



THE INSIDE STORY OF MOTOR CYCLING

# On Two Wheels

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## NEXT WEEK'S ISSUE

**Touring** — *Bruce Preston.* For most motor cyclists there is little to equal the joy of a sunny day, a clear road and a fully fuelled machine. Touring can be tremendous fun, but a long trip, if not properly planned and organised, can turn into a nightmare. Next week we look at some of the things you need to bear in mind when planning a trip. All it needs is a little knowledge and thought and the world, literally, can be your playground. Bruce Preston, himself a vastly experienced tourer, passes on some of the more vital tips gained over years of practice.

**Tourist Trophy** — *L.J.K. Setright.* There is no other place like the Isle of Man, nor is there any other race like the Tourist Trophy. Like it or loathe it, the TT has been the single most important sporting event in the history of motor cycle competition. Many have tried to kill the TT over the years, but none has succeeded. The TT has become the race that refused to die.

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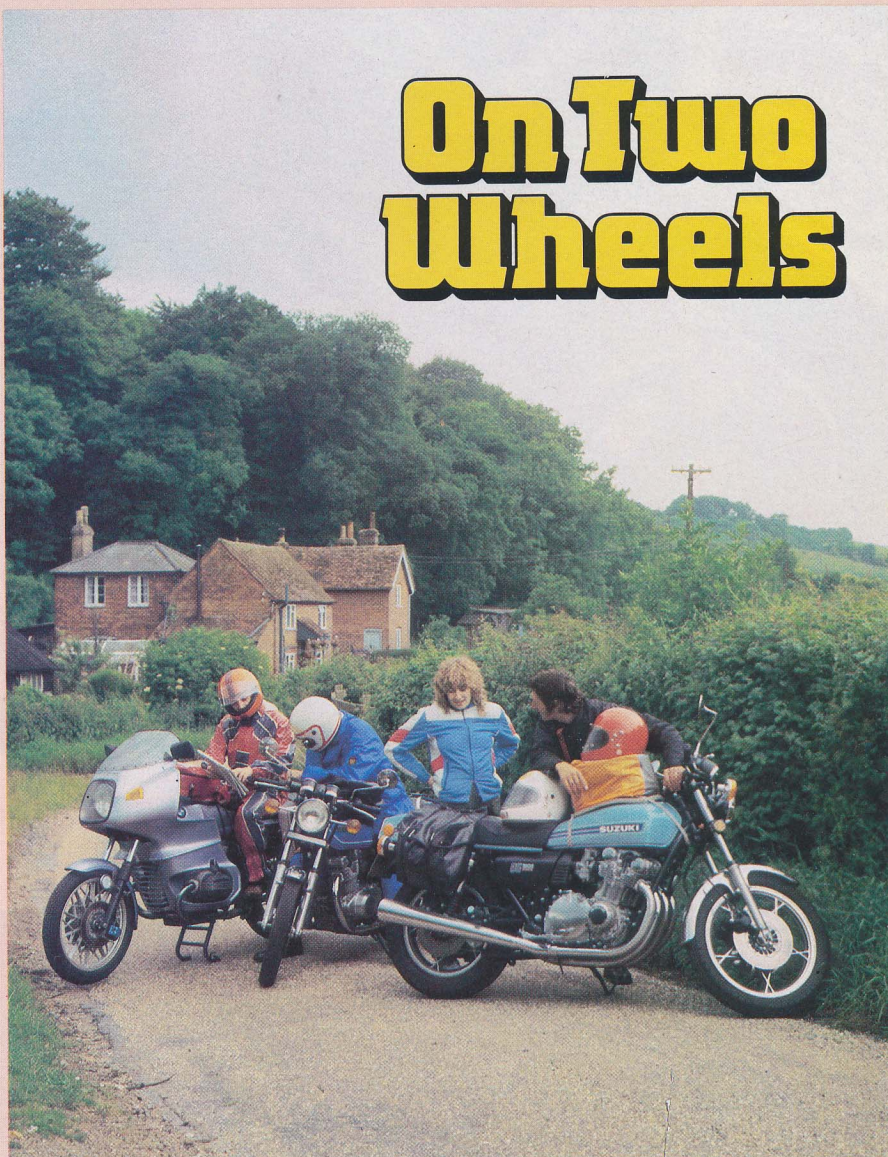
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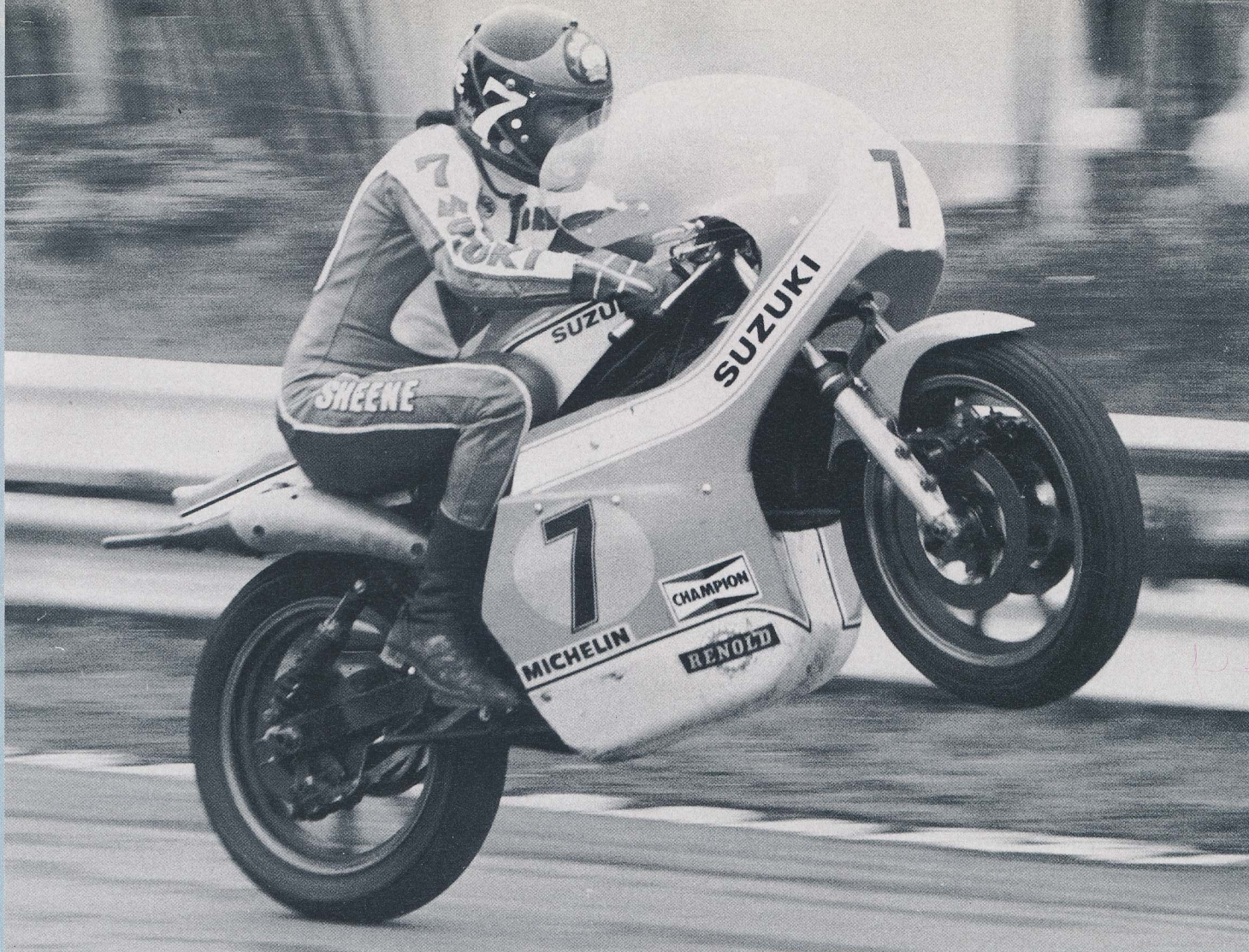
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# On Two Wheels







# A Turn for the Better

PEOPLE WHO TALK glibly about power often encounter the strangest problems in discussing torque. Engine ratings are generally expressed in terms of power output, and have been ever since the steam engineer James Watt conceived his classical unit of horsepower by which to relate the *rate of doing work* possible with his new machine to the performance of the only motive device (the horse) generally available to people at the beginning of the steam age. After a couple of hundred years of industrial revelation, we should be familiar with the terminology of mechanics; yet, it is as much a problem of vocabulary as anything else which makes it difficult to conceive what torque is. Take a little time to consider the problem, and you may see that time is what relates torque to power: power is the rate of doing work (Watt's horsepower represented 33,000 foot pounds per minute), and torque, which is a measure of resistance being overcome by a shaft or some other body turning about its axis, is a mode of work. To call it twisting power is therefore as wrong as to call it twisting force or rotational pressure; one might as well call it Fred.

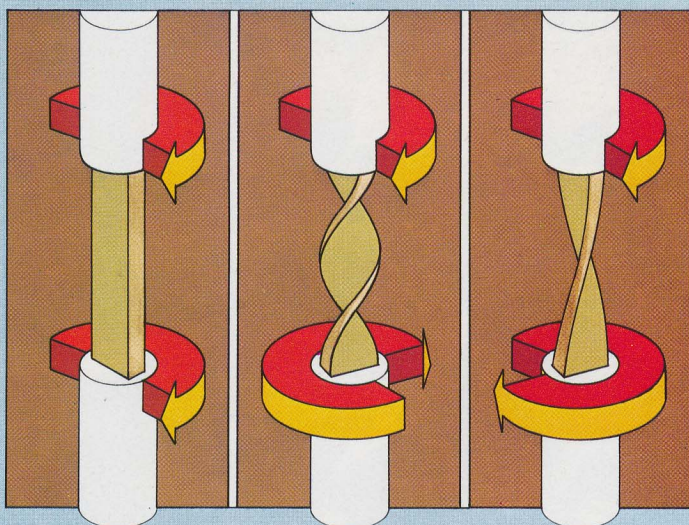
In a motor cycle, torque is best traced back to its beginnings in the combustion of fuel and air in the engine's cylinders. The mean effective pressure in a cylinder can be measured in convenient units, such as kilogrammes per square centimetre (kg per cm<sup>2</sup>) and in a good four-stroke specimen running at full throttle and full load it might amount to 10 kg per cm<sup>2</sup>. This pressure is exerted on the crown of the piston, the area of which can be measured in similar units: a piston fitting a cylinder of 56.4mm diameter would have an area of 25 square centimetres. Multiply the pressure (kg per cm<sup>2</sup>) by the area

(cm<sup>2</sup>) and the answer must be in kilogrammes (actually it is 250kg) and is a measure of the force being applied downwards on the piston by the mean pressure of the gases within the cylinder. Since it is a force rather than a mere weight or mass, we ought strictly to distinguish it by use of the unit kgf, which stands for kilogramme-force, but people seldom bother. This force applied to the piston is transmitted through the connecting rod to the crankshaft. If the stroke of the piston is 50mm (which would give the cylinder a displacement of 125 cubic centimetres or cc), the radius of the crank throw will be half this, and to maintain continuity in our units of measurement we should express it as 2.5cm. This radius, the distance from the centre of the crankpin to the axis of rotation of the complete crankshaft, is equivalent to the length of the lever whereby the piston forces the crankshaft to turn: the axis of rotation of the crankshaft is the fulcrum, the crankpin is where the force is being applied. Multiply the force (250kg, remember) by the length of the lever (2.5cm) and the product is 625 kilogrammes centimetre (kg cm).

It seems a curious unit of measurement and an almost meaningless one but, by examining how it was produced, its meaning becomes clear. It is a measure of the work load being overcome by applying a force through a lever and, since

*Above: the terms torque and horse power are often confused and cause a great deal of debate. Here Barry Sheene accelerates his Suzuki RG500 out of the hairpin at Mallory Park and discovers that his machine has both torque and horsepower in abundance*

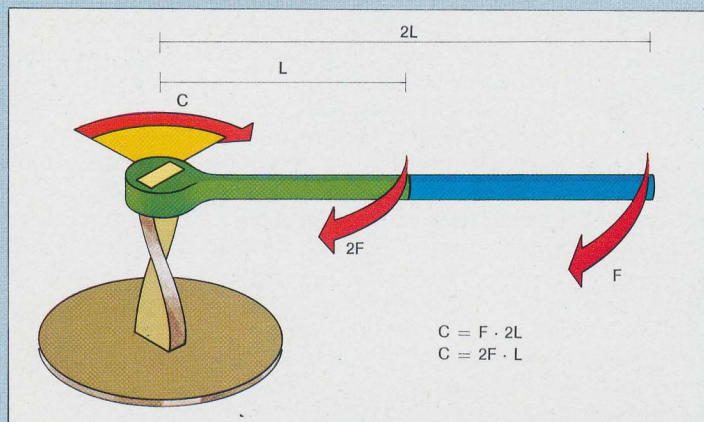




the leverage is in this particular case being maintained around the fulcrum so as to cause the crankshaft to turn on its axis, we call it torque. Perhaps that is begging the question. Very well: the word torque is derived from the Latin *torquere* which means *to twist* and, if the end of the crankshaft were held fixed, the effect of the leverage applied by the piston through the crankthrow would be to twist the crankshaft. Thus, in mechanics, torque is what induces a twisting or torsion in a body. So far, so good; the only snag is that the translation of linear force into circular motion by the familiar con-rod-and-crank mechanism produces a cyclic variation in the leverage applied, forcing us to divide our nice figure of 625cm kg by the transcendental number  $\pi$ , leaving us with 198.9cm kg. Again, because we are dealing with a four-stroke in which one of every two revolutions of the crankshaft is idle, we must

*Above: if a metal bar of low torsional rigidity were to be inserted in the drive shaft of a bike, it would demonstrate the torque being applied to the wheel. The torque required to climb a hill (centre) is far greater than that needed for a level road (left) while if the rear, or driving, wheels are lifted off the road surface they will spin freely, with very little torque involved (right). This also demonstrates the description that torque is the power of a twisting or rotating force; it is the product of one of two equal, opposite and parallel offset forces and the distance between them*

*Below: this diagram demonstrates the effect of torque on a metal bar; the amount by which the bar twists is directly proportional to the torque applied to the lever, which in turn depends on the length of the bar and the force applied to it. Incidentally, many people confuse torque with horsepower. Torque is the effort exerted on a shaft to move the vehicle along. When the torque is great enough to move the shaft through a given distance in a given time, this is horsepower*



halve the answer and emerge with 99.45cm kg. While we are about it, we might as well bow to the conventions which (before the new SI units of measurement were introduced by the scientific purists of Europe to throw matters into even more confusion) bade us express torque in metre kilogrammes: dividing by 100 leaves us with about 0.99m kg.

Take another look at our calculations and you may spot that what we have done in effect is to multiply pressure by cylinder capacity and apply a couple of constants to cater for the four-stroke cycle and the shortcomings of the piston-con-rod-crank mechanism. Thus, it becomes obvious that torque is related to cylinder displacement: if we doubled the number of cylinders to make a 250cc engine, it should develop twice as much torque, and a 500 four should give 3.96m kg – which might look more familiar and realistic, to readers accustomed to Imperial units of measurement, as 28.6lb ft. The important thing to note is that the rate of revolution of the crankshaft has nothing to do with it: torque is an instantaneous measurement involving no time element. If we made a 500cc single-cylinder engine with the same stroke: bore ratio, and (which is unlikely) the same thermal and volumetric efficiencies so that it developed the same mean effective pressure within the cylinder, it should produce the same torque as the 500 four; the only differences would be minor ones reflecting differences in mechanical losses according to the bearings and other machinery involved. The four could run at higher revolutions per minute than the single, however, because its smaller pistons and shorter stroke would reduce the mechanical loads – and this is where time becomes significant. Both engines might develop the same torque, but the four would, by virtue of its faster running, have a greater rate of doing work; in other words, it would develop more *power*.

Power and torque seldom occur at the same rpm. Torque is at a maximum when pressure is at its maximum, at whatever speed the breathing and burning of the charge of fuel and air is most efficiently conducted. At higher speeds, these efficiencies may fall but, until they are falling faster than the revs are rising, the power output will continue to increase as the rpm figure is increased. When eventually that point is reached, the power reaches its maximum; any further increase in rpm will be accompanied by a fall in power output.

Torque from the crankshaft can be multiplied by gearing. If the primary drive from crankshaft to clutch entails a reduction in rpm so that the former does 1.414 revolutions for one turn of the latter, the clutch will be subjected to a torque 1.414 times greater than the engine produces. Let the clutch feed this into the gearbox through cogs which impose a further reduction in the same ratio, and the torque at the gearbox output shaft or sprocket will be twice what the engine develops. Follow this with a final drive ratio of 4:1 so that the rear wheel turns at quarter the rate of the gearbox output shaft, and the torque will be correspondingly multiplied so that finally it will be eight times as great at the rear wheel hub as it was at the crankshaft. In the case of our notional four-cylinder 500, it will amount to 31.68m kg and, if we divide this by the rolling radius of the tyre (call it 306mm for a 4.10 H18 TT100 Dunlop), we deduce a force of 103.5kg applied by the tyre to the road. This is the thing which matters, the tractive effort: the greater this force in relation to the mass of the machine and rider, the stronger will be the hill-climbing or accelerating ability. Hence, the importance of gearing: it enables the torque, and thus the tractive effort, to be increased to meet demand. What it cannot do is to increase the power, for power is the rate of doing work: it makes no difference to the engine whether it be pushing the bike along at maximum speed in top gear or just managing to maintain the same crankshaft rpm up a steep hill in bottom gear. The resistance and the tractive effort may be three times greater in the latter case as in the former, but the road speed will be only a third as great: the rate of doing work is the same.

LJKS