The Nuts and Bolts of Threaded Fasteners

Among life's minor irritants is finding that one of the tiny screws holding together an eyeglass frame has worked its way out of its assigned place at an inopportune moment — in a darkened movie theater, at a cocktail party or on the tennis court. You're left with a loose lens or a frame without adequate support. Lacking a paper clip to refasten the separated parts, you sometimes end up balancing your thick-lensed spectacles on your nose long enough to see your way home.

The same waywardness that afflicts eyeglass screws can apply to bolts on a lawnmower, in an appliance or in heavy machinery. Vibrations and temperature fluctuations eventually loosen even the most secure nuts and bolts.

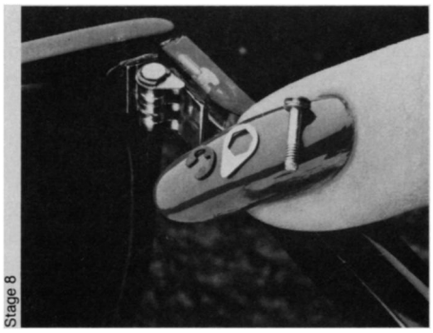
The problem of loose screws has not escaped the scrutiny of engineers and the ingenuity of inventors. For example, Stage 8 Fastening Systems of San Rafael, Calif., markets a simple, effective method for keeping bolts from rotating once in place. The company's three-part system consists of a grooved bolt with a six-sided head, a retainer that fits over the bolt's head and a spring clip that slips into the groove to hold the assemblage together (see photograph).

Inventor Bruce A. Bennett says his reusable, adjustable fasteners can be used in applications ranging from tiny screws for eyeglass hinges to huge bolts holding together a 40-ton rock crusher. A railroad equipment manufacturer recently switched to the new fasteners after extensive testing. The tests showed that whereas conventional nuts and bolts often shake loose in fewer than 10 hours, the Stage 8 fasteners remained secure for at least 200 hours.

Stage 8 fasteners are featured in the May issue of MECHANICAL ENGINEERING in one of several articles on the subject of threaded fasteners. The cover illustration shows a heap of bolts. It's not the kind of image likely to snare customers at a newsstand. But in an age of supercomputers and superstars, its stark simplicity brings to mind how important — and how complicated — the seemingly simple things in life can be.

Consider the plight of automobile manufacturers. To forestall corrosion, they routinely apply thick layers of primers and paints to their partially assembled vehicles. The electrodeposited paints stick to everything, including threaded fasteners. These thick coatings make nuts and bolts difficult to remove, prevent movable parts such as door hinges from sliding smoothly and interfere with efforts to tighten bolts to a specified degree.

Unwilling to give up primer treatments completely, automakers experimented with various ways of masking the threads. Tapes and plastic caps worked, but each one had to be attached then removed by hand before and after the painting operation — an undesirable feature on a high-speed, high-volume assembly line. Wax and paper masks contaminated the primer and paint baths.


Stage 8

The solution was to coat threads on both bolts and nuts with a thin layer of Teflon. The coating prevents paint and primer buildup and easily survives the high-temperature primer bath without contaminating the liquid.

One added bonus: The Teflon coating smooths the thread's surface, reduces the friction encountered and allows machines to drive fasteners into place at high speed. Tightening the fasteners wears away the Teflon coating wherever metal scrapes against metal. Once the coating's job of preventing primer buildup is over, it doesn't interfere with the rest of the assembly process.

Tightening bolts properly is no simple matter either. Engineers can identify literally dozens of variables affecting the assembly of bolted joints. Too much tension, and a bolt can snap; too little tension, and the joint is loose. "As engineers throughout industry are learning, better control over bolting procedures in the field and on the shop floor is both desirable and difficult to achieve," says John H. Bickford of Raymond Engineering Inc. in Middletown, Conn.

Engineers in the steel industry sometimes use high-frequency sound waves to measure bolt tension during and after assembly. But the equipment needed is too expensive and specialized for most structural steel work, say, at a construction site. More often, inspectors must rely on checking that workers are properly using carefully calibrated tools designed to tighten bolts to a specified degree. That isn't always enough.

The answer lies in designing bolts that provide the right tension automatically or indicate in some way that the bolt has been tightened correctly. One possibility is a bolt with an appendage that twists off when the bolt reaches the right tension. Another is to use a bumpy washer between the nut and the surface through which the bolt protrudes. Tightening the bolt partially flattens the washer's bumps, giving an indication of the amount of tension created.

However, even these improved fasteners aren't foolproof. A rusty twist-off bolt may break off before it reaches the right tension. Workers have been known to flatten the bumps on a tension washer with a hammer or file to make a bolt easier to tighten.

Bolting problems with potentially serious consequences have surfaced in the nuclear-power, automotive, aerospace, pressure-vessel and piping industries. "Virtually all of the most common bolting problems known to mankind have been reported by the utilities: improper tightening, incorrect materials, stress-corrosion cracking, fatigue failure, vibration loosening," says Bickford. "But only a small percentage of the millions of bolts used in nuclear power plants were at fault. It was also discovered that the occurrence of problems varied significantly from plant to plant, with older plants reporting far fewer bolt troubles than newer ones." That discovery suggested the need for better worker training. As a result, the Electric Power Research Institute, based in Palo Alto, Calif., produced several training films and manuals on good bolting practices for engineers and mechanics.

"However, in today's high-speed and litigious world, better knowledge of how to assemble bolted joints is needed," Bickford says. That has led a group of engineers to form the Bolting Technology Council, based in New York City, "to sponsor research, to collect and exchange information, and to do whatever else is required to reduce the uncertainties of assembly results."

That's really getting down to nuts and bolts. — *Ivars Peterson*