

MOTOR CYCLE MECHANICS

AUGUST 1975 25p

TRAIL **5** TESTS

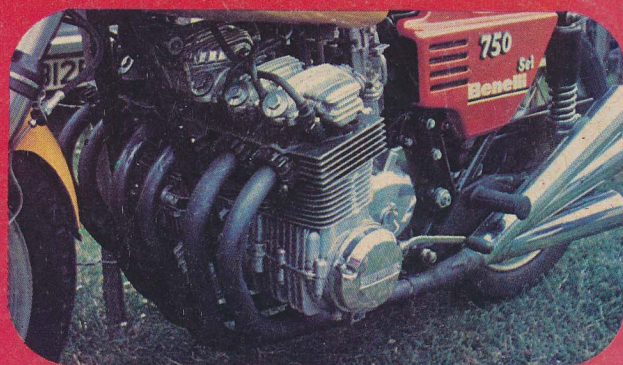


WIN A
GOLDWING
Great new competition starts inside



VIBRATION:
CAUSES AND CURES

ROAD TESTS **MOTO-GUZZI 750 S3**
KAWASAKI SI 250



YAMAHA FSIE SERVICE

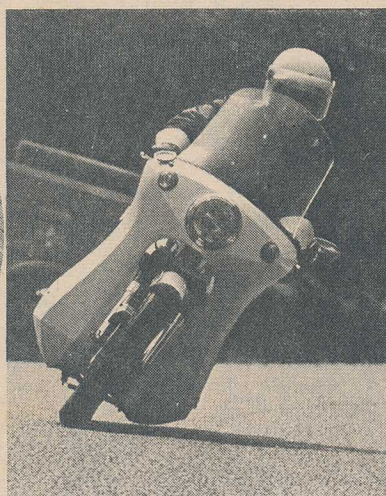
TT TRENDS



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East Midland Allied Press Ltd. Editorial and Advertisement Offices: Aqua House, London Road, Peterborough PE2 8AQ. Telephone: 0733 63100.
 Editor: COLIN MAYO
 Deputy Editor: JOHN ROBINSON
 Technical Editor: MIKE CAZALET
 Photographer: ROD SLOANE
 Designer: KATHERINE LELOUP
 Graphics: BILL BENNETT
 RICHARD ELFORD
 Advertisement Manager: PETER CREW
 Assistant Advertisement Manager: DEREK STONE
 London 01-242 8938
 Northern Advert Office
 Manager: JOHN FRENCH, 44 Station Road, Cheadle Hulme, Cheshire, Telephone: 061-486 0246.
 Circulation: Park House, Park Road, Peterborough PE1 2TS, Telephone: 0733 63100
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AERODYNAMICS

MOTORCYCLING'S LOST CAUSE

Do you drive on four-wheels as well as ride on two? Then the chances are that at some time or another you have compared the fuel consumption figures between the two types of vehicles. A superficial comparison will make the motorcycle look by far the most economical, but if you get into the matter more thoroughly it will quickly become obvious that once weight is taken into account the car is far more efficient.

Let me give you an example to emphasise the point that I am trying to make. Driven over the same route a car of just under 1,000cc and a 500cc motor cycle gave 46.5 to the gallon, and 67mpg respectively. Total weight shifted from point A to point B by the car's engine was 1700lb while total weight moved by the motorcycle's engine was some 600lb. Average speed achieved by both car and bike were virtually the same. Analysing the facts the car has moved some three times the weight for only about 22 per cent greater fuel consumption. If the bike was anything like as effective at transporting its mass from point A to point B as the car, then its fuel consumption should theoretically be 167mpg.

Maybe we can't expect theory to work out perfectly in a very imperfect world, but why should the motorcycle be some 100mpg shy of what might be expected? I shouldn't think it will come as a surprise to many of you, but the answer is aerodynamics. A motorcycle, less fairing and with a rider sitting on it must have about the dirtiest aerodynamics of anything on the road.

If you think the comparison I've made makes it look bad, then I'll go one step further and make it look even worse. The average car's aerodynamics is nothing to shout about either. When sheet metal designers stop pandering to the whims of fashion and start designing some really aerodynamic shells, then we may get some vehicles which will look nice and expend a lot less hp moving a bit of air from one point to another.

Okay, so much for my beef about car designers, but what about motorcycles? If they are so bad why aren't all the motorcycle designers suffering from an over-powering guilt complex from their failure to cater for such an obvious point? I suppose there is a sort of excuse for this in as much as streamlining a motorcycle has definite problems which don't crop up with a car. A car just has to have a body with doors to get in and doors to get out. When a car comes to a stop, you don't need to put your feet down to stop it falling over. A bike is another thing altogether. Whereas a car is a box with all its mechanical aids stuck inside, a bike is a conglomeration of appendages looking for a body to call home, and that is about the size of the problem.

These days we are forever getting it rammed down our throats, and I think rightly so, that the world's resources are running out. The big problem is that there are too many of us using its resources too fast. This being the case, bike designers are going to

TYPICAL COMPUTED DRAG FACTORS

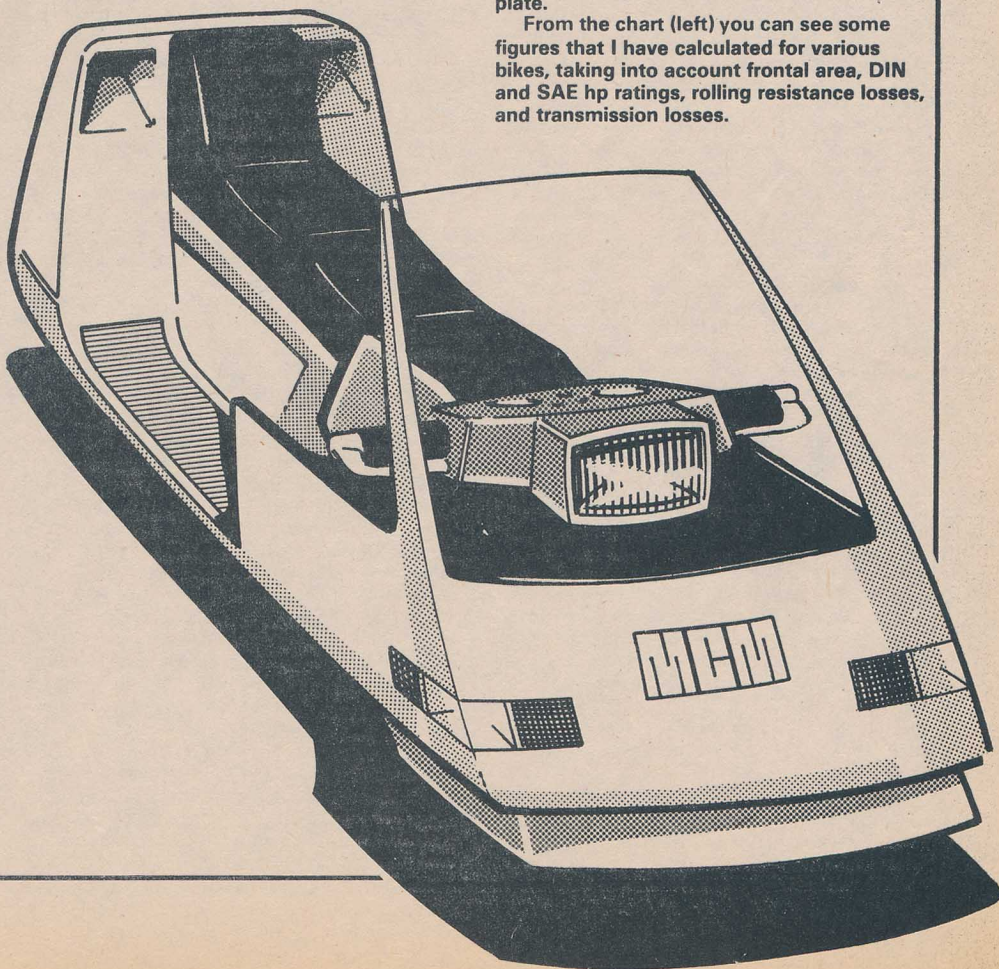
With allowance for transmission losses and DIN and SAE engine ratings.

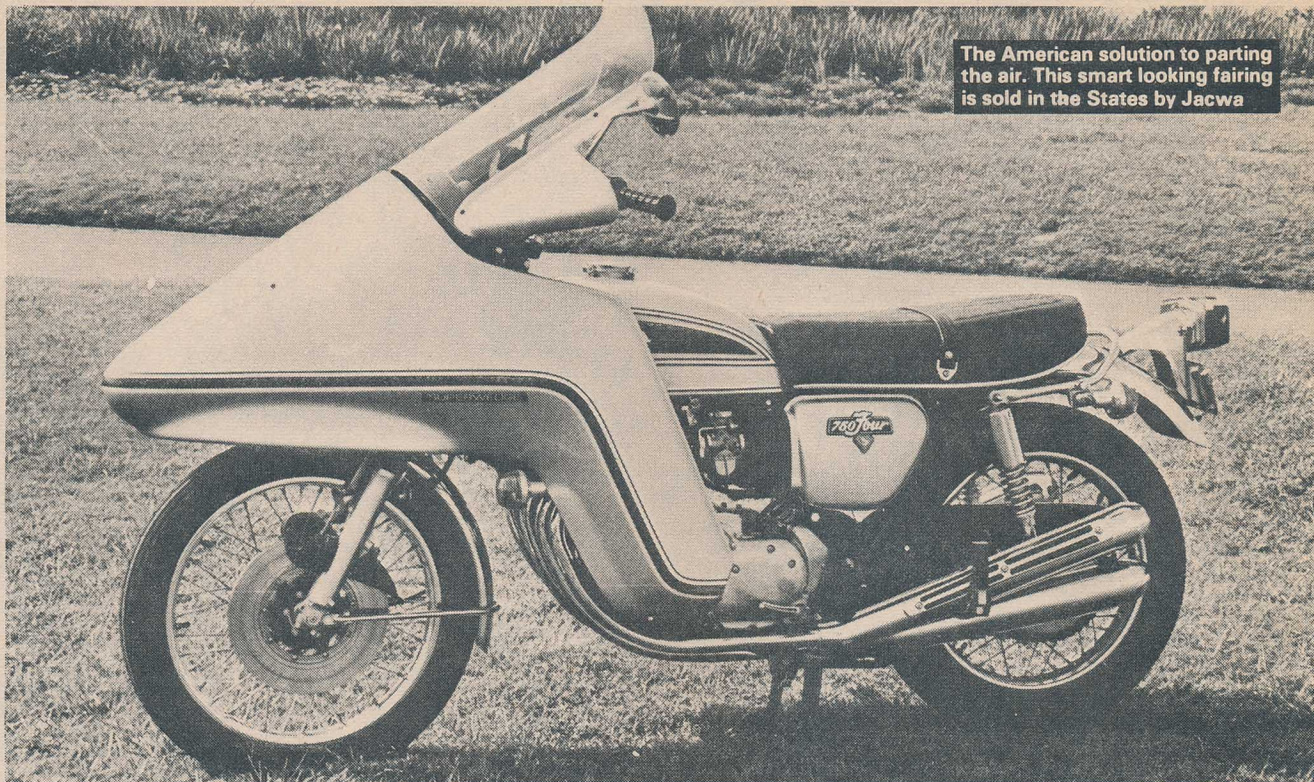
M/C	Co
HONDA CB360.....	1.18
HONDA CB250 (1974).....	1.13
HONDA CB250 (1972).....	1.05
HONDA CB500.....	1.05
HARLEY D 350 (upright pos)	1.39
KAWASAKI 3, 2 stroke, 500.....	1.05
KAWASAKI 90	1.05
MORINI 350 V-twin.....	1.11
AVERAGE OF ABOVE.....	1.15
FLAT PLATE.....	1.2

have to face the problem of aerodynamics if they are going to get machines which will give more mpg and more speed. They are certainly not going to get more from engine technology. It's an accepted fact that motorcycle engines tend to be far more advanced than anything the four wheel industry can offer.

To see just how big the aerodynamic problem is, have a look at the figures in chart one. A flat plate 90 degrees to the direction of wind is about as unstreamlined as a simple geometric shape can be. It has a drag co-efficient of 1.2 (the bigger the number, the worse the drag). A long, streamlined object has a drag co-efficient of around 0.1. This means that it takes only about 8 per cent of the power a flat plate needs to drive it along at the same speed through the air. How does a bike fare? Pretty badly I'm afraid. The average bike is only just a little better than a flat plate, and that's when you have everything going for you — chin right down on the tank, and your arms and legs and shoulders pulled in as tight as possible. As soon as you sit up — bang! — frontal area goes up and drag co-efficient gets even worse than a flat plate.

From the chart (left) you can see some figures that I have calculated for various bikes, taking into account frontal area, DIN and SAE hp ratings, rolling resistance losses, and transmission losses.





Now I will be the first to admit that you can't take these figures as being absolutely spot-on as there are too many variables involved. They ought, however, to be in the right ballpark, and its significant to note that the Harley-Davidson 350 which has a very upright riding position, making it almost impossible to really get down on the tank when you are doing speed testing, has a significantly higher drag factor than the others.

What does all this mean in terms of performance? To cut down wind resistance two things must be taken into account: first, the frontal area of the machine and, second, its drag co-efficient. In practice there tends to be a limiting factor as to what can be done to reduce frontal area of a machine. Four square feet is about the rock bottom limit for a sane riding position on a bike which retains anything like conventional seating. In practice, $4\frac{1}{16}$ square feet for a machine designed for speed is a much more practical figure, and 5 square feet is not too far off normal. If you really want to try and attract a lot of wind, then you can raise that figure to $6\frac{7}{16}$ or 7 square feet, like on the big Harleys.

Having aimed for the minimum frontal area practical, the next job is to streamline the machine by paying careful attention to its aerodynamic shape. Take a look at Chart and Graph and you will see just how much hp it takes to drive a bike along at a given speed. At low speed there is not a great deal of difference, but the difference starts to become very real from 30 or 40mph upwards. A bit of thought as to the aerodynamics and even a 50cc machine could make quite a bit of difference to its performance.

The second line and group of figures in our chart and graph shows the hp/speed requirement for a motorcycle having a drag co-efficient of 0.75. That might sound a big

drop from 1.15 down to 0.75 but when you consider that the average car is around 0.45 I don't think it's asking a lot. Bonneville style streamliners get down to 0.15, but riding a bike like that is totally out of the question on the road. However, trying to hit something between these two extremes might provide an answer.

Anyway, let's go back and survey our figures for a moment and see if we do in fact gain anything worthwhile. Take a 50cc machine with about 4hp to drive it along. Unstreamlined its top speed would be about 44mph. With a 0.75 drag co-efficient the same bike would have a top speed of 52mph. From the fuel consumption point of view the picture is similar. At a steady 40mph the unaerodynamic bike would do 196.9mpg whereas the aerodynamic one would manage 270. That's at steady speeds. In practice, under stop-start conditions these figures wouldn't be achieved, but the difference would be there none-the-less.

Some designers argue that a small bike isn't fast enough to warrant streamlining. That could be negative thinking, because you could also say that it doesn't go fast because it isn't streamlined. Assuming that anything which is capable of running up to about 70mph is capable of cross-country rides without undue strain, then the difference between a streamlined and unstreamlined machine could mean that whereas you need a 150cc machine to reach 70 before, a 100cc motor will get the job done in its aerodynamic state. While we are talking about economics, the difference in fuel consumption at 70mph between our hypothetical aerodynamic bike and our unaerodynamic bike is the difference between 73mpg and 105 at steady speeds.

Although the argument for streamlining is valid for small bikes, it really holds strong for big machines, and principally for one reason: wind resistance suffered by an object goes

up with the square of the speed. That means if you double your speed, you have got four times the wind resistance to contend with, and what is worse is that it needs the cube of the hp to overcome it. In simple terms when we double our speed, we have four times the force of wind resistance to overcome, and to overcome it we need eight times the hp.

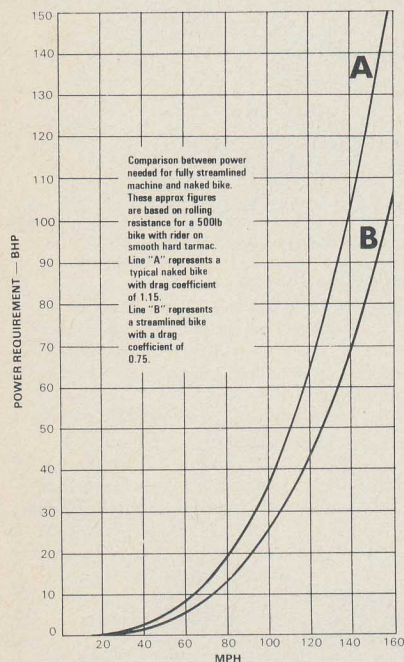
If we have a machine with a lot of hp, why waste it all? Looking at a middleweight bike first, the Morini 350 V-twin tested a few issues ago has just enough hp to make 100mph. Streamlining it to give a 0.75 drag co-efficient would have tacked 15mph on this. By cutting down the drag by this sort of figure on a fast bike, it doesn't mean just more top speed, but it also means much better top end acceleration. Cruising at 90mph, the Morini only had 10hp left for extra acceleration in its unfaired form. Streamlined, it would have left 20hp to accelerate it from 90 upwards. It might be adding weight to the bike to streamline it, but nothing like enough to make a significant reduction in the gains made in other directions.

What about a big bike with plenty of power, say 70hp? With a top speed unfaired of 122mph, top speed faired in and streamlined would be 140mph. With big bikes, fuel consumption starts to be a factor which needs a great deal more consideration, especially with the price of fuel as it is these days. Flat out at 122mph a 70hp superbike is doing about 26 to the gallon. Streamlined it should do 37mpg or, conversely, driven flat out in its faired condition, 28.5mpg. So that's the argument for aerodynamics, but before we turn to the arguments against, let's just have a look at drag bikes. These days there are machines on the strip with plenty of hp and terminal speeds are high, 150mph being common. Streamlining a bike inevitably means extra

MOTORCYCLING'S LOST CAUSE

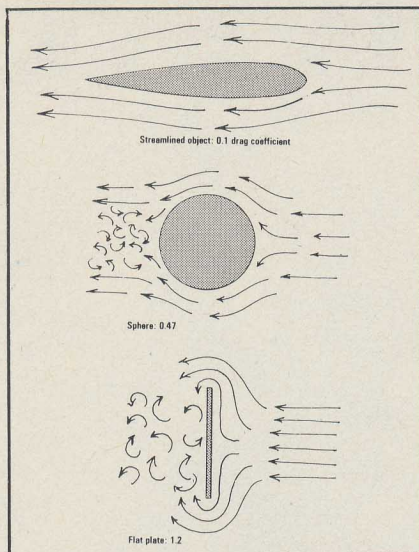
weight, and weight for a drag racer is worse than a bank overdraft. If some efficient streamlining can be done on a drag bike though, it looks like it could well be worth it. Consider the case of an average 150mph drag bike. My guess is that such a bike will reach 100mph very early on its journey down the strip, say at most between 120 and 150 yards. At the point its using 40hp to overcome wind resistance and the rest of its power to accelerate it. In streamlined form it's only using 26hp to overcome wind resistance and the rest of its power is available to accelerate it. In other words, even at this early point down the strip, dropping drag co-efficient to 0.75 is worth 14hp. At the other end of the strip just before it crosses the finish line at 150mph, 130hp is needed to overcome wind resistance in an aerodynamically dirty state. With fairing it needs only 87.5hp to combat the air, so just before crossing the line, the faired machine has 43hp in hand for extra acceleration.

In spite of what you may be thinking, I realise that fairings exist for motor cycles,



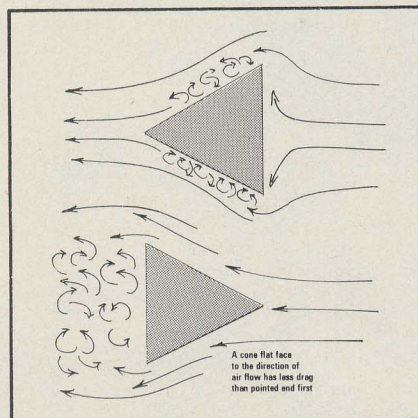
but just how effective are they, and can they be improved upon? There are no two ways about it, most fairings do cut down drag, but by how much. There is certainly a great deal of room for improvement on all motor cycle fairings and with the exception of the Bonneville Streamliners, they all seem to suffer from one particular drawback. The biggest problem with wind resistance is not how you meet the air, but how you leave it. A cone going into the airstream pointed end first has more wind resistance than if it is turned round with the pointed end trailing.

Up to now every road fairing has been concerned only with the approach to the airstream. While anything helps you can run into a problem if you concentrate completely on the front end. The fully enclosed front end dustbin type fairing suffered from instability at high speed, principally because the centre of wind pressure had been moved too far in front of the centre of gravity, thus making it aerodynamically unstable. One of the most



aerodynamically stable items is a dart and that's because the centre of gravity is well forward of the centre of wind pressure. If it starts to go through the air sideways, it becomes self-correcting.

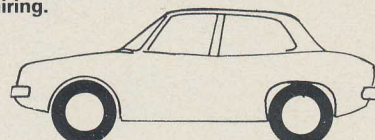
The only way to overcome the adverse centre of wind pressure characteristic on a full frontal fairing is to have an equivalent fairing behind the centre of gravity to even things up, or better still, even move the centre of wind pressure back to increase stability at high speed. The problem with such fairings is that machines need to be designed right from the outset to be able to



accept streamlining. The Ariel Leader and Arrow of the early sixties represented the first serious attempt at aerodynamics on mass produced bikes. Unfortunately, it was little better than a half-way measure. Had it been more radical, it may have set the pattern for years to come, but as it was, it was just a machine which was a bit different at the time.

The modern, aerodynamic machine is going to have to be designed along slightly different lines if it is to take full advantage of all the practical streamlining that can be done. First, overall wheel diameters are going to have to go down, so as to reduce frontal areas. Along with this, engines will probably be better having lower overall heights, thus allowing the seats to be nearer the ground and the rider to place his feet squarely on the ground while the machine is at a standstill.

The average wheelbase length will also have to go up, possibly by as much as 12in or so. A longer machine will allow two people to ride and still offer a seating position that can be more easily encompassed by a fairing. Apart from that, an increased wheelbase length isn't a bad idea from the point of view of cutting down pitching. It can also aid straight line stability, especially if the centre of pressure and centre of gravity positions are put in the right places. At high speed this is critical on a machine which may not have a lot of fairing.



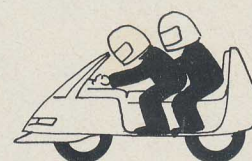
COMPARATIVE DRAG COEFF



MOTORCYCLE, CROUCHED RIDER: 1.1-1.3



FAIRED MOTORCYCLE: 0.9-1.15



STREAMLINED MOTORCYCLE: 0.75

Taking things several steps further but far more complex in nature, I envisage the layout shown on page 25 as being relatively practical. It is possible, though, that there are a few things I haven't included, but if some of the ingenuity which is put into the design of the modern motorcycle engine was re-directed to motorcycle aerodynamics, I am sure that a practical design could be produced very quickly.



Vizard the Wizard