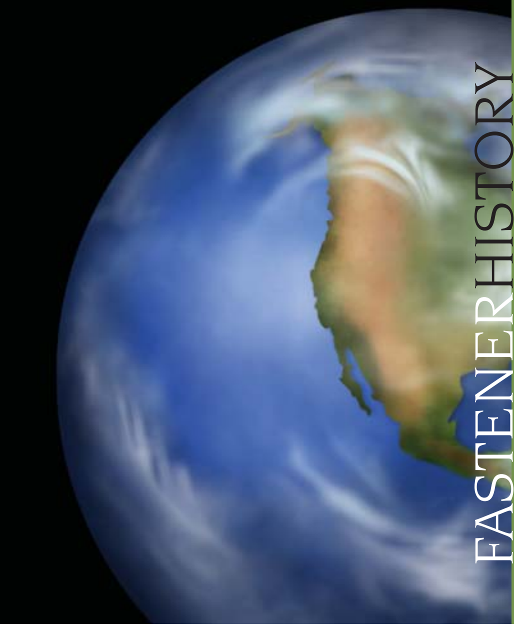

SELF-SEALING FASTENERS: past, present and future

by Larry Bogatz

As I look at a breathtaking view of earth from the window of my million-dollar-a-night suite, I ponder what changes in sealing technology will be required to meet the demands of this new millennium. I notice the fasteners sealing the window and take comfort in the thought that the same quality I have seen throughout the inside of this orbiting hotel also went into selecting the self-sealing fasteners used to seal its outer structure.

Although we are not quite at this point, it's not far off. The first intergalactic spaceport with scheduled commercial flights into space is expected in 2010, and Hilton's first orbiting hotel is anticipated in 2012. In this new millennium, quality, reliable, self-sealing fasteners providing 100 percent pressurization of products with a zero failure tolerance will be paramount. When designing products for space, self-sealing fasteners are an obvious requirement, but what about applications on earth? Products that need to seal in or out liquids, gases, radiation, the environment, or anything else require self-sealing fasteners.

Surprisingly, there have been numerous instances where design engineers didn't realize their product required a self-sealing fastener. As a result, the production engineer is faced with resolving product leakage and costly retrofit. In desperation, many unreliable sealing methods have been used, including sealants, adhesives, locking materials, washers of different materials, and fasteners with rubber or poly molded or bonded to the undersurface of the head.

The superior method of sealing in any product design is indisputably the self-sealing fastener, so this article will focus primarily on industrial, self-sealing fastener inventions that were patented by Carl Emil Hayes, Iaia of Abscoa Industries, Morse of APM Hexseal, and the current patents by Bogatz of Sealtight® Technology (B&B Hardware, Inc.). Also discussed are the shortcomings of the MS self-sealing fastener specifications. So buckle up, and enjoy this journey into the fascinating history and advancements of self-sealing fasteners.

The 1880s were at the heart of the Industrial Revolution, and with it came the development of steam-powered ships, trains and machinery. Recognizing the need for a fastener that would act as both a fastener and a seal, Carl Emil Hayes designed a fastener with a panned out triangular shaped groove in the undersurface of the fastener head that retained a series of three rubber/asbestos washers to seal these steam products. The first two washers closest to the head were relatively the same outside diameter, while the third washer was smaller in diameter. The idea was for the smaller washer to fold the larger washers as they were compressed, so that the washer series would take on the relative shape of the groove. On April 28, 1885, Hayes received the patent on his advanced design, making him the father of self-sealing fasteners. The Hayes design held as the best self-sealing fastener technology until the 1950s.

World War II ended in 1945, and the 1950s brought the Cold War and a focus on nuclear power, nuclear weapons, advanced rocket technology, and the space race. Russia launched its Lunik Lunar Probe to photograph the moon, and everyone wondered who would set foot on the moon first. Incidentally, new rubber molding technology made possible the creation of the O-ring, patented in 1937 by Niels Christensen, a 72-year-old machinist. The O-ring expanded the possibilities for self-sealing fastener technology, but it wasn't until 1956 that Joseph A. Iaia of Abscoa Industries would put it to use. Iaia designed a rectangular shaped groove that held the rubber O-ring in a com-

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LARRY BOGATZ

Larry J. Bogatz is the chief design engineer and CEO of Sealtight® Technology (B&B Hardware, Inc.). He has designed thousands of different fastener products, and he is the only holder of multiple current patents for specialty self-sealing fasteners. His designs have been used in the Mars Rovers, the Alvin & Jason submersibles, Medtronic's insulin injectors, various NASA projects, and numerous other military and commercial applications. He has more than 20 years of experience in the fastener industry. As a professional mechanical engineer and a veteran of the Navy Seabees, he has extensive hands-on, real world experience. In addition, he has authored a book, numerous articles, and has appeared on ABC television and numerous talk shows.

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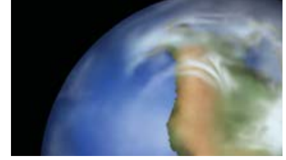
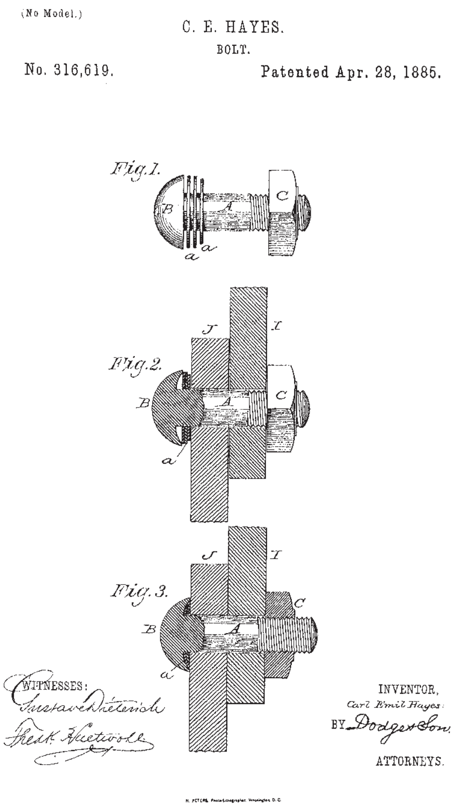
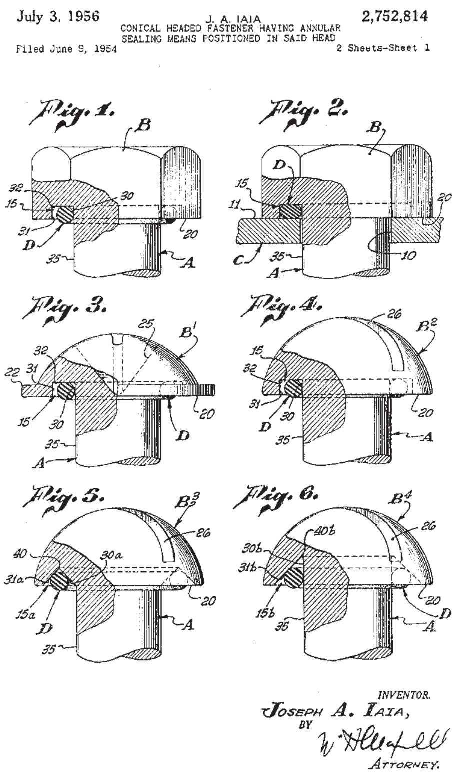
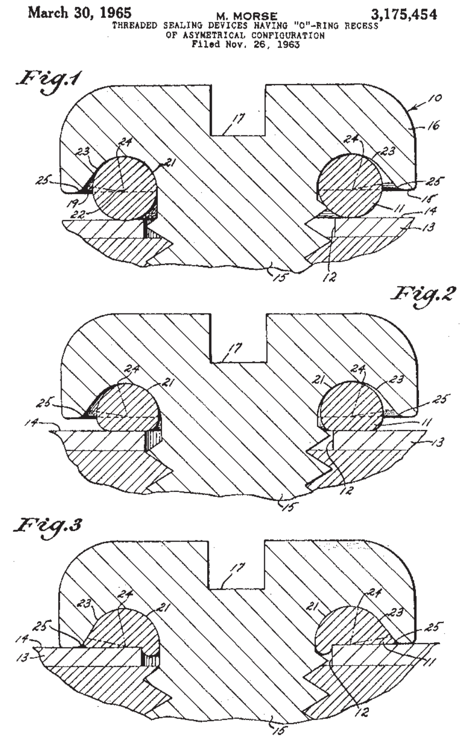




C.E. Hayes. Bolt. Patented April 28, 1885



J.A. Iaia. Conical Headed Fastener Having Annular Sealing Means Positioned in Said Head. Patented July 3, 1956



M. Morse. Threaded Sealing Devices Having "O"-Ring Recess of Asymetrical Configuration. Patented March 30, 1965

pressed state when the fastener was fully engaged. However, his design did not precisely calculate O-ring compression. Without a precise compression calculation, there cannot be an assurance of fastener sealing or reusability of the O-ring. Nevertheless, this design was a vast improvement over the Hayes design. The design disadvantages are no assurance of fastener sealing or O-ring reusability and higher manufacturing cost due to holding specific groove tolerances. The design advantages include greater probability of sealing over Hayes and metal-to-metal contact for proper O-ring containment and accurate torque readings. Iaia received his patent on July 3, 1956. The Iaia design was considered the best self-sealing fastener technology until the end of the 20th century.

On March 30, 1965, Milton Morse of APM Hexseal patented his self-sealing fastener. The only dimensional requirement was that the O-ring must be larger than the groove receiving it. Since there is no calculated compression, there can be no guarantee as to whether the fastener will seal. This design assumes the O-ring, when compressed into its rounded groove, will flow inward towards the fastener shank, sealing the threaded area and achieving metal-to-metal contact between the outer rim of the groove and its mating product. However, although the inside diameter of the O-ring will affect its outward flow slightly, the inward and outward flow of the O-ring is almost equaled during compression, making metal-to-metal contact unlikely. The design disadvantages are excessive O-ring compression causing O-ring failure; twisting, pinching, and deforming of the O-ring upon installation as a result of inward and outward O-ring extrusion; and a spongy torque reading caused by the outward extrusion between the outer rim of the fastener head and the mating surface. The only advantage of Morse's design over Iaia's is lower manufacturing costs, due to the ease of punching a groove where holding tight tolerances is not required, making the end product less expensive. There are many non-critical applications that can use this product without incident, especially where cost is a primary factor. However, buyers should be aware that the probability of this design providing a reliable seal is minimal; therefore, it should never be used in critical applications.

The 1960s was a time of much technological advancement, culminating in the moonwalk of Neil Armstrong on July 20, 1969. Approximately a year before this historic event, on May 27, 1968, in an attempt to regulate the quality of self-sealing fasteners, the Naval Ordnance Systems Command approved the Military Standard for self-sealing fasteners known as the MS3212 & MS3213 Series. Unfortunately, the Military Standard Drawings cannot specify groove designs because they are proprietary of the companies that patented and produce the self-sealing fasteners, and when it comes to self-sealing fasteners there is nothing more important than the groove design.

The best groove design precisely calculates compression and contains the O-ring within the groove in its compressed state. This is a delicate balance, since too much compression causes O-ring failure (compression set), while too little compression prevents the O-ring from maintaining a positive seal line between the surfaces, resulting in product leakage. Since the self-sealing fastener is only as good as the groove design used in its production, and this is not included in the drawings, fastener buyers can purchase self-sealing fasteners certified to the MS3212 and MS3213 specifications that won't even seal.

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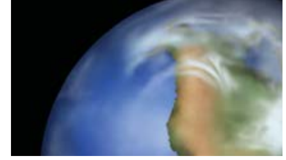
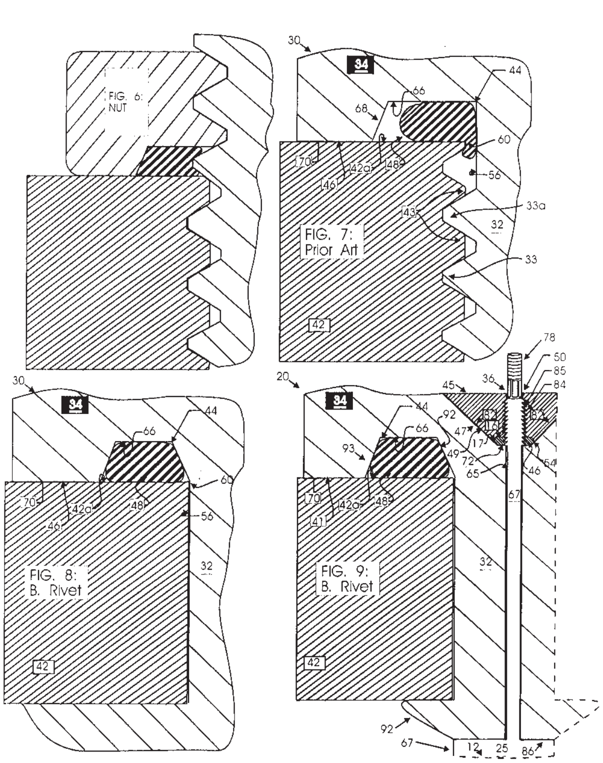
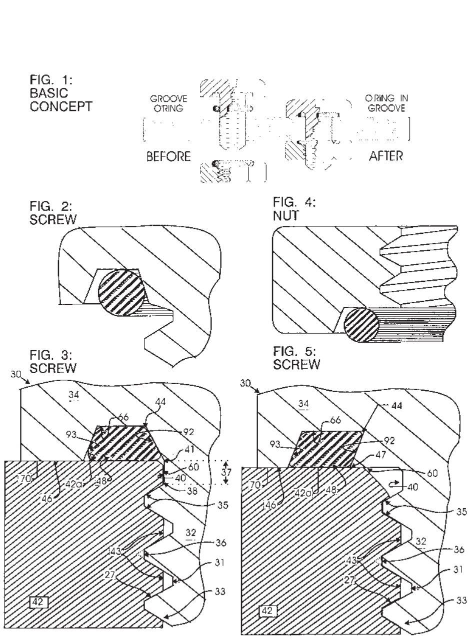


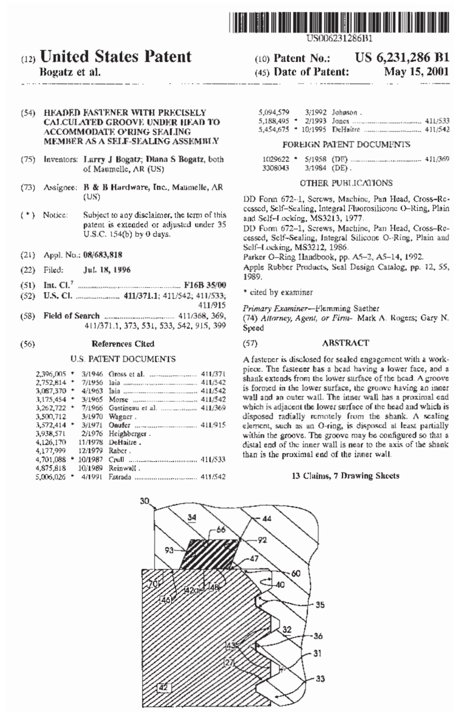
U.S. PATENT 5,957,641 Sept. 28, 1999



Bogatz et al. Headed Fastener with Precisely Calculated Groove Under Head to Accommodate "O"-Ring Sealing Member as a Self-Sealing Assembly. Patented September 28, 1999

U.S. PATENT 6,231,286 May 15, 2001





US006231286B1

(12) **United States Patent**
Bogatz et al.

(10) **Patent No.: US 6,231,286 B1**
(45) **Date of Patent: May 15, 2001**

(54) **HEADED FASTENER WITH PRECISELY CALCULATED GROOVE UNDER HEAD TO ACCOMMODATE O'RING SEALING MEMBER AS A SELF-SEALING ASSEMBLY**

(75) Inventors: **Larry J Bogatz; Diana S Bogatz**, both of Maumelle, AR (US)

(73) Assignee: **B & B Hardware, Inc.**, Maumelle, AR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/683,818**

(22) Filed: **Jul. 18, 1996**

(51) **Int. Cl.**[7] **F16B 35/00**

(52) **U.S. Cl.** **411/371.1**; 411/542; 411/533; 411/915

(58) **Field of Search** 411/368, 369, 411/371.1, 373, 531, 533, 542, 915, 399

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(57) ABSTRACT

A fastener is disclosed for sealed engagement with a workpiece. The fastener has a head having a lower face, and a shank extends from the lower surface of the head. A groove is formed in the lower surface, the groove having an inner wall and an outer wall. The inner wall has a proximal end which is adjacent the lower surface of the head and which is disposed radially remotely from the shank. A sealing element, such as an O-ring, is disposed at least partially within the groove. The groove may be configured so that a distal end of the inner wall is near to the axis of the shank than is the proximal end of the inner wall.

13 Claims, 7 Drawing Sheets

Bogatz et al. Headed Fastener with Precisely Calculated Groove Under Head to Accommodate "O"-Ring Sealing Member as a Self-Sealing Assembly. Patented May 15, 2001

The Space Shuttle Challenger disaster emphasizes the importance of a proper groove design. On January 28, 1986, within seventy-three seconds after lift-off, a rubber O-ring failed, which subsequently destroyed the Space Shuttle Challenger. Many believed that it was caused by a material breakdown of the O-ring; however, it was improper compression of the O-ring that caused the failure, which demonstrates the importance of a design that precisely calculates compression.

Anticipating the 21st century needs, Larry and Diana Bogatz of Sealtight® Technology (B&B Hardware, Inc.) patented multiple self-sealing fastener designs that have vast improvements over previous designs. The grooves are designed to apply a specific predetermined optimum sealing compression on the O-ring to achieve a positive seal line between compression surfaces, assuring that every fastener will effectively seal. In its compressed state, the O-ring is held completely captive within the groove, creating a reliable and reusable seal.

Several novel designs are introduced by the Bogatz patents, utilizing various geometrical shapes depending upon the intended application of the self-sealing fastener. For instance, the oversized head configuration utilizes a parallelogram shaped groove so the O-ring will snap up into the head. It is primarily used in applications where the clearance hole size is too large for a standard self-sealing fastener. In addition, the first-ever glueless nut design allows for the O-ring to be held captive in the groove without adhesives. Other designs include 100 percent-pressurized blind rivets, made-to-order special fasteners, and the original self-sealing fastener series.

The design disadvantages are higher manufacturing costs due to holding tight groove tolerances and using the highest quality materials. The design advantages include no glues or adhesives to break down, complete metal-to-metal contact for proper O-ring containment and accurate torque readings, and precision O-ring compression that assures optimum sealing reliability and reusability of the fastener/O-ring combination. Patents were issued on September 28, 1999, May 15, 2001, and September 4, 2001, consecutively. ■