

SIX OF THE BEST

Transmissions are technological marvels. BMW is gradually moving to six-speed transmissions for all its cars.

Text: Michael Seitz Photos: Igor Panitz

Bernhard Rastinger still remembers his first conversation with Eberhard von Kuenheim in the early 1980s. BMW's former CEO had called the young engineer and head of manual transmission development to his office in BMW's cylinder-towers headquarters. Afterwards, Rastinger and his team set out to design a new five-speed transmission. Ever since, BMW transmissions have been famous for precision gear changes and ease of shifting. Even in the U.S., where automatic transmissions rule the roost, the 3 and 5 Series cars with manual gearboxes are extremely popular.

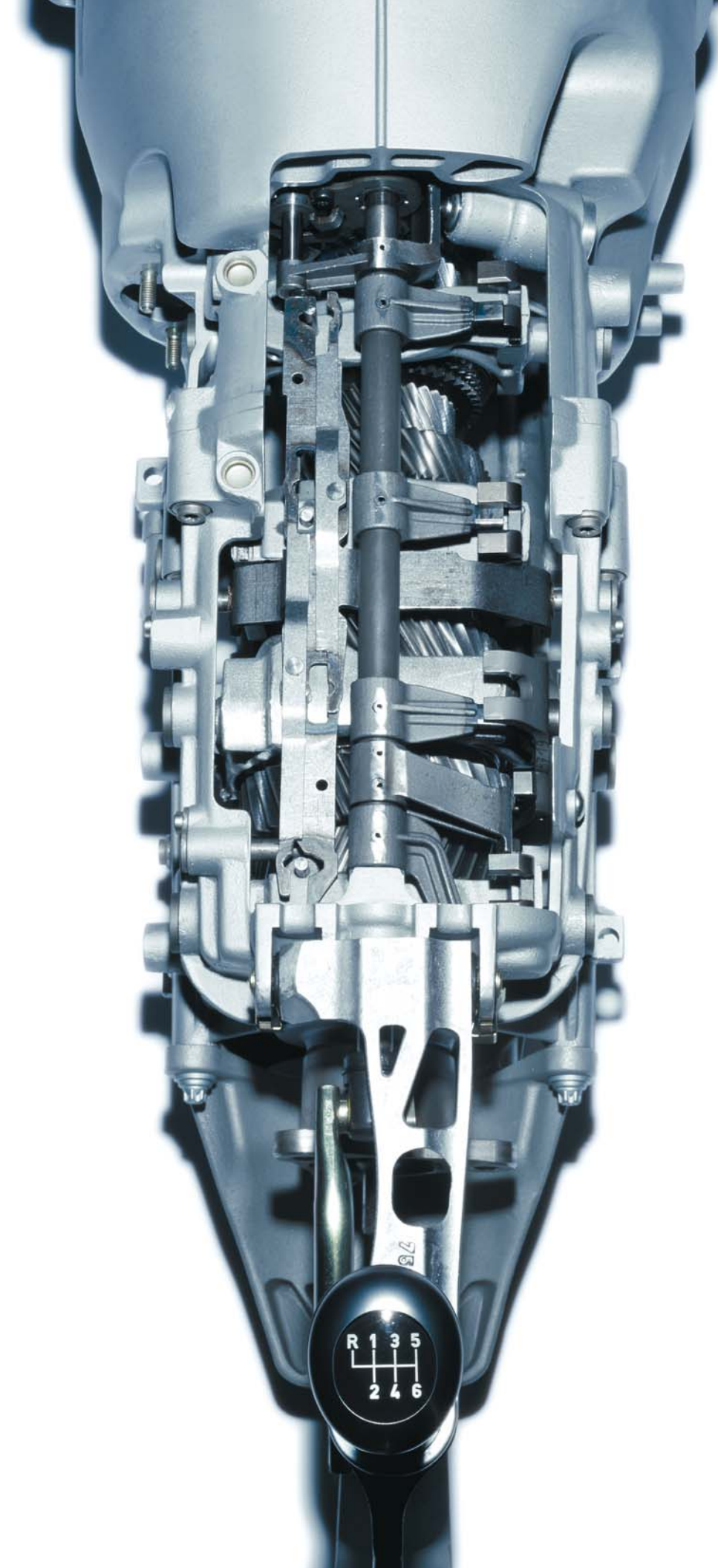
Engineers consider the BMW transmission to be the class standard. The new six-speed gearbox first appeared in the Z4 and has been a great source of pride to Rastinger and his 30 co-workers. It took three years to develop and affect a host of advantages in addition to its great precision.

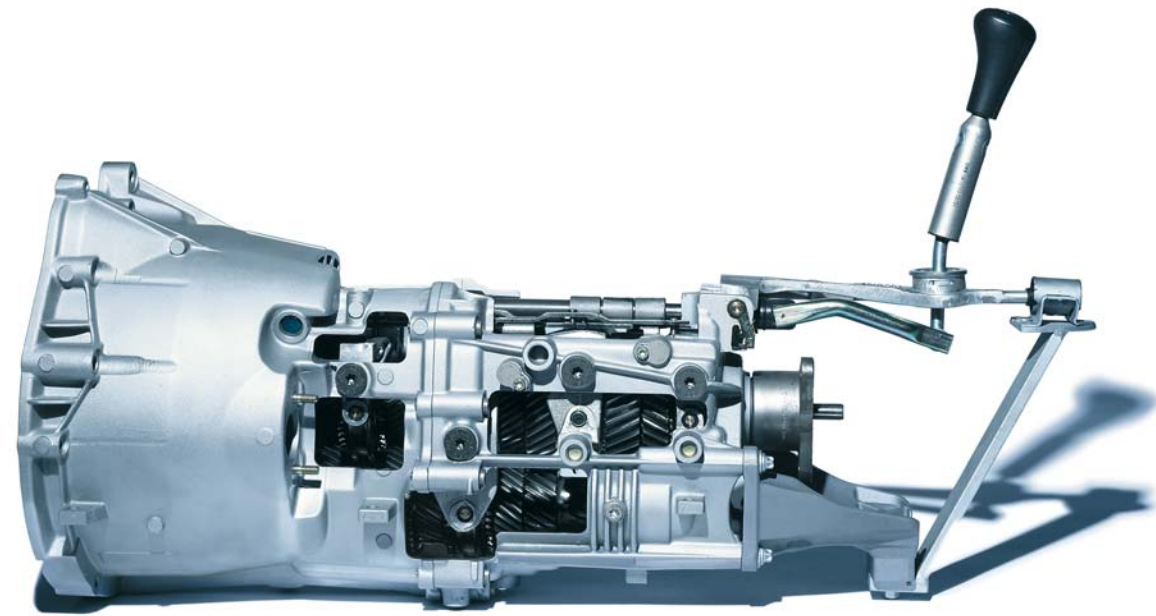
Most significant is the greater spread of the gears. The strong power and torque of BMW engines are used more effectively with six speeds.

A shorter first gear provides more dynamic pick-up, and an extended sixth gear permits moderate revs at high speeds. The new transmission also handles the greatly increased torque without any trouble. The manual version in the new 5 Series sends 443 lb-ft of torque to the rear wheels. To achieve their ambitious goals, the BMW engineers had to re-design almost all of the 150 transmission components. The gears were hardened, modified to reduce noise, and mounted in wear-resistant bearings. Despite the greater torque, however, there was no need to increase their size. Each gear tooth in the new transmission exerts more force. To accommodate this, as well as to reduce noise, the gears are helically milled. They engage with a hardly perceptible wave motion.

Rastinger's team is exceptionally pleased with the synchronization. If gears are to engage smoothly, they should be revolving at the same speed. When they are not, a disturbing jarring of the gear lever results.

Economical and high performing: the new 6-speed manual transmission





“THE GEARBOX GETS IT RIGHT EVERY TIME”

Sporty gear sets: hardened, noise-optimized and provided with wear-resistant bearings

The effectiveness of the synchronization determines the speed and precision with which gears can be changed, and the force to do so. The counter force that drivers sometimes feel on their wrist just before a gear engages is largely due to the synchronization.

Small cones, arranged ring-fashion one above the other, are used to slow down or increase the rotation speed of the gears, crankshaft and clutch plate. The rev jump between first and second gear is the greatest, so the synchronization here is triple; between the third and fourth gears it is double, and between fifth and sixth, single. Even the adroit parking expert gets his due: the single-synchronized reverse gear can be engaged without crunch even if the car is still rolling forward.

One of the distinct advantages of this sophisticated technology is that each of the six gears can be changed with a uniform effort. With singly synchronized transmissions, the lower gears are harder to shift than the higher ones. But the driver can only be 100 percent sure that the next gear is engaged by always exerting the same force. This regularity also helps him to develop his own shift rhythm sooner.

To eliminate even the least snag, Rastinger's team used high-speed photography in analyzing the synchronization process. An unclad transmission was photographed in the laboratory; this helped the engineers to improve the six-speed manual gearbox in many ways. It was also made more compact and lighter. The weight of the larger 6 Series transmission was reduced from 132 lbs. to 117 lbs.; it will now fit into the smallest transmission tunnel on the drawing board. Rastinger says of this impressive performance, “Along the way, thousands of reasons cropped up why it wouldn't work. But our engineers were persistent and one supplier, ZF, gave us super quality products, so we came up with a work of art.”

The compact form and light weight are all the more astonishing given that the production of sporty SMG variants of all the manual gearboxes had been planned from the outset. In Sequential Manual Gearboxes (SMG), hydraulic actuators perform the clutch and gearshift operations. The driver starts the process either with paddles located on the steering wheel, or else a shift lever on the central console. Other SMG components are housed within the transmission. The actuators are at the side of the transmission and, to save space, the hydraulic unit that delivers the shifting power is at the rear. That's why drivers of SMG-equipped cars recognize theirs by sound. As soon as the door opens, a hydraulic pump whirs as it begins to build up pressure. You can drive off immediately. Wolfgang Hall, the head of transmission development, has this to say about the SMG: “It's a dynamic and sporty alternative to a manual gearbox. Gear

changing is precise, fast and very sporty. But don't think of it as another convenient automatic – it's more of an automated manual shift. The way it's designed results in a delay of 120 milliseconds between shifting and the new surge of traction.” With a twinkle in his eye, he adds, “That's darn short from kiss to kiss,” referring to the whole gear change process from uncoupling the clutch to engagement of the new gear. It took some doing to achieve this speed. The actuators exert considerably more force in shifting gears than a driver ever could. The SMG doles out spurts of rpm's every time gears are changed, which comes as music to the driver's ears, and also gives a break to the synchronization process. Hall points out that synchronization is the time-limiting factor. The 120 milliseconds are alright for the double and triple synchronization, but a further increase in gear change force would simply burn up the cup-sized precision rings.

A masterpiece of precision engineering – that's how the specialists view the new six-speed automatic, comparable to a

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large clock mechanism. Since their introduction in 1964, the demand for automatic transmissions in BMW cars has steadily increased. Worldwide, about 50 percent are currently automatics, with the expectation that this will rise to 70 percent. There are good reasons for this trend. Automatic transmissions – at first three-speed, then five-speed and, beginning with the new 7 Series, now six-speed – are considered to be the ultimate convenience. That’s why BMW decided to offer the 7 Series only with automatic transmission.

The new transmission is better all around, and has been accepted as the standard for automatics.

The additional gear takes the transmission ratio between first and sixth gears to 6.4, which previously was only possible with stepless transmissions. The gains are significant: better driving performance, lower fuel consumption, and reduced polluting emissions. Since the ratio jumps are smaller, especially in the lower gears, the changes are smoother and faster. Unlike earlier automatic transmissions, the driver now is hardly aware of the gear in use. Hall comments, “That’s how it should be – the automatic always gets it right.” The smooth, imperceptible operation of the engine, the transmission and the drive train, and their harmonious integration is one of the main challenges that transmission specialists confront.

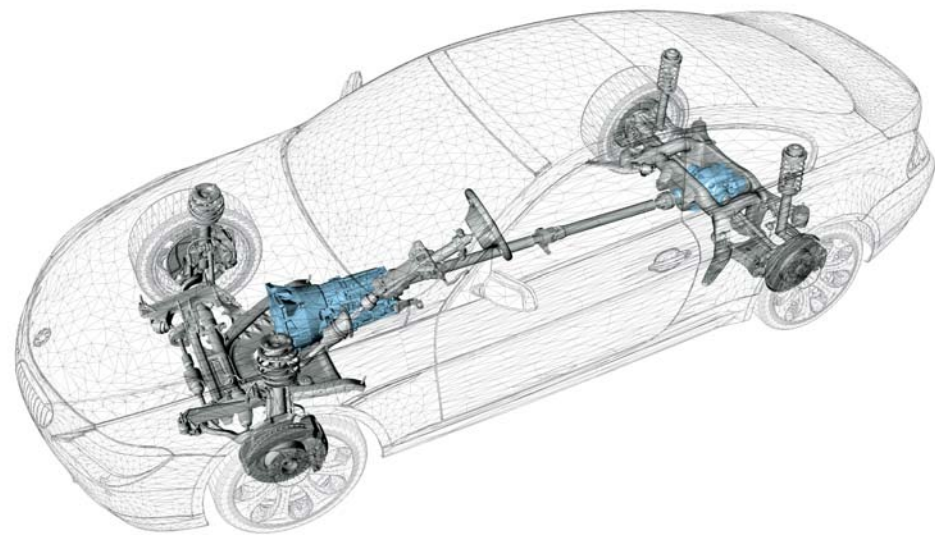
The basics of the automatic transmission have remained much the same since the idea was first conceived. Planetary gears are placed around a central sun gear and several uniformly sized planetary gears surround it, the whole cluster being kept in place by a large ring. Gears are engaged or braked depending on the desired ratio, and a torque converter assures uniform power

transmission by means of a turbine wheel and a pump wheel, each housed in oil.

It took time, but, with the new transmission, BMW has made another big leap forward. With the introduction of the six-speed automatic, BMW began using the gear set developed by a Frenchman, Pier Lepelletier, in the late ’80s. It requires 30 percent fewer components, and reduces the number of parts from seven in the older gear set to five: three clutches and two brakes. What’s more, the transmission is some 30 lbs. lighter and two inches shorter.

The design of this six-speed transmission relies heavily on a converter lockup clutch. As in the conventional gearbox, the clutch engages gears directly but without the converter’s toll in efficiency. When the car is at rest, the converter disengages. Wolfgang Hall hopes to develop his clutch even further until one day, it will allow him to make the converter smaller, or perhaps even eliminate it altogether. That would increase the efficiency of the transmission and lead to still greater fuel savings.

With all its advantages, the automatic transmission has a strong hold on the future, especially because it is so convenient. “Nonetheless, stick shifts are certainly going to be with us for the next few decades. That’s the transmission that speaks to the BMW driver’s sport gene. That’s the one that lets you drive with all your senses,” Hall says. BMW sees the trend in stick shifts clearly going in the direction of sportiness as provided by SMG – increasingly faster gear change times, without interruption of torque. That would be a tantalizing challenge for manual shift meister Rastinger, except that he is retiring in 2004. Naturally, he won’t be going without first revealing the secrets of his precision transmissions to his successor. □



ILLUSTRATIONS: TECHNICAL ART/SCHÄFER

“THE TRANSMISSION FOR BMW DRIVERS WITH A SPORT GENE”

Clutch, transmission, rear axle differential