Fig 3.3 Original (left-hand) and modified oil pick-up strainers.

put a straight edge across the cut face. This represents the new bottom face of the oil containment, and the oil pump pick-up should be sited 3-5mm above it. Too low and you may restrict the entry of oil, too high and you risk the oil running away under hard cornering (the rule to avoid starvation is that the area around the bottom of the strainer through which the oil will enter should be larger than the cross-sectional area of the pump inlet. As an example, suppose we have a pump inlet diameter of 15mm; its area will be:

$\prod \times 15 \times 15 \times \frac{1}{4} = 177\text{mm}^2$
where $\prod = 3.142$

Supposing now that the inlet strainer is 50mm in diameter, the minimum height above the bottom of the sump will be:

$177 \div (\prod \times 50) = 1.1\text{mm}$

This dimension, I would stress, is the minimum required, and in practice would be difficult to achieve with any confidence due to distortion of sump and strainer housing through welding, which is why I recommend the aforementioned figure of 3-5mm.

The pick-up usually consists of a strainer on a stem, sometimes flange-mounted on the pump inlet, sometimes a plain pipe located in the pump inlet and sealed with an O-ring. It will be necessary to shorten the stem. This can be done by cutting out a section of the appropriate length then opening up the hole in each of the ends and spigoting them together with a suitable piece of tube. As long as these are closely fitted, an application of one of Loctite's stronger products (Type 275 being my preference) will adequately maintain the assembly. (See Fig. 3.3)

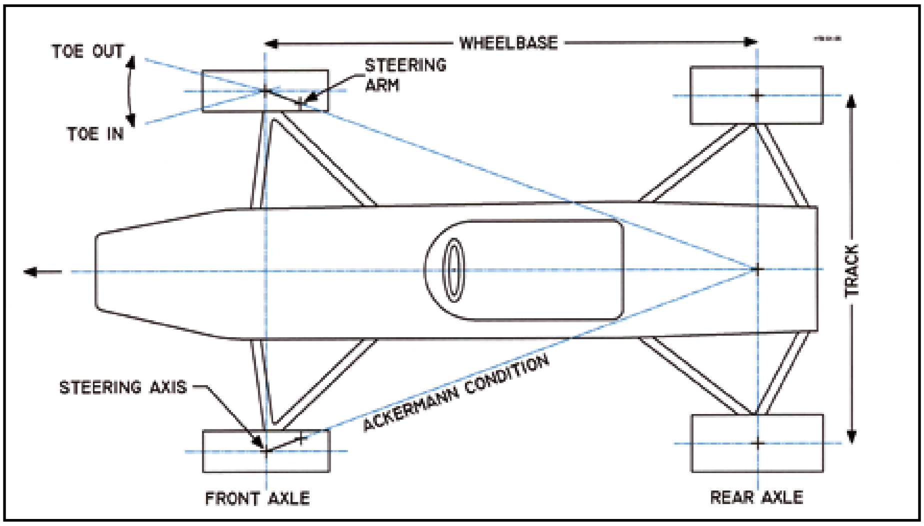
Alternatively, with flange-jointed pick-ups, it may be possible to remachine the flange faces and bolt holes at an angle suitable to lift the strainer by the correct amount.

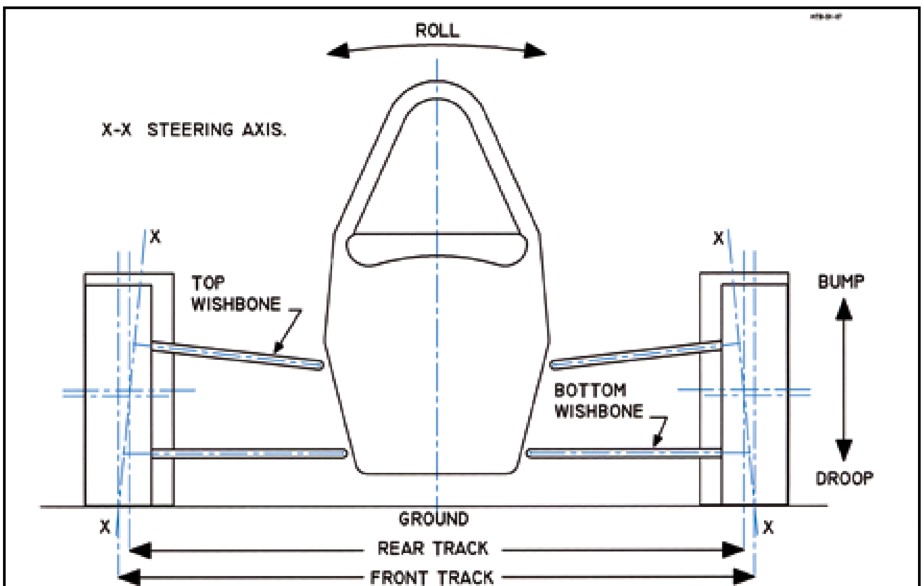
Where the pick-up pipe is a sliding fit in the pump, it's likely that its vertical position is maintained by a protuberance on the bottom of the sump, in which case similar arrangements will be needed on your new closure plate. There are engines which have an oil pump relief valve which is dependant upon the sump or an extension thereof for its location. This will have to be treated in the same manner as the pick-up pipe. (See Fig. 3.4)

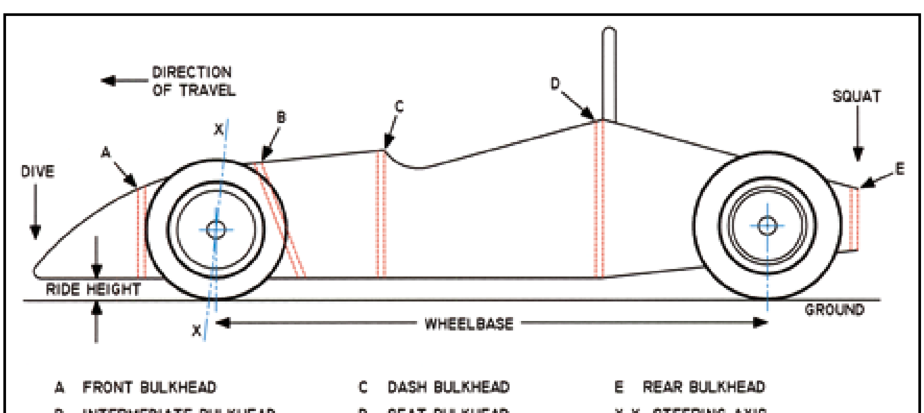
Fig 3.4 Oil pump pick-up, strainer and relief valve.

It's now time to bolt the modified sump back onto its stiffener and weld on the closure plate. (See Fig. 3.5)

Fig 3.5 Modified sumps.







Top: Fig. 6.1 Steering/suspension terminology 1.
Middle: Fig. 6.2 Steering/suspension terminology 2.
Bottom: Fig. 6.3 Steering/suspension terminology 3.

track rods, into rotary motion around the steering axis.

Track. The distance between the fore and aft centre lines of tyre contact patches on the same axle (or end of the vehicle), as this is likely to vary slightly with suspension movement we should qualify this as being with the vehicle at its normal ride height.

Track rod. A link with a means of articulation at each end which joins the steering arm on the front upright to the steering rack and pinion (or alternative mechanism). In some instances, such a link is used in the rear suspension where it's commonly known as a tracking link.

Trail. The distance between the line of the steering axis and the vertical centre line of the wheel at the point where they both touch the ground when viewed from the side of the car.

Upright. The steering/suspension component which incorporates the upper and lower steering bearings and the steering arm (or track adjusting link) and the wheel bearings.

Wheelbase. The distance between the vertical centre lines of the front and rear wheels when viewed from the side of the car, again at normal ride height.

Wheel rate. The relationship between wheel movement and shock absorber/spring displacement.

Wishbone (suspension arm, A-arm). An essentially triangular structure pivoting at two inner points on the chassis and at one outer point on the upright. Two wishbones, upper and lower define the path of the wheel during movements of the suspension.

AIMS

In practical terms, the suspension design process begins with the four patches of rubber touching the road. I should point out here that our purpose in designing the suspension and steering is to attempt to maintain the wheels at the optimum angle to the road surface at all times and under all conditions, and hence maximise tyre grip. This angle, customarily negative, varies from a fraction of a degree from the vertical in the case of crossply tyres to several degrees for radial ply tyres.

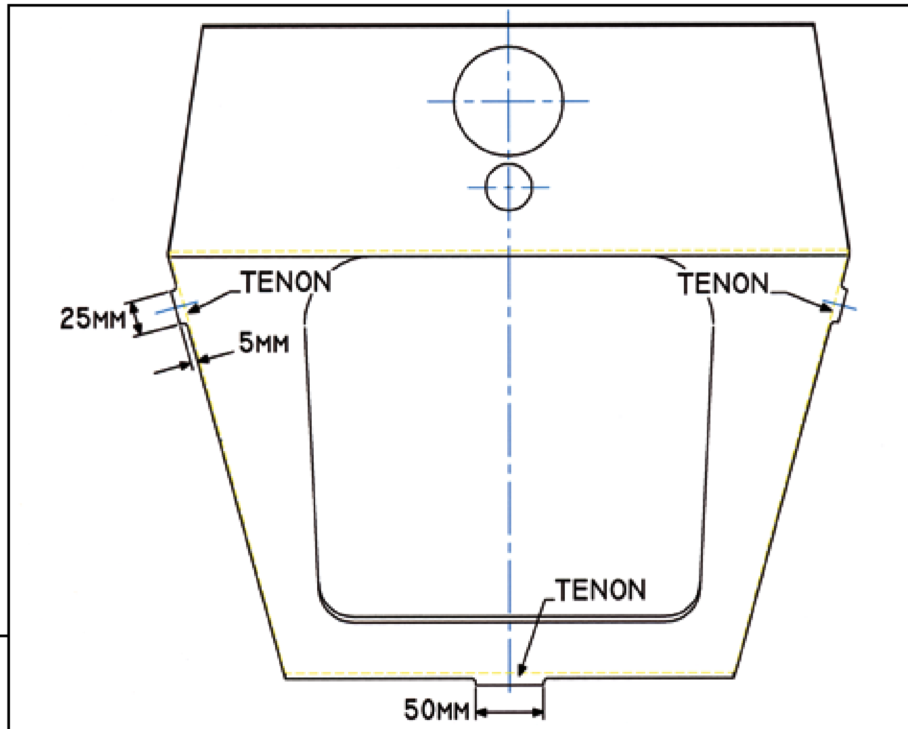
Right: Fig. 8.10 Typical bulkhead.

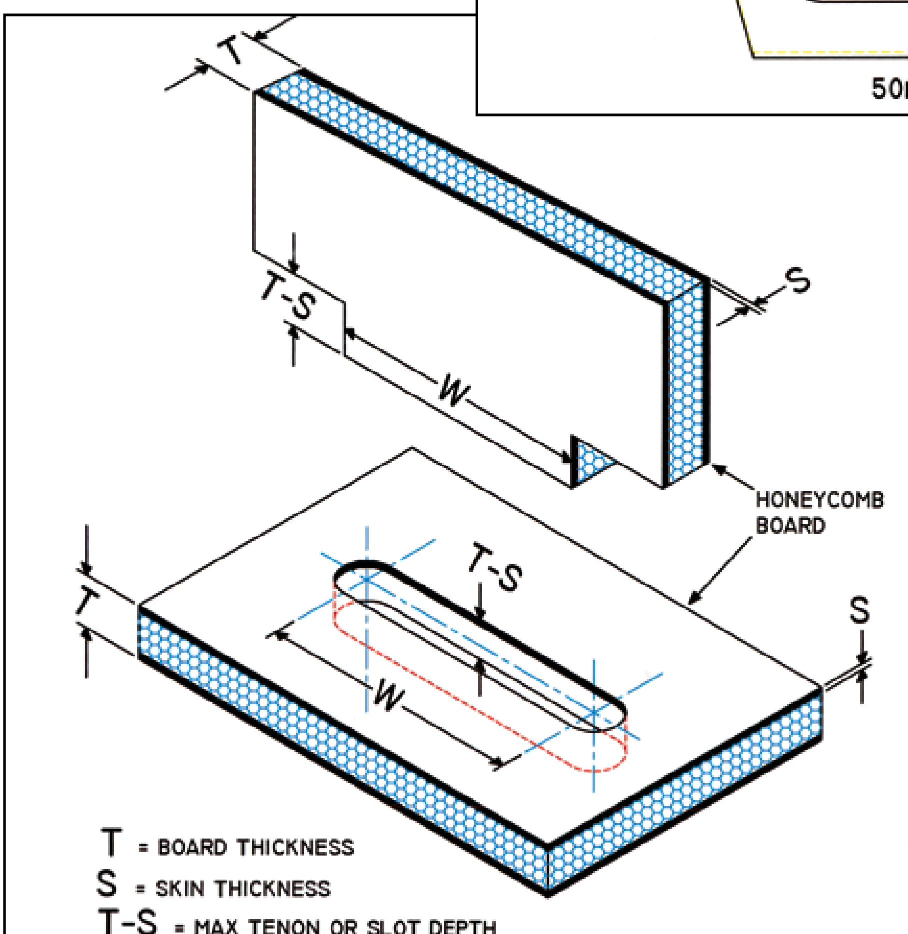
Below: Fig. 8.9 Honeycomb tee joint.

on around the periphery of the bulkheads on both sides; a) to further strengthen the joint, and b) to obscure the view of those who may be curious to see how accurate our bulkhead manufacture and fit was.

The third type of joint is that used when the board is being folded. This joint applies to one skin only. We almost thrashed this one to death under the 'folding' discussion. It should suffice to repeat that, before folding we should insert a liberal quantity of adhesive into the exposed honeycomb cells and, after curing, we should stiffen and seal the joint by fitting an aluminium angle piece across it. (See Fig. 8.3)

At the ends of our monocoque we will have a variation on the folded joint. This is to add some confidence-boosting 'beef' to the brake master cylinder mountings, and to the interface between the monocoque and the rear sub-frame. We will do this by folding and gluing suitably extended portions of the monocoque shell around the front and rear bulkheads thus locally doubling the wall thickness. (See Fig. 8.13)





HANGING STUFF ON OUR HONEYCOMB

There will be two basic methods of attaching components to our monocoque. Firstly, for equipment which has no effect upon the strength of the car (principally electrical apparatus of limited weight) it's sufficient to fix a suitable carrier on to the inside of the monocoque with adhesive.

The second category is for those items which are feeding loads into the chassis, those items which need to be rigidly integrated, and those which may need to be removable for maintenance. Examples of the above three would be: front suspension and rear sub-frame attachment points; brake master cylinder and seat mountings; and dashboard fastenings respectively.

These items we should attach by the use of threaded fasteners, or, to speak in common parlance, nuts, bolts and screws.

Fig. 8.11 'Dry' fitting of bulkheads.

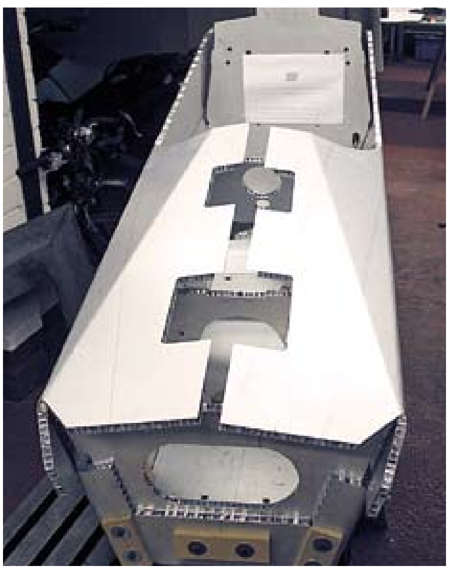


Fig. 8.12 Dummy run of monocoque folding.

Fig. 8.13 Awaiting the final fold.

Front wishbones	A minimum of two points per inner end, i.e., four per wishbone, thus sixteen in total
Rocker arm pivots	Two per side, total four
Front shock absorber	A minimum of three points at the fixed end, a total of six
Rack and pinion	Four points
Master cylinders	One of each, hence, two or three
Nose box	Four
Instruments/switches	About four
Gear change lever	One
Safety belts	Six
Rear sub-frame/chassis	Six
Chassis stiffeners (2)	Eight
Brake hoses	Six
Control cables	Six
Seat	Six
Wiring loom	One
Steering column	One
Air intake	Two
Gearchange linkage	One
Plank	Twelve

Perhaps here we should have roll call of what we might expect to attach to the chassis by this method to avoid, as far as possible, having to put unforeseen fittings into an otherwise completed structure. (See table above)

We cannot bolt directly through our material as it will not withstand the compressive stresses which that will involve. We must, therefore, fit load bearing inserts in the board, and locally reinforce the area around them. For convenience we'll christen our inserts 'bobbins' as, when assembled, they resemble cotton bobbins. The bobbin consists of two components; one passing right through the monocoque side, its actual length being the board thickness plus the recommended thickness of the adhesive film. The second component is a good fit inside the first, and is fitted into it from the reverse (normally inner) side of the board. (See Fig. 8.14) The outer component has a plain hole through it, whilst the inner one can be plain

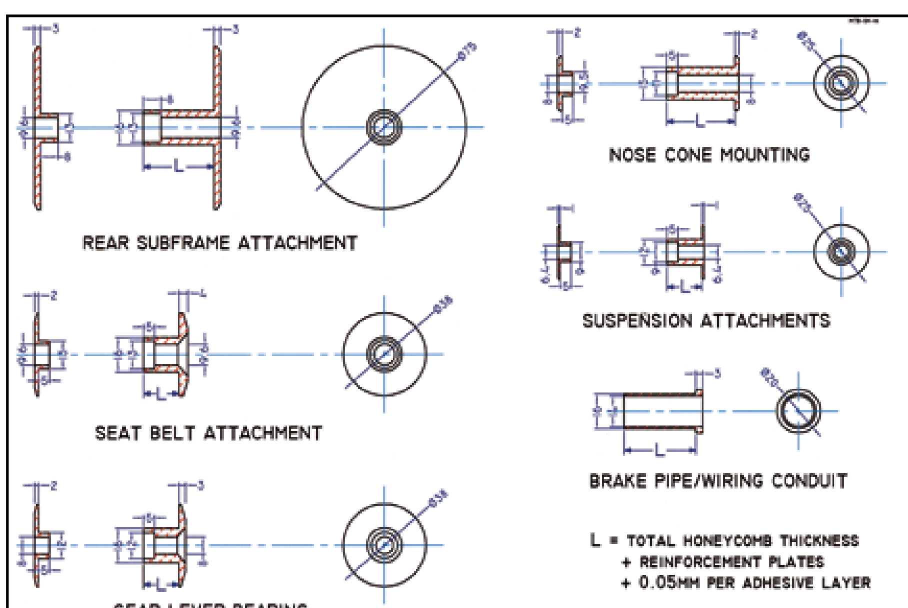


Fig. 8.14 Bobbins (illustrative inserts).

In addition, there will be penetrations for such items as brake pipes and cables which pass through the skins. These will be plain two-part sleeves fastened in the same manner as the attachment bobbins.

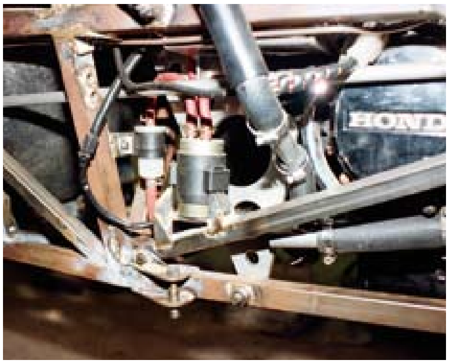


Fig. 13.2 Fuel pump and filter for carburettor setup.

Fig. 13.3 Fuel-injection system showing injectors (red wires attached), fuel rails, dump valve (to right of centre), and engine breather discharging to airbox.

Fig. 13.4 Fuel-injection throttle bodies.

have been fitted with fuel-injection as standard. This hasn't been done just for us, i.e., for performance reasons, but also to enable compliance with ever stricter exhaust emission regulations.

It has a spin-off for us, though, as these systems, once set up properly, are a great advance on carburettors, giving at least as much power, better throttle response, and consistent fuel/air ratios throughout the engine speed and load range.

Invariably, these systems are controlled by the ECU which apportions the fuel quantity in response to incoming signals from sensors located around the fuel/air inlet path.

These sensors measure the following:

Fig. 13.5 'Power Commander.'

Intake air temperature	Situated in the airbox
Intake air pressure	Situated in the airbox
Atmospheric air pressure	Situated on the vehicle out of any airstream
Coolant temperature	Situated in the cylinder head
Throttle position	Situated on the throttle butterfly spindle

The more complex systems also feature an oxygen (Lambda) sensor in the exhaust, to give even more control over the fuel/air mixture. In addition, there's an engine speed signal to the ECU from the ignition trigger on the end of the crankshaft.

Some systems have a sensor which uses the camshaft orientation to supply data from which the ECU determines which cylinder's injector to energise.

The ECU uses the sensor inputs to determine the ignition timing, the injection timing, and the amount of fuel fed to each cylinder, this being achieved by varying the duration for which the appropriate fuel-injector is open.

Besides the above inputs, there are signals to the ECU which veto engine operation. These may vary between motorcycle manufacturers, but usually are:

Lean angle cut-off switch – this stops the engine if the motorcycle falls on its side.

Side-stand switch – this stops the engine if the bike is put into gear with the side-stand down.

Clutch lever switch – this won't allow the engine to start when in gear unless the clutch is operated.

Some of the very latest machines have an inductive ignition key recognition device which also relays information to the ECU.

For our engine to function correctly we must supply the ECU with the required data from the above switches. We can do this either by fitting the switches to our car, even though their purpose is redundant, or we can fool the ECU into thinking that we are in compliance with all conditions necessary for the engine to run. Reluctantly, I would suggest that the former course of action might be preferable, as the required signals are not of an on/off nature, but rely upon subtle changes of voltage.

The ECU determines an air/fuel mixture strength, the consistency of which over the engine's speed and load range is adequate for road use but can be improved upon for racing. We can accomplish this improvement by installing a device known as a 'Power Commander' which is inserted in the wiring loom between the ECU and the fuel-injectors. (See Fig. 13.5) The Power Commander has an adjustment facility which overrides the signal from the ECU to the fuel-injectors. To set this device, the car is run on a rolling road dynamometer, and the exhaust gases are analysed by the use of an oxygen (Lambda) sensor inserted in the exhaust pipe. (See Fig. 13.6) The Power Commander is then set to give the most