

History and Functionality of the Modern Flushable Toilet

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Abstract

Flushable toilets took several centuries to evolve from initial concept into what we have today.

Overcoming challenges such as plumbing, design, proper drainage and even dealing with the smell of sewage gas resulted in more efficient ways to manage household waste. This document reviews a brief history and functionality of the flushable toilet.

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Introduction

Flushable toilets are something used several times daily, but how did they come to be and how do they function? While a variety of different toilets exist, such as composting and vacuum toilets, this report focuses on flush toilets, the history of their design and the mechanics of their functionality.

A Brief History of Modern Plumbing in the United States

Modern plumbing was introduced to the United States in 1842 when the New York City Croton Aqueduct was completed, and pressurized water, mainly intended for fire hydrants, became available. In 1845, sanitary sewers from buildings were permitted by the city to be connected to public storm drain sewers. Within five years, wealthy residents were beginning to have indoor plumbing installed in their homes and by 1900, codes were enacted in large industrial cities requiring a toilet room in every tenement unit. (Lutz, 2004)

Plumbing codes were developed over the next 50 years, with most new housing being built with complete plumbing, including a toilet that flushed. (Lutz, 2004) By 1990, only one percent of American homes did not have complete plumbing. (U.S. Census Bureau, 2012)

A Brief History of the Flushable Toilet

The earliest modern flushable toilet was documented in 1596 by Sir John Harington, the godson of Queen Elizabeth I. His design called for a deep bowl, also known as a cistern or tank, above the toilet that would enable the user to flush the toilet. Harington installed a flushing toilet for the Queen at Richmond Palace, however modern toilets would not be commonplace for centuries. (Barksdale, 2020)

The first patent for a flushing toilet was granted to English inventor Alexander Cumming in 1775. His innovation was an S-shaped pipe below the bowl, preventing sewer gas from rising through the toilet. (Barksdale, 2020)

Several pioneers developed new toilet designs and received patents for their inventions, but it was not until 1861 when English businessman and plumber Thomas Crapper founded his sanitary equipment company, Crapper & Co that flushable toilets became more mainstream. (Thomas Crapper, 2021) Crapper expanded upon the existing designs and patents and eventually held nine patents for his inventions. (Petsko, 2020) One of his most remarkable developments still used today was the ballcock, also known as a ball valve or flush valve, which improved tank filling. (Barksdale, 2020)

In 1870, Crapper opened the world's first bathroom showroom to accompany his plumbing services. His company, Thomas Crapper & Co Ltd, continues to develop and sell toilets and other bathroom fixtures to this day. (The History of Thomas Crapper, 2021)

Components of a Flush Toilet

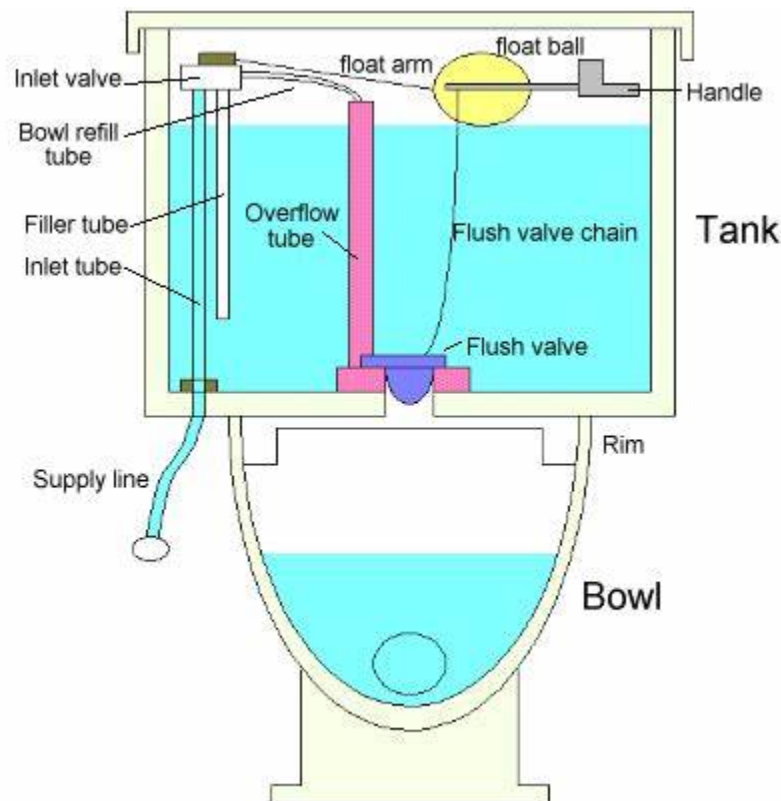
Most flush toilets are mechanical, meaning they function using levers and gravity. (Woodford, 2020)

Components of a flush toilet include (see figure 1):

- **Cistern or tank:** a ceramic tank above the toilet bowl that holds water and contains levers and other components.

- **Bowl:** a ceramic bowl-shaped component below the tank that typically has a ring-shaped seat and may have a lid. The bowl holds a small portion of water to assist with flushing waste.
- **Rim:** the top of the bowl on which the seat is placed that contains holes through which water can flow into the bowl from the tank when flushed.
- **Handle:** a metal or plastic knob on the outside of the tank connected to a lever on the inside of the tank that is connected to the flush valve chain.
- **Flush valve chain:** a plastic or metal chain that connects the handle lever to the flush valve and lifts the flush valve to drain water from the tank.
- **Flush valve:** a round or partially round, typically rubber device that controls water flow from the tank to the bowl. Also known as a ballcock, flapper or ball valve.
- **Supply line:** a tube that connects the water source, typically located behind the toilet bowl, to the inlet tube.
- **Inlet tube:** a tube that connects the supply line to the inlet valve to fill the toilet when the inlet valve is opened.
- **Inlet valve:** a valve that controls water flow into the tank through a filler tube.
- **Filler tube:** a tube through which the inlet valve fills the tank.
- **Overflow tube:** a tube-shaped reservoir that is filled by the bowl refill tube and fills the bowl with a small amount of water after flushing. It also prevents the tank from overfilling by adding more water to the bowl if the flush valve malfunctions.
- **Bowl refill tube:** a tube that fills the overflow tube through the inlet tube and inlet valve from the supply line.
- **Float ball:** a hollow ball that sits on the surface of the water in the tank.
- **Float arm:** a rod that connects the inlet valve to the float ball which opens the inlet valve when the water level drops.
- **S-trap:** an s-shaped passageway, also known as an s-bend, that connects the bottom of the bowl to the drainpipe, through which water and waste travel when flushing. Part of this passageway is elevated so the elevated part is filled with air and the lower part holds water in the bottom of the bowl. (see figure 2)

Figure 1 - Components of a flush toilet



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How a Flush Toilet Works

Flush toilets use water and gravity to push waste products through a drainpipe and into a sewage line. (Wikijunior: How Things Work/Flush Toilet, 2021)

The following steps outline how a flush toilet functions (see figure 2):

1. The tank is initially filled with water which travels from the supply line through the inlet tube, which is controlled by the inlet valve, and through the filler tube.
2. The inlet valve is opened and closed by the float arm which is connected to the float ball that sits on top of the tank water, controlling the water level in the tank.
3. When a user is ready to flush the toilet, the handle is pressed, pulling the flush valve chain which opens the flush valve and quickly empties the water from the tank into the bowl through flush passages and holes in the rim. (Brain, 2000)
4. As the bowl water level rises above the elevated, air-filled portion of the s-trap, a siphon is created, and the pressure of the water forces the bowl to empty through the s-trap and into the drainpipe. (Knight, 1999)

5. Once the tank is empty, the flush valve drops back into place, preventing water from emptying from the tank. When the tank refills with water, the weight of the water holds the flush valve in place, preventing water from leaking into the bowl.
6. Inside the tank, when the toilet is flushed, the float ball drops with the tank water level causing the float to open the inlet valve so water from the supply line can travel through the inlet tube and out through the filler tube, filling the tank once again. While the tank is refilling, water is also directed into the overflow tube through the bowl refill tube and slowly fills the bowl with a small amount of water, held in place by the air pressure in the s-trap. (The ABC's of Plumbing – Overflow Tube, 2021)

Figure 2 A flush toilet S-trap diagram



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Conclusion

Although the development of the flushable toilet took centuries, much of the functionality has remained the same for the past 150 years. While toilets themselves use simple mechanics, coordinating a water supply to the toilet and providing proper drainage routes created challenges for mass distribution. Once modern plumbing became widespread, so did the existence of flushable toilets into most U.S. homes.

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