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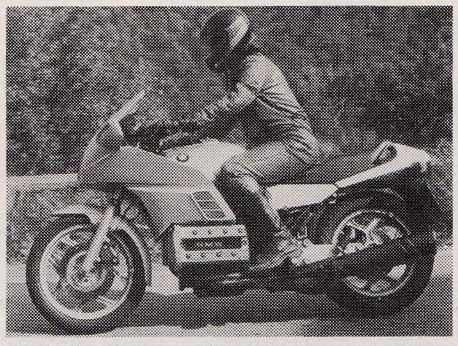
HOW THEY MADE THE K100

It was a big job, because the bike has to have a long, long life

THE MOST valuable parts of an interview lie not in the great bulk of fact provided by the individuals concerned but their occasional, frequently off-hand remarks which at the time pass barely noticed yet, for some apparently indefinable reason, are never forgotten.

Two years ago Stefan Pachernegg, BMW's director of (motorcycle) product development, who is currently trying to cope with his unexpected elevation to star status, described his major problem as having to design not for purely functional requirements, but to appease frequently emotively-inspired political demands. Two weeks ago he clarified that irritating little crumb of wisdom. "Of course, we had to overcome all sorts of mechanical defects during the development of the K100, but the worst thing of all was having to design an engine that would satisfy all sorts of restrictive legislation we cannot imagine now, for another 20 years."

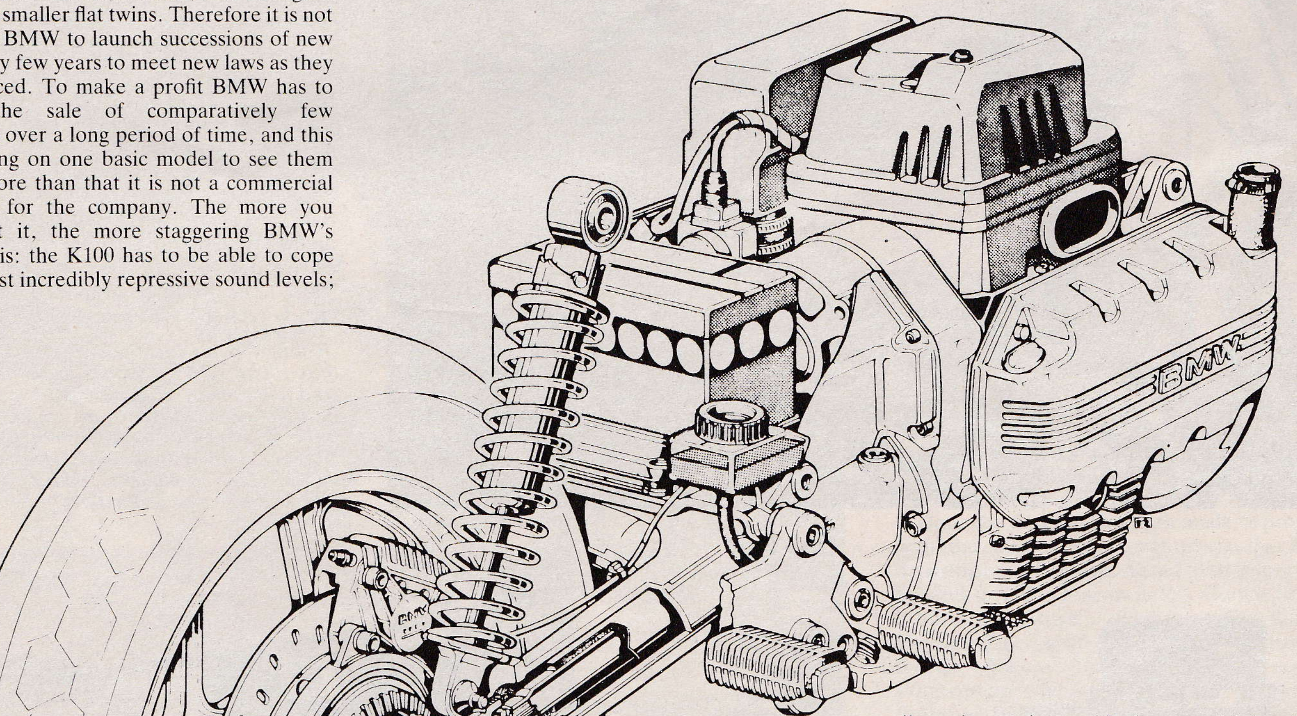
If you accept that the upward accelerating curve of progress will continue then Pachernegg's formidable ordinance is given its true, awesome perspective. BMW is satisfied that it cannot sell more than 45,000 motorcycles annually in the forseeable future, and this figure includes the smaller flat twins. Therefore it is not possible for BMW to launch successions of new models every few years to meet new laws as they are introduced. To make a profit BMW has to rely on the sale of comparatively few motorcycles over a long period of time, and this means relying on one basic model to see them through. More than that it is not a commercial proposition for the company. The more you think about it, the more staggering BMW's future task is: the K100 has to be able to cope with the most incredibly repressive sound levels;



staggering fuel costs increases; total changes in styling, including some pretty radical anatomical alteration, major safety demands and some important aerodynamic contribution; and adaptation to robotisized manufacturing systems offering vital cost savings. It is doubtful whether any other motorcycle currently in production will stay that 20 year course, although it is probable that all manufacturers, including the Japanese will have to start thinking this way soon if they want to keep building big bikes at low prices. It is not enough to quote, for example, the Kawasaki 1,000 cc four as having lasted the past decade perhaps better than any other. The same engine launched now could not live through the next 10 years.

As it stands now, the K100 is very much a motorcycle of the moment, inasmuch as it offers none of the robust individualism of the old twins it's replacing. They survived because they were different; the K100 is intended to survive on the strength of its conformity, albeit at an oblique. BMW's courage in "joining" the Japanese-inspired camp was terrific if, perhaps, a little disappointing at first glance, but its pragmatic marketing approach must be correct for any large-scale company in this world. I would hazard a guess that once the K100 has become a pillar of the two-wheel establishment, BMW will more strongly begin to emphasize its determination towards a recognizable identity.

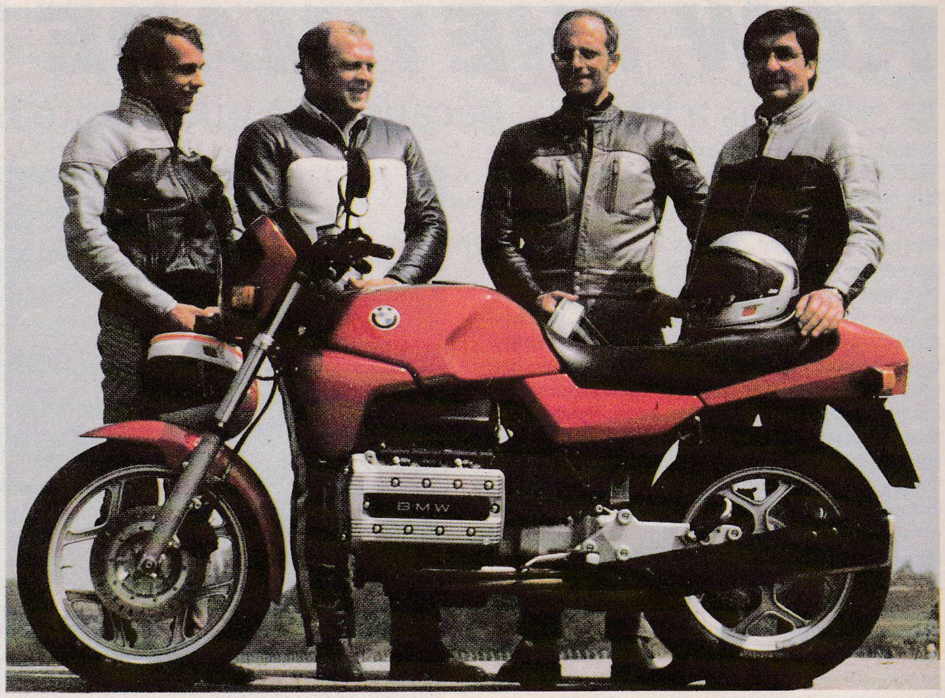
I will not attempt to enlarge on the comprehensive all-round description of the K100 in the December issue. Instead, you may be interested in what makes it tick. And for the cynics among you — yes, I have ridden it; 200 miles to be precise, and in that unsatisfying short period learned to love its elegant form.



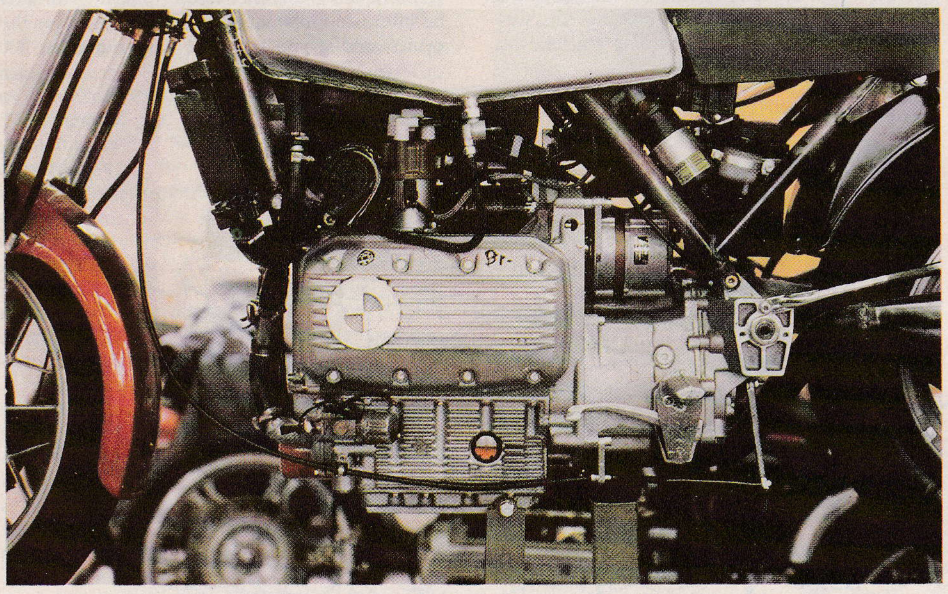
"Bridge-type" frame with engine and drive as load-bearing elements

Stefan Pachernegg is not the designer of the K100. This responsibility is Josef Fritzwenger's who, as a member of BMW's then small R&D team, was exploring alternative engine types as early as 1975, one year after the launch of the R90 series. These engines had been developed to satisfy BMW's marketing department's need for a "1000" with which to combat the Japanese fours. Only under protest did the engineering department supply the big engine, for its members were convinced that the flat twin lost most of its inate attractiveness once it exceeded 750 cc. On a purely personal note I might add that I recollect Helmut Werner Bonsch, who was Stefan Pachernegg's counterpart during the post-war years, telling me that his R&D department were of the same opinion about the Earles fork range 600 cc capacity. As time passed so BMW's skill with the flat twin improved until their 600 cc maximum became 750, but it got no further than that, as the majority of BMW enthusiasts will agree: most people vote the 797 cc R80 (almost 750, eh?) as the best of the flat bunch.

As soon as the development work on the R90 had been completed, BMW engineers began searching for the replacement they knew was inevitable sooner or later. Various types were considered and even tried, including an uprated and watercooled version of the big boxer, but in Pachernegg's own words: "It had lost all its charm, believe me — I've tried it!"



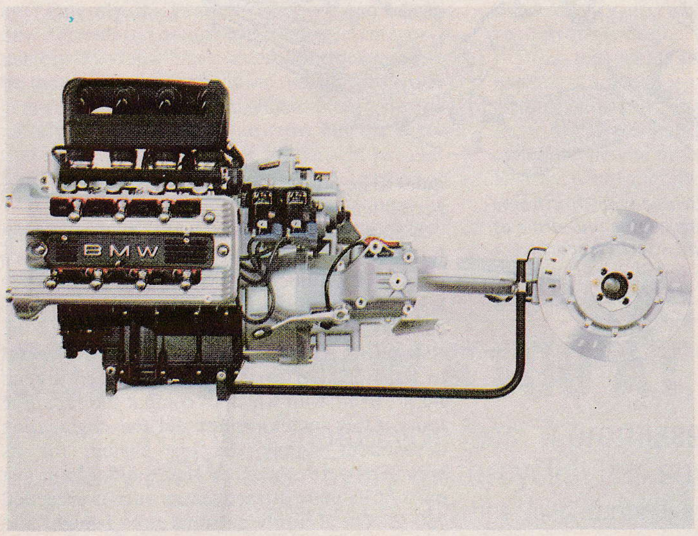
BMW motorcycle division's top management. All are expert motorcyclists, which doubtless has something to do with the fact that BMW survives while BSA has gone — well, more-or-less anyway. L to r: Stefan Pachernegg, 40 years old and head of development. Hans Glas, 40 years old and head of production. Karl Gerlinger, 45 years old and head of sales. Dr Ebenhardt Sarfert, 46 years old and chairman and member of the BMW group board

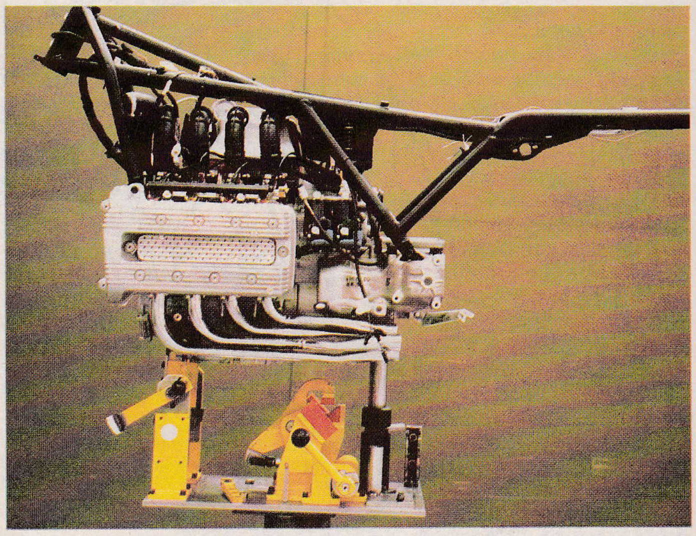


Left: The one that got away — the late 1970s model K3 with its 1,000 cc, three-cylinder, sohc engine. Although a bulkier engine than the K100, note the numerous shared characteristics which so convinced BMW it was on the right road

For purely experimental purposes BMW bought a Peugeot 104 car engine. This watercooled, all aluminium, one-litre four is a near-flat longitudinal engine and was quickly adapted by Fritzwenger to fit into a modified BMW chassis. It convinced him he was on the right track and in 1977 BMW management decided to develop the theme. Two models were chosen, the 1,300 cc, four cylinder K4 and the 800 / 1,000 cc, three cylinder K5. They were closely related to the sohc BMW car engines of

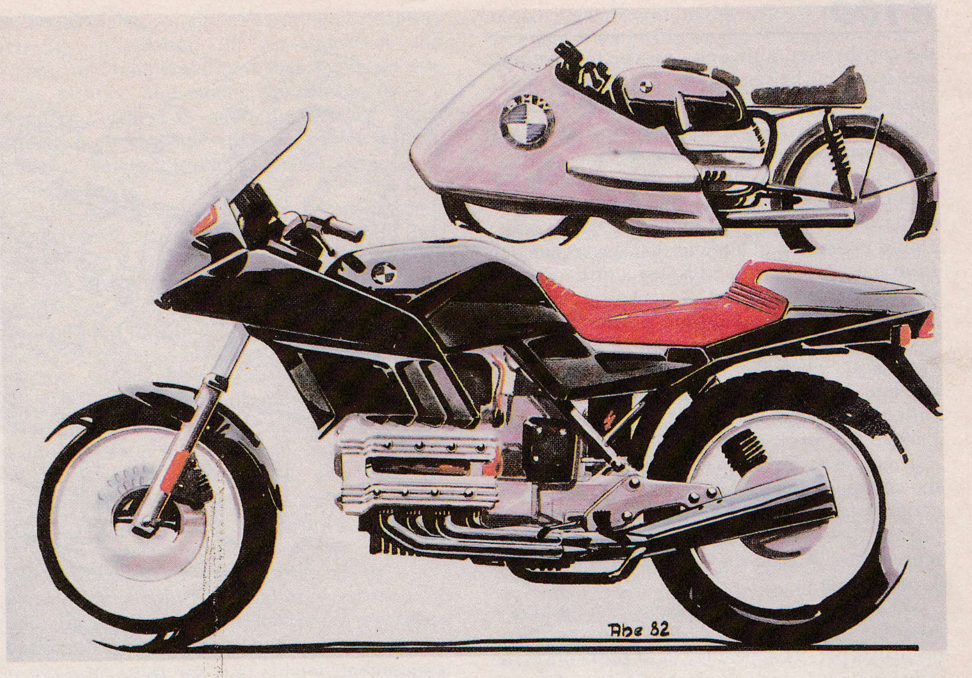
Below: The complete power pack. All this weighs just 100kg (220 lb) thanks to the use of plastic and aluminium alloy wherever possible. Less gearbox and shaft drive, the engine weighs 75kg (165 lb) and measures 515mm (20.2in) long, 504mm (19.8in) wide and 55mm (21.6in) high, including all ancillaries. Below, left: Showing engine and frame as load-bearing members



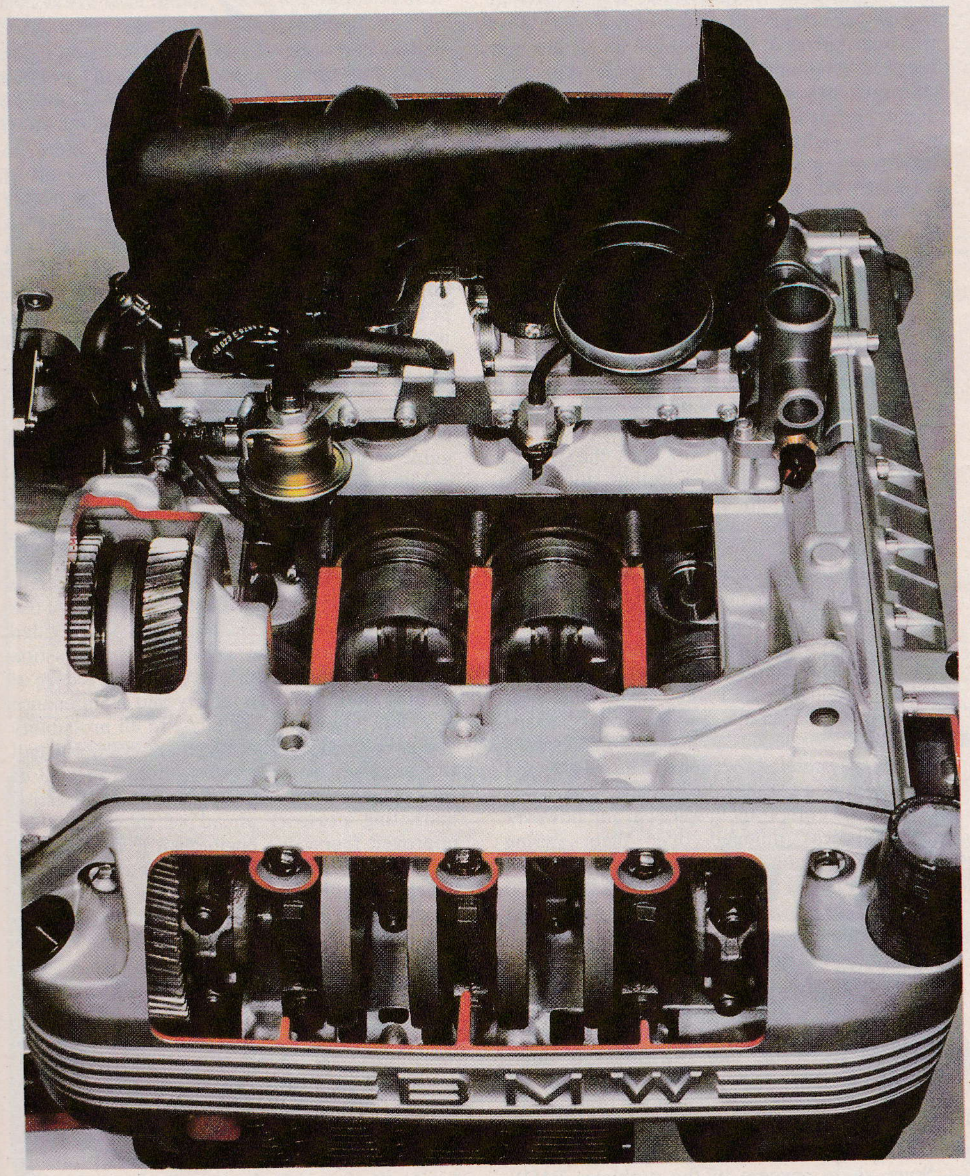


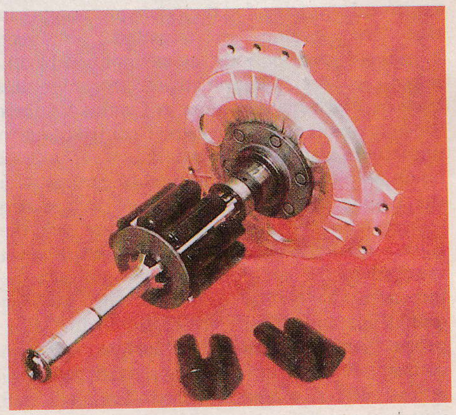
the time and, perhaps in consequence, made unconvincingly ponderous motorcycles. Experience with these machines persuaded BMW management that, despite the then current enthusiasm for monstrous motorcycles, it would settle company future on a much lighter motorcycle of no more than 1,000 cc and 100 hp.

For whatever reason, a change in top management occurred in January of 1979. The new chairman was Dr Eberhardt Sarfert, who was also the executive director of the motorcycle division. Fortunately for BMW, the new board members decided to continue with the development of the existing project, perhaps because after so much time and energy a return to year zero would have been unthinkable. A few more alternatives were juggled around, including an orthodox, transverse, chain-drive four! This because its low development cost proved attractive, but its indistinct personality did not impress the management.



Right: Stylist's dreams, for whatever the marque connection, there can be nothing of tangible worth between the two RSs. Perhaps a future K100 model might one day hopefully be fitted with a stylish "dust-bin" fairing: it would be more functional, after all





Above: Clutch body and the engine secondary shaft displaying the starter shock absorber rubbers. Left: Engine cut-away showing pistons and crankshaft. Note the gear-cut web, or bob-weight number eight at the bottom left of the picture that drives the generator gear and starter free-wheel gear seen above it

Once the decision had been made to progress with the K100-type of motorcycle the R&D department staff was increased from its previous handful to 240. These included: Gunter Schier, head of chassis development; Richard Heydenreich, head of overall motorcycle format; Klause Volker, head of styling; Fritzenwenger himself, of course; and Martin Probst and Stefan Pachernegg.

Pachernegg was in charge of the whole development team and it was his job to turn Fritzenwenger's brilliant concept into a commercially feasable proposition. Without any attempt whatsoever to reduce the original notion at all, I would suggest that when Pachernegg took over, the project was only 15 per cent complete. He immediately "robbed" the car division of Probst, who was the man behind BMW's all-conquering F2 racing car engine, which is recognized generally as incorporating some of the most advanced gas-flow and fuel injection operations ever.

It is not true, as I confess freely that I once believed myself, that the engine is a product of the car division, although it is true that without the technical liaison of the car division R&D engineers, the K100 engine would not have been what it is now. In fact it probably would never have seen the light of day.

Pachernegg is an Austrian, who grew up in the country's second city and industrial centre of Gratz. He's a slim, quiet individual with a light, almost elfin sense of humour that singles him out from most Germans, and is just a little tweedy. He studied at Gratz's AVL technical institute, specializing in diesel engine efficiency in the Professor List laboratory. As a motorcycle enthusiast when he graduated he made a bee-line for Rotax, where he was concerned with two-stroke development, before moving to Puch.

There, as an auxiliary to his job of developing the combined Puch / Mercedes 4WD Mercedes car project, he joined the Puch enduro team and proved to be so successful that he five times represented Austria in its ISDT (now ISDE) Trophy team.

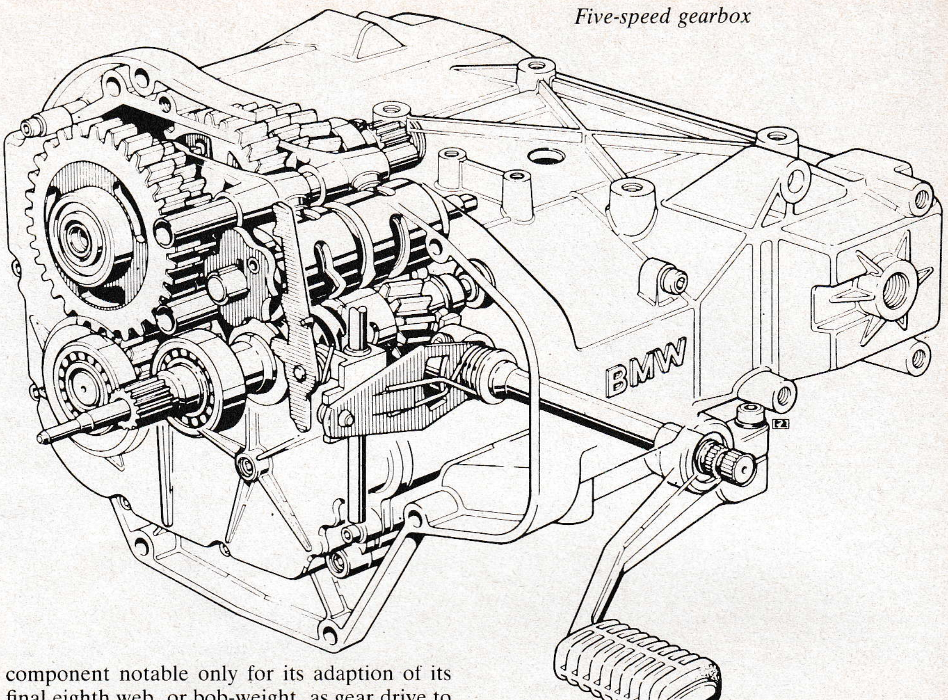
Whatever the real reasons for BMW's adoption of the in-line flat four as their particular pet, its appeal lay most probably in its individuality. I seriously doubt BMW's claim of improved servicing for the company points out that the engine is intended for long between-service periods, as exemplified by the adoption of fuel injection and electronic ignition both of which have become as famous for their longevity as they have for their contribution to improved combustion. And the advantage of being able to change bottom-end bearings with the engine in-situ cannot be one that would seduce many buyers! Nor is it likely that the K100's centre of gravity can have been much lowered by the laid-down engine, although the improved aggregate centre of its working crankshaft and pistons are closer to the static centre than is possible with an upright engine, of course. It is true, however, that general accessibility is extremely good, for plug, fuel injector, camchain, top end and numerous other servicing tasks may be completed without even fuel tank removal.

Crankshaft details

In common with most cars, the K100 engine is constructed around a "block" comprising cylinder barrels and crankcase, a method that thankfully eliminates that inexplicably traditional joint half-way down most bike engines. The block itself, and the cylinder head, are chill cast in an aluminium, silicon and magnesium light alloy. Chill casting is by no means new and is a die casting method used to improve the quality of complex shaped components designed to carry high loads. Cooling during casting is controlled, frequently by water, in various parts of the die to ensure that neither "vacuum bubbles" nor stress points are entrapped. Following recent flat twin practice, the cylinder bores are spray linered under the "Scanimet" system, now by BMW itself. This nickel / silicon carbine coating reduces manufacturing cost, friction and weight while increasing bore life but it involves new part replacement at major overhaul time. In an attempt to rectify this BMW R&D department is currently involved in producing a recycleable Scanimet block suitable for exchange at lower cost.

Five plain main bearings of 45mm (1.7in) cast iron support the drop forged steel crankshaft, a

Five-speed gearbox



component notable only for its adaption of its final eighth web, or bob-weight, as gear drive to the all-important secondary engine shaft that transmits power to the generator and clutch and receives it from the starter motor. The four split-shell big-end bearings have a diameter of 38mm (1.5in) and carry forged steel connecting rods. The eighth web is heavily drilled to match its partnering seventh web's counterbalance.

In fact, this unique secondary engine shaft is the most significant design feature of the K100: it eliminates at a stroke any presumed advantage to be found in crankshaft and transmission alignment, thus negating what should have been a major advantage of the horizontal four, but it also provides the foundation-stone of the big new Beemer's excellent handling. The eight-geared web of the crankshaft drives the uniquely powerful 460 watt alternator, about which more shortly, which turns in opposition to the crankshaft direction. So does the 180mm (7in) single plate clutch. Together, these two contra-rotating components negate the lateral torque reaction that had so profoundly affected BMW past history, however unfairly. As a point of interest, the 0.7kW starter motor drives the engine through a geared free-wheel device on the generator drive-shaft, which appears to be a pretty orthodox centrifugally-inspired sprag clutch at a gear ratio of 27:1.

High sound levels issuing from the gear coupling of the crank and secondary shafts provided Pachernegg's team with most of its mechanically related problems. The two big 1:1 gears continued to make intrusive meshing noises however their teeth were cut and however much oil was pumped over them during development until finally the secondary shaft gear was reduced in width by approximately 30 per cent. Then a second gear of identical type and which made up that lost 30 per cent was matched against the original gear and held by spring loading a degree or so from perfect alignment. The result is a gear with what appears to be a "step" of perhaps one millimetre across all its teeth, and the effect is quiet meshing as the spring step takes up all mechanical slop. Beyond this, at the front end of the secondary shaft, are the gear driven water and oil pumps.

Some slight concept of the problems BMW had to overcome during the K100's projection into the future may be judged by the extraordinary effort made to suppress mechanical noise, witness the previous story. It would seem to have been logical, therefore, to have used toothed plastic belt camshaft drive. Pachernegg admitted that the chain finally appointed was inherently noisier but it complicated engine construction by requiring a separated chamber, as well as increasing the engine's overall dimensions and reducing its potential good looks. Chain drive is inherently noisy, though, so to reduce the "thrash" of all working chains, the K100's was equipped with a rubber faced tensioner that runs almost its entire length, as well as the more usual automatically adjusted hydraulic tensioner, and plastic faced guide wall behind the two camshaft sprockets.

Valve timing, measured somewhat bafflingly at three millimetres lift, is: inlet opens 5° ATDC, inlet closes 27° ABDC, exhaust opens 27° BTDC, exhaust closes 5° BTDC. Inlet valve diameter is 34mm and exhaust diameter is 30mm, although in some technical literature this is given as 28mm. Exactly why BMW decided not to employ four valves per combustion chamber is not known, but the official reason of wishing to optimise simplicity and maintenance is so much hokum these days. In all probability two valves per combustion chamber supplied all the necessary power characteristics required of the engine at present, with the attractive marketing prospect ahead of introducing an improved four-valve engine as the need arises. valve angle is remarkably shallow at a mere 19° which has the double advantage of ensuring clean-topped pistons and a shallow combustion chamber skull contributing to a usefully broad squish band, and the steep induction and exhaust gas angles ensure improved swirl and combustion efficiency at low and medium revs, thus presenting the BMW with the 86 Nm (63.3 lbs/ft) at 6,000 rpm high torque it demanded along with the cleaner combustion required to deal with emission laws. Everyone who has ridden the K100 has commented on its rare mid-range punch. In part this is probably due to the fact that the machine (*sans* fairing) weighs less than any other four of similar size and very little more than skinny sportsters like Ducatis. Its strength lies in its low speed torque output, which is prodigious at 57 lbs/ft at 3,500 rpm, or 55 mph in top gear.

It may well be that the choice of a long-stroke engine has assisted marginally towards low speed torque development, because even in this day and age, the advantage of high gas speeds, which are the main attraction of long-stroke engines, must be advantageous, all else being equal. BMW claims that the long stroke was necessary to ensure engine block compactness, although the evidence for this is pretty tenuous in view of the dimensions involved. The saving of a few millimetres per four bores could not possibly alter overall engine length by more than 20mm (.78in). Nor does the long stroke seriously increase stress, which is the long-stroke engine's traditional main disadvantage. I do not know the actual weight of the K100's pistons, but if we accept a theoretical weight of around one pound for the entire piston group, at the maximum torque speed of 6,000 rpm or 95 mph in top gear, the correct stroke of 70mm involves a force of 1,408 lb on the piston while a shorter one of, say, 64mm reduces this to 1,283 lb at direction changes. These are pretty low, as they always are with multis, and it's improbable that the nine per cent improvement would contribute much at all. Once again, it seems more likely that the current bore and stroke relationship is an adoption that allows for greater design flexibility at some future date.

The 125mm-long connecting rods are forged steel with bushed small ends to take the 18mm diameter gudgeon pins.

Fuel and ignition systems are controlled by on-board digital computers informed by sensors relaying information on air induction and volume and temperature, engine speed, throttle valve position and engine temperature. It's a complex business in operation but for which there is no worthwhile alternative if we want to continue riding through a world in need of protection.

BMW itself recommends that the operation is only clear if broken into three sections. Fuel supply is the first of these. An electric pump compartmented within the 22-litre (4.8 gal) aluminium main tank, and which is accessible for servicing through the removed mounting frame of the fuel filler cap, supplies the four injector nozzles at a constant 2.5 bar (36 psi). Two filters, one either side of the pump ensure cleanliness. Between the pump and the filters is a small reservoir which ensures equal pressure to all nozzles and which returns any excessive petrol back to the tank via an escape valve. A sensor in the cylinder head controls mixture through a programmed computer memory. When the starter button is pressed on a cold morning the mixture is temporarily richened and once the engine fires the mixture is weakened back according to engine temperature. Fuel flow is shut off completely when the throttles are closed on over-run at engine speeds in excess of 2,000 rpm, although flow resumes again once engine speeds fall below 2,000 rpm.

Air flow starts in the plenum chamber by the radiator, passing over a diaphragm-connected butterfly valve which opens according to the air pressure rather than through any direct twist-grip or throttle connection. Interestingly enough a tiny air screw acting on the diaphragm at this point can be adjusted to regulate carbon monoxide emissions in the exhaust as necessary. In effect it's a mixture control because the air it by-passes is not checked by sensors which would otherwise adjust and correct. Inside the plenum chamber are four separate pipes, each carefully tuned to supply an optimum smooth air flow and each one of which is equipped with a butterfly valve connected directly to the twistgrip.

Below 900 rpm, mixture richness depends entirely on engine temperature rather than air flow, or induction velocity, but richness occurs during hard acceleration when the opened throttles signal a switch connected to the injector control unit (one computer), and during speeds at more than two-thirds throttle opening. This suggests that cruising speeds of much more than 6,000 rpm would be imprudent for the cost-conscious tourer. Incidentally, the correct idling speed of 950 rpm can only be set using the special workshop synchronizer across all four butterfly throttle valve adjuster screws.

The injectors themselves incorporate electromagnets which are sensitive to impulses supplied initially from the ignition trigger unit, but which are computed by the injector control unit. These impulses control the duration of the electromagnetic opening of the injector nozzles, which varies from between 1.5 to 9 milliseconds, depending on rpm and induction volume.

Although the Bosch-developed LE Jetronic system has been "borrowed" from BMW's six-cylinder cars, the motorcycle development team discovered that, unlike the cars, which relied on a single throttle valve ahead of the diversification in their induction tracts, the motorcycles reponded better when equipped with one butterfly valve for each cylinder. This adaption has now been incorporated into the F2 car racers with beneficial results.

Ignition is by a contactless transistorized coil system. A Hall-effect signal generator is situated at the front of the engine. Two magnets in the generator are excited by a rotor of conductive material behind an insulated shield bearing a 37° window. The velocity of this window past the two magnets controls the signal, or impulse quality, which is assessed by the ignition control unit (the other computer) before the two HT coils are excited. The same signal is also utilized by the injection control unit.

Two ignition advance curves complicate the issue of understanding — although much improving performance! It all depends on the enthusiasm of the rider's right fist. Plumbed into number four cylinder's induction tract is a "vacuum switch" and, depending on its air pressure, either the light-load or full-load ignition curve is switched to. Both start at six degrees BTDC but then divide at 1,300 rpm (20 mph in top gear), the light-load advance immediately accelerating ahead of the full-load by 12°. By 6,500 rpm (103 mph in top gear) the two converging advance curves meet and from there up to 8,650 (138 mph in top gear) they are one. At that point the ignition control unit is alerted by the changing signal quality from the trigger unit and it retards the advance curve by six degrees. It would take a lamb-brained rider to not appreciate this, but should he, or she, continue unchecked then at 8,770 rpm the injection control unit, alerted also by the changing trigger impulses, steps in and averts probable engine damage by switching of fuel supply at the injector nozzles by eliminating their electromagnetic responses.

Two safety devices are fitted in the form of a starter motor cut-out above 700 rpm and a fuel switch-off should ignition suddenly fail.

Perhaps the final engine part of interest is the alternator, a positively gargantuan thing turning out enough power to satisfy an Arab prince's overloaded Rolls Royce. There are two reasons for this, perhaps three if you consider the fact that it was probably cheaper for BMW to accept one of Bosch's popular car generators — for that is what it is, adapted for motorcycle use by means of a rubber vane drive connection, than pay for a brand new one. Be that as it may, the 460 watt output is intended to satisfy the most demanding fleet users auxiliaries such as radios, lights, loudspeakers and sirens, many of which are required for continuous static use with the engine on idle, and also for the heavier loads anticipated for future customer and legislative demands, around which you may fantasize yourself. The alternators output is further increased at low revs by means of gearing up to a ratio of 1.5:1, which means it spins half as fast again as the engine. At the correct idling speed of 950 rpm a total of 153 watts are developed! Think about it, Miller buffs — if such odd fellows exist!

Oil circulation is orthodox and restricted to the engine alone. The gear pump operates at between 5 bar (72 psi) and 6 bar (86 psi) and normally delivers 3,500-litres (771 gal) an hour. All bottom end bearings are pressure fed, the cylinder walls are mist lubricated and hollow camshafts carry oil to the five camshaft plain bearings while cam and tappet (inverted bucket) lubrication is from special oil pockets. Ostensibly a wet sump system in practice the oil reservoir is a close relation of the old Royal Enfield system. In both, oil is carried below the engine but compartmented quite separately from the crankshaft in order that it makes no contact with the whirling crankshaft, a practice that creates heat through energy absorption.

Water circulation is by the normal thermostat controlled, water pump method, although in this case the entire radiator is aluminium and must require the most painstaking attention to detail in all things coolant and anti-freeze if it isn't to rot away within the first winter or two. A 60 / 40 mixture of water and glycol is recommended. Capacity is 2.8-litres (five pints).

It isn't only the radiator that is aluminium, or, come to that, the previously mentioned fuel tank. The engine is all-aluminium alloy — including some magnesium, plastic is used in profusion on all lightly stressed parts, and aluminium alloy is used in such components as the swinging arm, gearbox selector mechanism and even the clutch, all in the name of low weight, which is claimed to be a remarkable 215 kg (474 lb) dry and 239 kg (526 lb) fully equipped for the road. It's not something I would care to argue with.

The clutch is a fine example of this determination to quite literally make the best of a brand new type of job. The body, or cage as BMW call it, is a high grade aluminium casting, so it would be true to claim that the K100 has no true flywheel for all its high torque development

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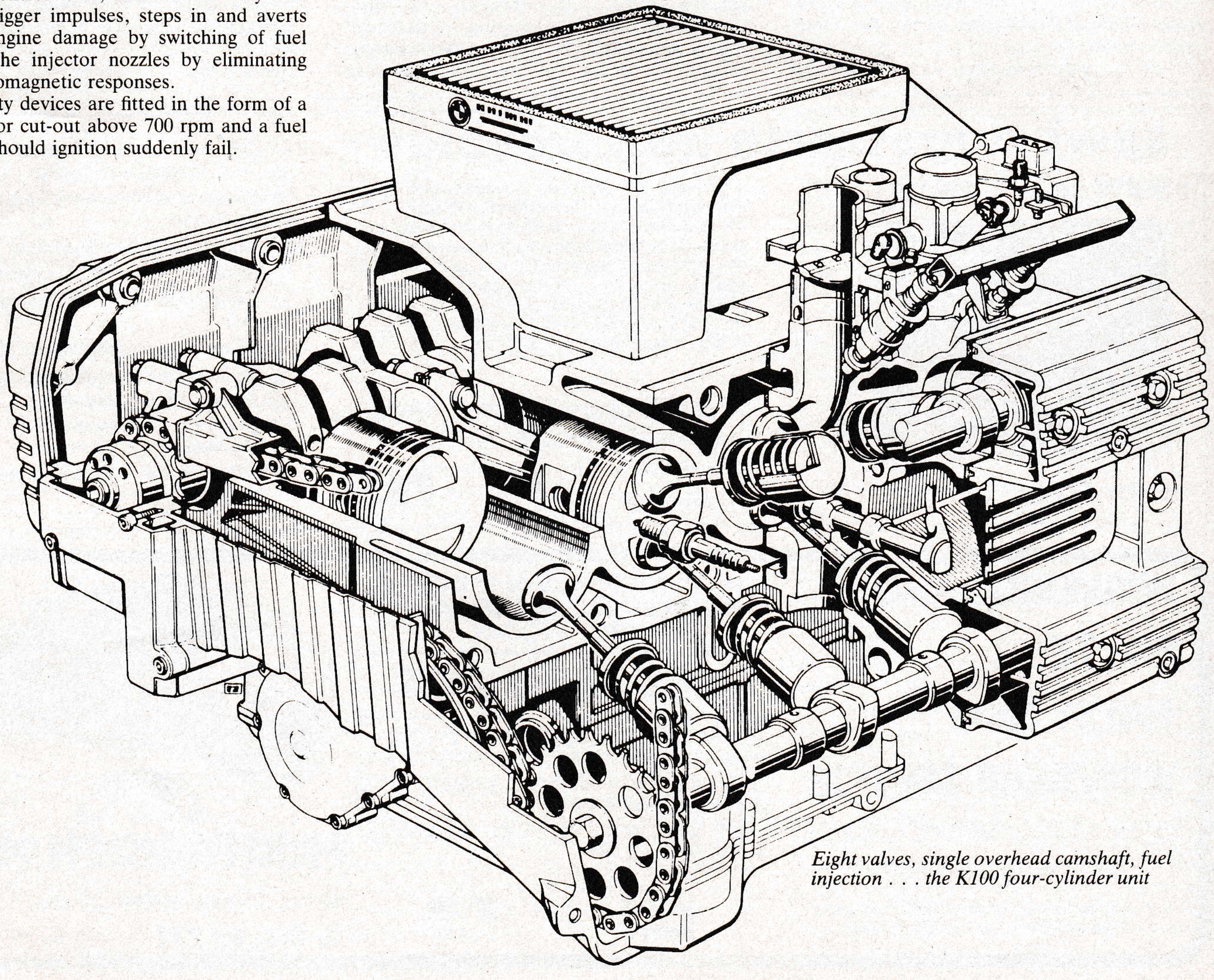

Eight valves, single overhead camshaft, fuel injection . . . the K100 four-cylinder unit away smoothly in top from around 1500 rpm. Engine braking is good, too, and the bike managed 43 mpg, usually running at between 80 and 90 mph. That's good enough for me. I managed just over 120 mph, before wind pressure made me back off, 80 mph translates into a relaxed 5,000 rpm in top gear. Perhaps I am asking too much, but the engine could do with a discernible power band to add more excitement.

The K100 felt like a 350 when nipping through the traffic on Paris's mad Peripherique, yet was stable and reassuring at high speeds on the open road. The front end felt a little light, particularly under accleration through a sweeping bend, and the rear monoshock was a bit too firm on bumpy roads, even on the softest setting. Front forks could do with slightly stiffer springs as they tend to dive under heavy braking in city traffic conditions. The Brembo brakes were, to me, beyond criticism. The seat is fantastic, as are the new controls and instrumentation.

I got to like the looks, but it really is daft to ride a bike like this without, at the very least, a small fairing. At the end of each day my neck and shoulder muscles were aching from buffeting from the wind pressure.

So, I liked the bike a lot and am convinced BMW have a winner. It is light, powerful and very easy to live with. It is also nice to have a bike that turns heads and stands out clearly in looks from the top Jap superbikes. Very cunning, BMW, that was a good move.

I can't think of a better bike as an all-rounder. It can't quite live with the Katanas, GPZs and CBXs on out and out performance, but give it 50 miles of French B roads and greasy city streets and it will leave them well behind, sticking like glue on its Pirelli Phantoms.

It's a happy bike, well finished and thought out. BMW deserve to do well with it and I am sure that they will. I even think the silencer has a certain chunky charm about it, so there.

The trip was a wonderful one. Good company, lots of memorable riding, despite the cold, and good food and drink to be enjoyed. Motorcycling can be a very hard sport, but it does give you so much in sheet excitement and experiences to be relived and enjoyed in later years. I have made so many new friends through the Professional and Executive Motorcyclists Club, and without doubt my motorcycling has been enriched by all of them. Such a trip, covering new ground, riding free of possible endorsements, (if not stiff fines) is to be recommended to everyone with red blood in his or her veins.

MIKE PARRY

DEVELOPMENT OF THE K100

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— as compared to its contemporaries, naturally, although I fancy that the effect of the revolving generator and secondary shaft and ancillaries must be strong, however well disguised. But the aluminium doesn't end there, oh no; it's used for the clutch pushrod, which is neatly capped with steel, and the clutch withdrawal arm (at a 4:1 leverage ratio). Rather than simply drill its fulcrum, stick it on a steel shaft then finish off the crude, if short-term effective job with a plastic bellows, BMW pivoted it on a needle roller bearing and *then* weathershielded it up in a bellows. What with that and what feels like a friction free cable you cannot tell it from an hydraulic clutch. BMW points out that as it was able to achieve a clutch lever operating force of 70 N (Newtons) it saw no reason to go to the complication of hydraulic operation. Maybe so, for that clutch is exceptionally light and progressive, but I'm damned if 70 N means anything to me, even after conversion to 15.7 lbs / ft. The notion that we — us humans, employ torque to disengage clutches has never entered my mind.

The five speed gearbox incorporates three shafts, the first being the input shaft from the clutch, which gear drives the lay shaft and through the gear-train to the main shaft, which is aligned with the final drive shaft and connected immediately ahead of the universal joint by splines. The gearbox is lubricated in the usual BMW fashion, independently of the engine. All shafts run on ball racebearings while the sliding gears employ either needle rollers or bronze bushes. Much of the gear selector mechanism is aluminium alloy, such as the selector forks and selector drum, although initial testing was carried out with steel items. These were discarded in favour of the toughened alloy ones when their low inertia became appreciated by test riders enjoying better gear changes. They do not wear appreciable more than steel items.

Internal gear ratios are: 4.49, 2.95, 2.30, 1.87 and top 1.66:1.

The frame, per se, is of minor importance because the engine clearly plays the major load bearing role and the simple lattice of tubes around it are little more than convenient ancillary hangars. As Pachernegg observed once during the development of the K100, although of that I was not aware at the time: "Where high speed stability is involved, frame design is easy. The most difficult part is the front suspension, followed by the rear and the frame a long, long way behind." From a professional mechanic's point of view the interest probably lies in the method of engine removal. Five bolts and a handful of electrical plugs comprise the major detachment focus, although from personal experience — usually frustrating in the extreme, I would imagine that there *must* be more to it than that. But with that small job finished the engine unit and rear wheel assembly can be left on the centre stand while the frame and front wheel assembly is "wheelbarrowed" away. It all sounds suspiciously simple. Life is never that simple, is it?

Certainly this frame bears no relationship to those cradling the flat twins, and thankfully so in my opinion. To rabid BMW enthusiasts who fly to defend their chosen marque in the face of such criticism, I should point out that within the ranks of BMW's own engineers exists a powerful dislike of the big twin chassis arrangement. This, however, is not the place to start such a discussion, although personally I disapprove of *any* frame designed specifically to encourage torsional movement, however slight and for whatever reason.

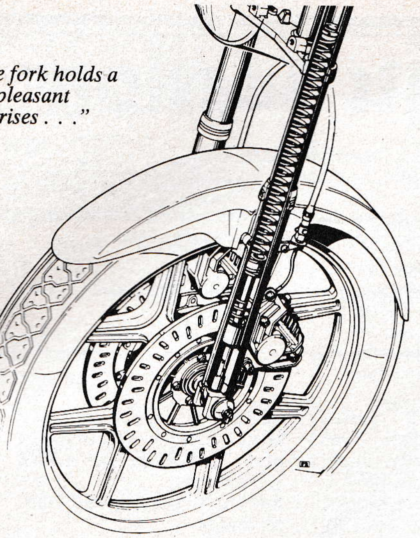
Without the torque reaction of the transverse heavy flywheel of the old twins to contend with, BMW is now in line with most of the world's top frame designers by stating: "The objective behind the choice of this frame pattern was to keep weight low, ensure high torsional rigidity and in this way obtain the desired high degree of riding stability." Incidentally, it is my suggestion that far from wanting to improve mere engine performance, the loss of the more recent big twins' heavy flywheel was an attempt, largely successful, to reduce wheel misalignment during power changes. Such shenanigans are no longer necessary with the current flagship.

The new frame weighs very little at 11.3 kg (25 lb) and is largely in a straight or semi-straight tube format, primary tubes being drawn steel 30 mm (1.18in) diameter by 1.5mm (0.06in) gauge and secondaries, such as the spine-type bracing strut, being 20mm (0.8in) diameter by 2mm (0.08in) gauge.

Steering geometry is about average at 63° steering head angle and 105mm (4.1in) trail but the fork itself holds a few pleasant surprises, the best of which is the determination to stamp out the traditional independent attitude of tele-legs during moments of stress. While on this subject you may be amused to learn that tests carried out by the TuV revealed that any auxiliary slider clamp type of brace strong enough to resist independent slider movement crushed the slider until it bound hard on the stanchion! Rather than fix a slider brace in the normal place by the mudguard, BMW has tackled it at root by fastening them together with a 25mm (2in) wheel spindle in what appeared to be forged steel, hollow drilled to save weight. Its clamps are unusually wide. There is no orthodox slider brace at all, nor even mudguard stays. Personally I am a little surprised that such a comparatively small wheel spindle diameter increase has achieved so much when two other engineers (Egli and Roe) quite independently of each other concluded after exhaustive research that a spindle close to 65mm (2.5in) would be necessary to achieve satisfactory stiffness. There is most certainly no doubt of the good handling and excellent stability of the K100, however. Doubtless the greater stiffness of the new hard-chrome plated, moly-steel 41.4mm (1.6in) diameter stanchions help a lot. Fork travel is approximately the same as the old twins at 185mm (7.3in) and it incorporates similar internal mechanism, although a short constant rate spring of only 395mm (15.5in) and far fewer coils take the weight. The damper relies on a Teflon coated aluminium piston. Neither air assistance nor spring nor damping adjustment is provided because BMW research has convinced the company that such equipment does not, as yet, functionally contribute to either a better or safer ride. Pachernegg is convinced that this is the responsibility of the manufacturers, not the rider.

Braking is provided by orthodox 285mm (11.2in) diameter stainless steel discs, dual on the front wheel. In the familiar Brembo style, the 38mm (1.5in) pads are activated by twin piston calipers and from 13mm (0.5in) master calipers, a combination that gives a nice balance of sensitivity, progression and power.

BMW is working in partnership with two companies, Bosch and Brembo, in what it is convinced will eventually be a successful anti-lock brake. Pachernegg has become aware of the pitfalls of such a device, however. "Anti-lock braking on a motorcycle is infinitely more difficult that it is with a car, because on a car it represents a comparatively small mass and cost, and does not need to be so very sensitive. This is exactly the opposite of a motorcycle's braking specifications. The brake (anti-lock system) must be compact, inexpensive and ultra-sensitive. I will not say how far advanced we are towards this because our main worry now is the probable political reaction to anti-lock devices when they are first introduced. All governments will pass laws to enforce them on



"The fork holds a few pleasant surprises . . ."

all two wheelers, including mopeds. We (in BMW) are very worried about this attitude. It is what I mean when I say that nowadays we are having to design for political emotion rather than logical progress. Can you imagine what it would do to motorcycle design, weight, and cost if anything but an absolutely *perfect* anti-lock system was introduced and inflicted on even mopeds by law? It would be stupid."

One reason for the light frame of the K100 must be due to the attachment of the rear suspension directly to the gearbox / engine unit, which high, stiff mass then spreads all rear wheel loads evenly through the entire frame. The L-shaped swinging arm, or "Monolever" as BMW has named it, pivots around two adjustable taper roller bearings held by aluminium spindles to the gearbox housing. The drive shaft itself is split into three parts, the first being the universal joint at the swinging arm pivot axis to which is welded an unusually large diameter steel tube. This is packed with rubber, into which is secured by bonding a smaller diameter steel tube, the end of which is female splined. The third part is the male splined stub-shaft connected directly to the palloid cut pinion gear, which runs in a large, twin ball-race bearing and a caged needle roller.

The rubber is in fact a shock absorber and this part of the shaft housing runs dry. The splines of the pinion, incorporated to provide a degree of operational and fitting flexibility, are nickel plated and greasepacked to resist wear.

An interesting little extra within the hub is a tiny magnet set in the crown wheel spindle itself which, as it passes a sensor set into the hub casing, transmits an impulse to the electronic speedometer head.

By Japanese factory standards, the new BMW wheels are very unfashionable, an observation which Pachernegg regarded wryly. "In BMW we are not interested in silly fashions for their own sake. Everything we do for the K100 had to contribute to a better performance. Of course we have experimented with little wheels but we decided on the wheels we use now because they gave the best results for road riding. If we went racing then 16in wheels would help because their low front profile improves overall aerodynamics. But the K100 has not been race developed because racing has nothing, as yet, to offer us. An 18in front wheel gives us a nice long, slim contact patch so we can use sensible steering geometry for good handling and stability at all speeds. It also gives the best comfort, by the way. A 17in rear wheel is a good compromise between a low seat, comfort and wear. This is the big problem at the back now: not performance, but wear."

After many years of campaigning against tubeless tyres because of the problems associated with on-route deflation, BMW has decided at last to capitulate because with the higher speeds possible with the K100, the advantages of safety outweighed those of emergency repair facilities. The machine I rode was equipped with Metzelers but Contis and Pirellis are also available I believe. In fact there is little doubt that owing to the improved chassis stiffness of the K100, as compared to the R100, it will accept a much wider choice of tyres than any previous BMW. This is acknowledged by BMW in its recommendations. The standard front tyre size of 100/90Vx18 is augmented by 3.50Vx18, 3.50x18 56 V and 100/90x18 56 V. Rear tyre choice is similar, ranging from the standard 130/90 V 17 to 4.50 V 17, 4.50x17 67 V, and 130/90x17 68 V. Rim widths are 2.50 front and 2.75 rear and the profile aerodynamics play an important role in the shape of the K100RS and RT, although the basic fairing shape is utterly different from the old R100RS. It is significant that whereas BMW engineers had to hire Pininfarina's wind tunnel to perfect their first attempt at stable streamlining, the latest one was shaped entirely within BMW's own tunnel at Berlin. It appears to include no downthrust spoilers but Pachernegg explained: "The new fairing *is* the spoiler, or rather, it gets most of what you call down-thrust from the windscreen. There is also another small one low down behind the front wheel, although this one does little more than smooth out an area of high turbulence immediately ahead of the engine that was actually affecting performance a little. But I should explain that it is not true about downthrust in motorcycle fairing design. We have experimented with motorcycles equipped with positive downthrust spoilers and their handling is very bad. They have major cornering problems: in fact over 30° banking handling becomes so serious they are almost uncontrollable. What fairing design does is to lessen the normal uplift of unfaired machines. The K100RS gives what you might call a 'negative downthrust':"

I must confess that this was news to me. In common with most riders, I had wrongly assumed that the R100RS, for example, really did load the tyres at high speed. Ah well; you live and learn.

Pachernegg agreed about the inferior performance of the K100 at high speed, although by comparison to others of its kind it was very little different at all. Against the aerodynamically stabilized RS model, however, it lacks that glued-down feel. It seemed illogical that BMW had not incorporated spoilers into the radiator cowling to redress this naked bike tendency (MZ owners should read no further for the subject concerns the most deplorably high speeds) at much over 120 mph. "We could have done; some of us wanted it but then we decided that BMW needed what we call a 'poor bike'. We had to have something people could progress *from* so we intentionally designed one model of much lower price than the others and without any high speed aids or weathershielding. Ownership of that model will create ambition for the improved model just ahead. You understand?"

I did and perceived with horrible clarity the unavoidable convolutions of commercial ambition. Better, perhaps, not to know. D.L.M.

MAUDES TROPHY

Continued from page 88

1938 — BSA. Two standard BSAs, 500 cc ohv and 600 cc sv, were purchased by the ACU from agents' showrooms. A list of 1,100 dealers was supplied from which the ACU selected the dealers to supply the machines. Details of test:
Hill-climbing: The machines made 20 consecutive ascents and descents of Bwlch-y-Pass with a further 20 ascents and descents of the same hill after a series of tests at Brooklands and on the road.
Fast-touring: Six hours' high-speed running at Brooklands.
Reliability: General performance assessed in all tests.
Flexibility: Performance in traversing London during traffic hours from north to south and from east to west using top gear and clutch only.

1939 — Triumph. Speed Twin and Tiger 100, 2,000-mile road tests and six hours non-stop at Brooklands. Speeds, 75.02 and 78.5 mph.

1952 — BSA. Three A7 Star twins selected at random. Object of test — to cover not less than 3,100 miles and in addition participate in the ISDT, a distance of approximately 1,500 miles.
Route: Birmingham — Hook of Holland — Antwerp — Brussells — Paris — Geneva — Zurich — Innsbruck — Vienna — Bad Aussee.
Completed in the ISDT — all three riders (and machines) gained gold medals.
Return route: Stuttgart — Dusseldorf — Copenhagen — Oslo.
Speed test: At Oslo aerodrome over 400 metres. Best times: S-start, 50.15 mph. F-start, 84.43 mph.
ACU Observer tested all three machines over rough tracks and found all controls, steering and braking fully satisfactory.
Total mileage for test: 4,958 miles.
Riders: F. M. Rist, B. W. Martin and N. Vanhouse.

1968 — Honda. Three Honda 50s. Object was to test general reliability and petrol consumption of the little C100 Japanese bikes for a period of seven days and nights at the Goodwood circuit, followed by a timed lap and brake test. Three machines were employed. Result:

	Machine 1	*Machine 2*	*Machine 3*
Mileage covered	5,897	4,935	5,023 miles
Average speed	35.10	29.38	29.90 mph
Miles per gallon	124.30	140.52	124.30 mpg
Timed lap	51.43	41.86	38.25 mph
Brake test (from 30 mph)	41ft 6½in	51ft 2in	44ft 11in

All machines finished without any undue mechanical wear being apparent on stripping and measuring.

The test took place between October 24 and 31 during high winds and a considerable amount of rain; there was ice formation on the track at night during the latter stages of the test. Hundreds of motorcycle journalists claimed that they rode in this attempt, which enabled Honda to sell thousands of the C100 Honda Cub machines in the UK.

And that brings us up to date with the BMW and, finally, the Suzuki attempts.

Today the Maudes Trophy rests (presumably) in Suzuki's offices and one wonders if anyone will again want to make an imaginative and exciting challenge to prove "manufacturing excellence". Perhaps those who make machines today are too concerned with marketing, and with planning the next junket for freeloading journalists, really to care that there are still challenges. And the motorcycle world is still waiting for the best all-purpose single-cylinder 500 to be made — and proved. ICHABOD