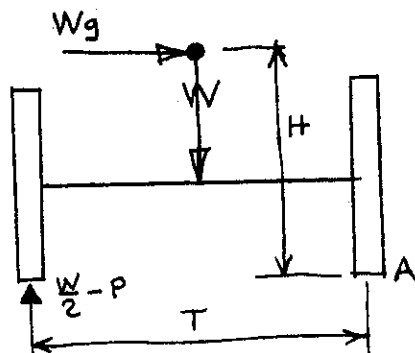
Arthur Mallock commenced his talk by explaining why the common theory that the centre of gravity of a racing car can be too low must be incorrect. The true state of affairs can be ascertained by a simple consideration of moments, which show that the total weight transferred from the inside to the outside wheel

$$\text{is equal to: } WG \times \frac{H}{T}$$

where W is the total weight of the car
 G is the cornering rate
 H is the height of the centre of gravity
 T is the track.

Thus for a given cornering rate the weight transferred is proportional to the ratio of C to G height to track.

Let the static weight on the inner wheels be $\frac{W}{2}$ and the weight transferred P , thus the reaction on the inner wheels whilst cornering $= \frac{W}{2} - P$. Consider moments about A , the outer wheel contact point.



$$WGH + \left(\frac{W}{2} - P\right)T = \frac{WT}{2}$$

$$\therefore WGH + \frac{WT}{2} - PT = \frac{WT}{2}$$

$$\therefore P = \frac{WGH}{T} \text{ or } WG \times \frac{H}{T}$$

It may be of interest to note that if H is less than half the track the car cannot turn over on a level surface, unless the coefficient of friction exceeds 1, which can normally happen only if the wheel hits a solid object.

If a constant track is assumed, then the weight transfer depends directly on H : slip angle depends on loading, so that the less weight transferred, the longer will the tyre remain within the limiting angle and hence the higher the cornering rate before breakaway occurs.

The effect of roll bars was next considered. Normally the idea of fitting a roll bar on a racing car is to increase the roll stiffness and hence the weight transfer at the end to which it is fitted. Therefore, if fitted to the front an understeering tendency will normally result, although the reverse sometimes happens on a car with a high C of G and low roll centre, as body roll causes the C of G to become displaced sideways, bringing it closer to the outer tyre contact path increasing the weight transfer.

The roll bar reduces this tendency and thus increases the cornering power, which can offset the normal effect.

The effect of roll centre height on weight transfer can be explained as follows, making the assumption that:—

1. The centre of gravity does not move relative to the tyre contact points.
2. The roll centre does not move.
3. The effect of the unsprung masses is neglected.

The formula for front end weight transfer can now be stated as:—

$$\frac{M R_f}{T_f(R_f + R_r)} + \frac{G H_f W_f}{T_f}$$

The rear wheel weight transfer is the same with the small suffixes f and r reversed. M is the roll moment and is equal to the total centrifugal force WG times the distance between the C of G and the roll axis.

T is the track

R is the roll stiffness

W_f is the static weight on the pair of front wheels

G is the cornering rate.

Suffixes f and r denote front and rear.

If we assume a symmetrical car with T_f equal to T_r and R_f equal to R_r and 50/50 weight distribution, then front end weight transfer simplifies to:—

$$\frac{M}{2T} + \frac{G H_f W_f}{T}$$

Now assume a cornering rate of $1G$, a track of $4ft.$, a C of G of $12in.$ and a total weight of 10 cwt. and roll centre at ground level.

The second term, the geometric weight transfer $\frac{G H_f W_f}{T}$ becomes zero, and all the weight is transferred via the first term through the springs.

$$\frac{M}{2T} \text{ now becomes } \frac{10 \times 1 \times 1}{2 \times 4} = 1.25 \text{ cwts.}$$

Rear end weight transfer will be the same, i.e., total is 2.5 cwts.

Now raise the front roll centre to 1ft., but keep the rear at ground level. The roll axis will now be 6in. below the C of G.

$$\frac{M}{2T} + \frac{G H_f W_f}{T} = \frac{10 \times \frac{1}{2} \cdot 1 \times 1 \times 5}{2 \times 4} + \frac{1 \times 1 \times 5}{4} = 1.875 \text{ cwts.}$$

At the rear the weight transfer now becomes:—

$$\frac{M}{2T} + \frac{G H_r W_r}{T} = \frac{10 \times \frac{1}{2} \cdot 1 \times 0 \times 5}{2 \times 4} + \frac{1 \times 0 \times 5}{4} = 0.625 \text{ cwts.}$$

The total weight transfer remains the same, i.e., 2.5 cwts., but by doing nothing more than raising the front roll centre from 0 to 12in. the front end weight transfer has become 50% more and the rear end weight transfer has been halved.

If the rear end roll centre is now raised to 12in. you are back where you started from, the weight transfer being the same at both ends.

Arthur considered that the confusion existing over this question arises from the effect of roll on the springs. The lower the roll centre the more the outer spring becomes compressed when cornering, which might suggest a greater

weight transfer. This, however, ignores the fact that only when the roll centre is at ground level is all the weight transferred via the springs. At other heights the second term of the weight transfer formula becomes significant. In the extreme, when the C of G and the roll centres coincide, all the weight is transferred via this term and none at all via the springs.

Arthur then went on to discuss some of the disadvantages of roll, amongst them unproductive weight transfer, adverse wheel lean, waste of suspension movement, dynamic affects particularly in connection with front-engined cars, passenger comfort in saloon cars.

Arthur mentioned "Racing and Sports Car Chassis Design" by Mike Costin several times in his talk, commenting that it was an excellent book to read if you are building a special.

Arthur also said that he considered that overall dimensions were more important than pencil slim body silhouettes when considering drag on open wheeled cars. This was confirmed at Rheims when the U.2 with a power deficiency of about 16 b.h.p. was only 5 m.p.h. slower than the works Lotus 20, the U.2 had a 10% narrower track. If drag is approximately proportional to track a 4in. increase in track will call for an extra 10 h.p. on a Junior to obtain the same maximum speed.

If these principles are applied to the new U.2 1172 car which Arthur is to race this season, this car should be even lower and narrower than the last one, which will be quite something to watch.

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