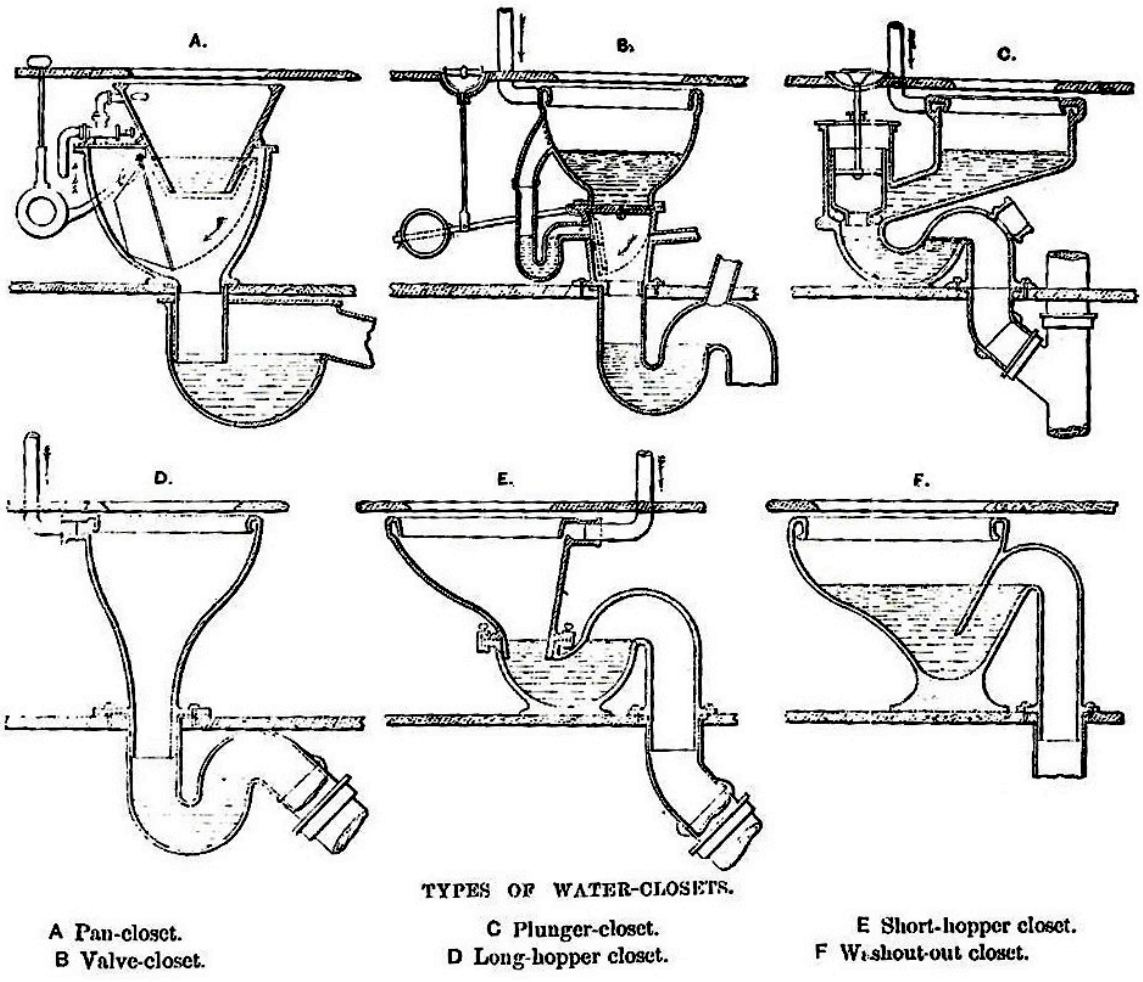
PLUMBING & SANITATION
FROM EARLIEST TIMES

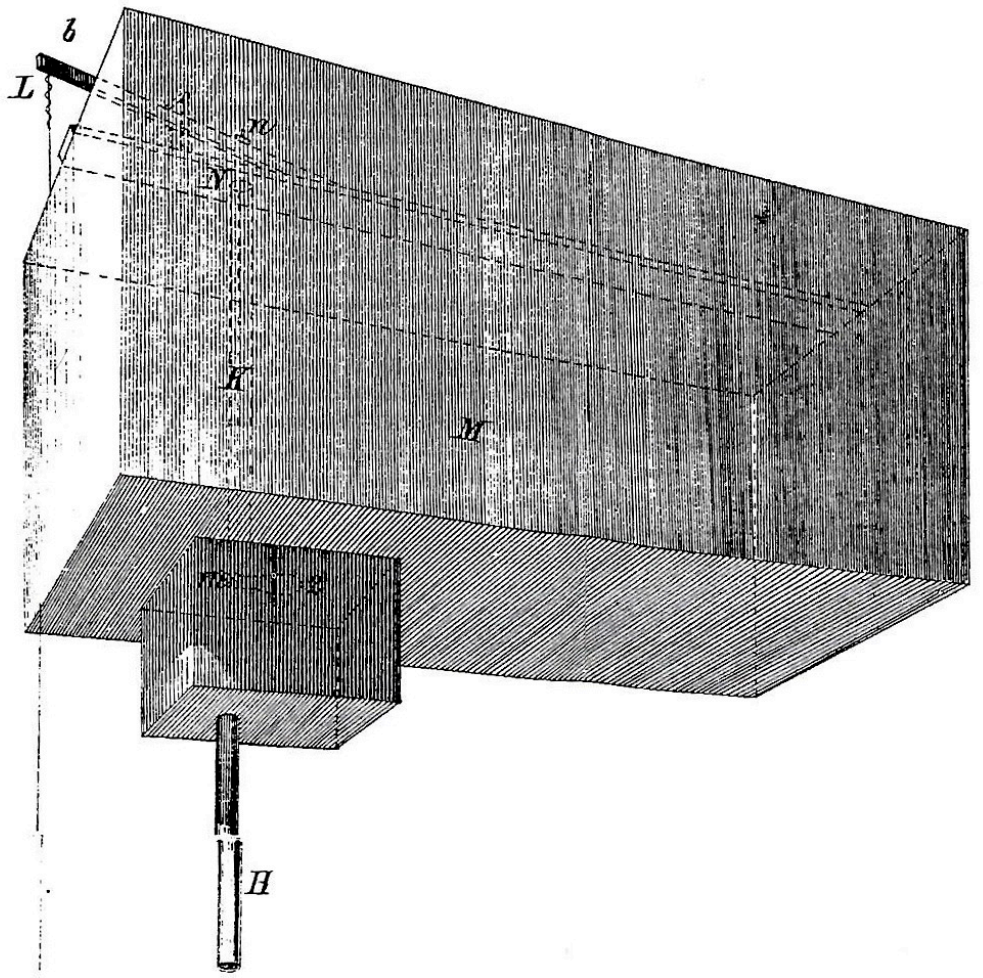
Technics



TYPES OF WATER-CLOSETS.

A Pan-closet.
B Valve-closet.
C Plunger-closet.
D Long-hopper closet.
E Short-hopper closet.
F Washout-out closet.

From TECHNICS AND ARCHITECTURE
Cecil D Elliot, MIT Press, 1993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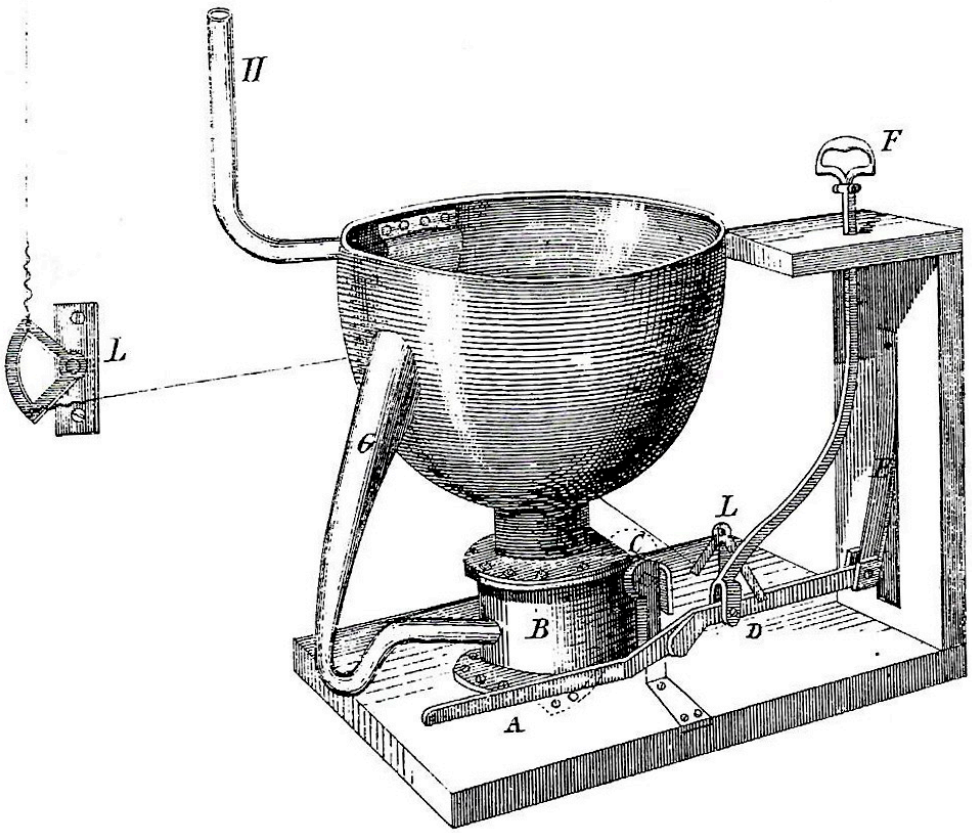
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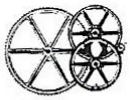
Because of the remarkable engineering skill of its empire, the city of Rome in the fourth century A.D. could provide 11 public baths, 144 public latrines, 865 private baths, and some 1,352 public fountains and cisterns.[1] These were supplied with water from 13 aqueducts, and around 70 aqueducts are known to have been built in other parts of the empire. (Repairing such aqueducts was often a medieval expedient for improving a city's supply of water.) Some public latrines had flowing water beneath seats of stone or wood. Containers were placed at certain street corners, and Vespasian instituted a charge for their use and a system by which the urine collected was sold for use by fullers of cloth.[2] Within Roman houses, chamber pots were used, being usually emptied into the street. But water was plentiful, and drainage was well provided in most Roman cities. All of these advantages declined with the empire.

As late as the middle of the seventeenth century even the nobility of England were little concerned with sanitation. After the court of Charles II visited Oxford to escape the plague, a local diarist wrote: "Though they were neat and gay in their apparell, yet they were very nasty and beastly, leaving at their departure their excrements in every corner, in chimneys, studies, cole houses, cellers. Rude, rough, whoremongers; vaine, empty, careless."[3] Medieval traditions had made city streets almost as much sewers as thoroughfares. With drainage in the middle of the paving, the pedestrian was forced at night to choose between walking in filth or passing within the reach of any thieves who might lurk in dark doorways. In Edinburgh the danger of having a chamber pot emptied over one was only slightly diminished by the custom of householders shouting "Gardy-loo" from upper-story windows a moment before hurling sewage into the street.[4] From the street such ordure drained into streams and was swept to the sea and the cities downstream. Englishmen on their Grand Tour complained that garments laundered in Rome stank forever of the Tiber's waters; just as some German visitors to London claimed that clothing washed in water from the Thames never lost traces of that river's sickening stench.[5] Visitors to Paris claimed they could smell the city's filth two miles outside its gates, and fastidious Parisians who ventured into the streets in the time of Louis XIV covered their noses with hands in perfumed gloves.[6] In smaller towns the problems were much the same. Viollet-le-Duc mentions that in towns of central France a stream through the center would customarily be called *merderel*, named for its foul contents.

Castles and monasteries often had privies projecting over their moats or streams. Built within towers or buttresses, these "garderobes" (wardrobe being a euphemism) emptied through shafts hollowed in the masonry. Where there was neither stream nor moat, cesspits were dug. Additional comfort was provided its users when the garderobe was warmed by being built into the masonry mass of a fireplace. For defecation peasants had the custom of retiring to a distance "a bow's shot" away from their dwellings. At the country houses of well-to-do Englishmen the gardens served a similar purpose, and leaving a social gathering "to pluck a rose" was another of the numerous euphemisms, meaning either a visit to a "bog-house" at the back of the garden or a more casual solution.

Chamber pots were provided inside houses of the prosperous, and the task of emptying them ranked high in servants' complaints.[7] Still at Versailles the ceremonies of Louis XIV's daily

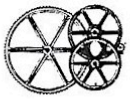
awakening included two *porte-chaise d'affaires*, attendants dressed in black velvet, who had the honor of removing the royal pot from beneath the king's *chaise-percée*. Those of noble birth or considerable wealth had such seats, ornately decorated, richly padded with velvet, and having a hole in the center of the seat cushion.



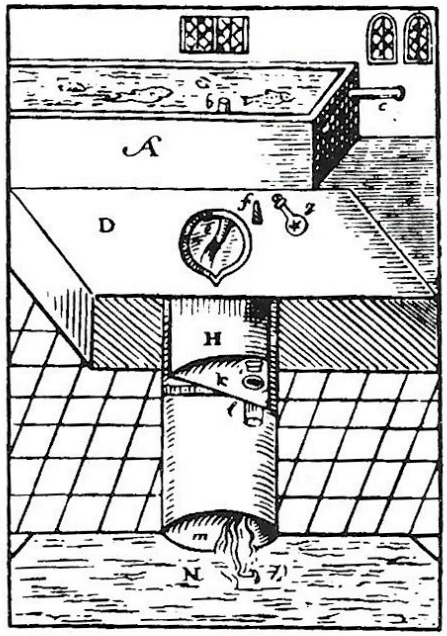
The lavish public baths of the Roman empire were not primarily intended for cleanliness. When a gong announced the daily opening of a bath, Romans, including citizens, slaves, freemen, and children, thronged there to watch sporting events, take pleasure in the luxurious decoration, hobnob with acquaintances of their own station, and perhaps bathe.[8] Smaller public baths were provided by the government or operated by private owners, and the houses and country villas of the rich were usually outfitted with a few small rooms that were the domestic bath, perhaps heated by circulating hot air beneath the stone floor as were the public baths.

Public baths continued to exist in much of Europe during the medieval period. The stews—as medieval baths, both public and private, were called—by the seventeenth century had become little more than brothels, although they were sometimes used for the steaming that might be prescribed as a cure for illnesses. Churchmen attacking the stews as centers of sin may have had some effect, but the decline of public baths was probably as much influenced by the increasing price of soap and fuel, as well as the years of plagues. Nobility continued to bathe splendidly. Tubs were hollowed out of marble for kings and dukes, although they sometimes required submerged sheets and cushions to protect royal rumps from the cold stone, a problem avoided in the wooden tubs that were used by people less grand. It is said that Louis XIV had at Versailles at least 100 bathrooms to serve the multitude of residents, visitors, and attendants, as compared with an inventory of 264 *chaise-percées*. Marie Antoinette bathed daily, but used only one tub rather than the pair considered proper, one for cleansing and one for rinsing. Except for sponge baths, the queen's subjects in Paris seldom took more than two baths per year, those during the summer and in public bathing places in the Seine. In 1800 there was not a single public bath in London and, when a lady of fashion was chided about her grimy hands, she laughingly replied, "If you think that dirty, you should see my feet!"[9]

When Queen Victoria assumed the throne in 1837 there was not a single bathroom in Buckingham Palace. For the most part, as in other houses of the wealthy, portable tubs were brought into bedrooms or dressing rooms, servants rushing up the back stairs bearing containers of hot and cool water and spreading many sheets around the tub to catch the splashing. Copper was the most desired material for making these tubs, but its expense frequently led to the substitution of tin. In simpler households a water seller might be summoned to bring a tub and the hot water required. In 1838 there were 1,013 water sellers offering that service to citizens of Paris, and there were only 2,224 tubs that were fixed in place.[10]



In 1596 the high sheriff of Somerset and a godson of Queen Elizabeth, Sir John Harington, published his design of a water closet. As a courtier, Harington had become known as a poet and man of wit, if not of impeccable taste. When he circulated about the court his translation of a salacious portion of Ariosto's *Orlando Furioso*, Elizabeth ordered him to depart from the court and before returning to translate the remainder of the poem, the literary work for which he is most remembered. Several years later Harington was again banished from court when he published *A New Discourse of a Stale Subject, Called the Metamorphosis of Ajax*. ("Ajax" is a pun on "jakes," a colloquial term for a privy.) Although filled with roguish humor and loaded with literary allusions, this and subsequent tracts on the subject give a clear description of the water closet that Harington had constructed for his country seat at Kelston near Bath (fig. 9.1)



9.1 In Harington's drawing of his water closet, water cleans the bowl and an iron rod extends from the seat surface (*f*) to the stopper (*k*) beneath. If water were scarce, it was recommended that the "stool pot" (*H*) be emptied at least once a day, and after being drained it was supposed to be filled with 6 inches of water. (Fish are drawn in the tank merely to indicate that it is filled with water.) (J. Harington, *Metamorphosis of Ajax*, 1596.)

9.2 In Alexander Cumming's water closet, an upward pull on the handle (*O*) activated a mechanism that simultaneously moved the "slider" at the bottom of the bowl and opened a valve that allowed water to flow into the bowl. (British Patent no. 1105.)

In the privy that annoys you, first cause a cistern, . . . to be placed either in the room or above it, from whence the water may, by a small pipe of lead of an inch be conveyed under the seat in the hinder part thereof (but quite out of sight); to which pipe you must have a cock or washer, to yield water with some pretty strength when you would let it in.

Next make a vessel of an oval form . . . two feet deep, one foot broad, sixteen inches long; place this very close to your seat, like the pot of a close-stool; let the oval incline to the right hand.

This vessel may be brick, stone, or lead; . . . the bottom and sides all smooth, and dressed with pitch, rosin, and wax; which will keep it from tainting with the urine.

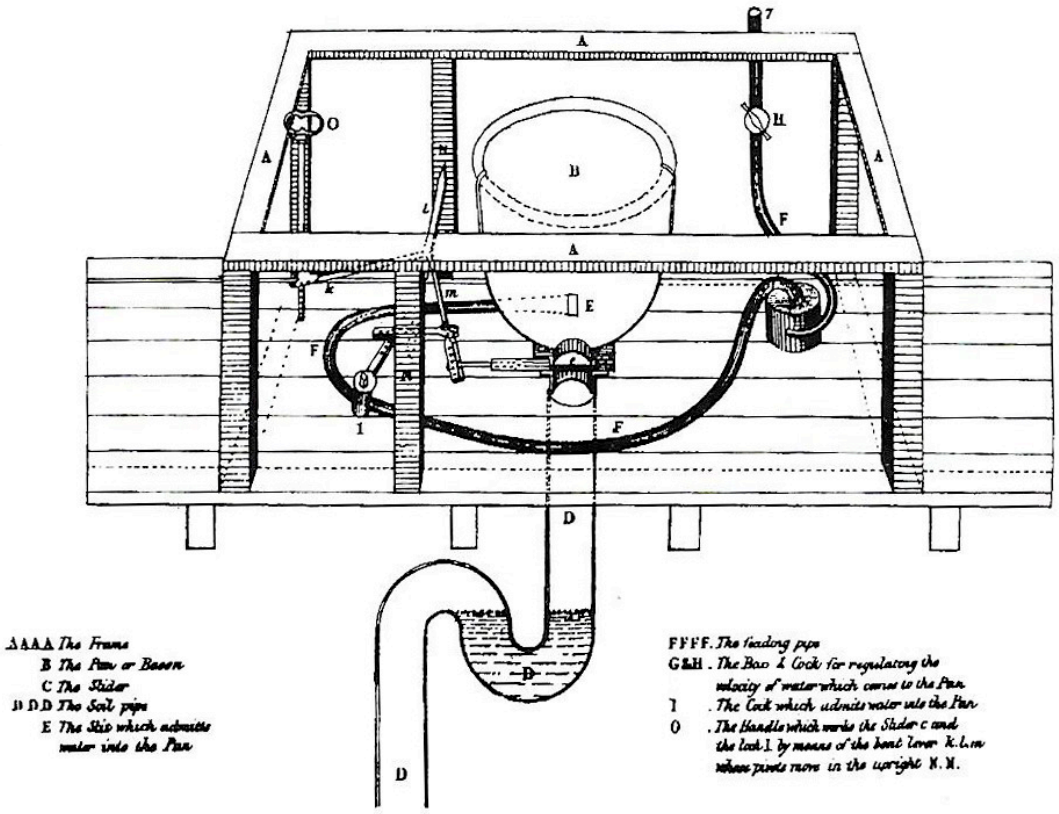
In the lowest part of the vessel which will be on the right hand, you must fasten the sluice or washer of brass, with solder or cement; the concavity, or hollow thereof, must be two inches and a half.

To the washers stopple must be a stem of iron as big as a curtain rod; . . . with a strong screw at the top of it; to which you must have a hollow key with a worm to fit that screw. . . .

These things thus placed, all about your vessel and elsewhere, must be passing close plastered with good lime and hair, that no air come up from the vault, but only at your sluice, which stands closed stopped; and it must be left, after it is voided, half a foot deep in clean water.[11]

A water closet of Harington's design was installed for the Queen at Richmond Palace, but this first example of the valve closet was not widely adopted and seems to have disappeared from use until almost two centuries later, when it was reinvented and introduced once again.

A British patent for a valve water closet was issued to Alexander Cumming, a London watchmaker, in 1775.

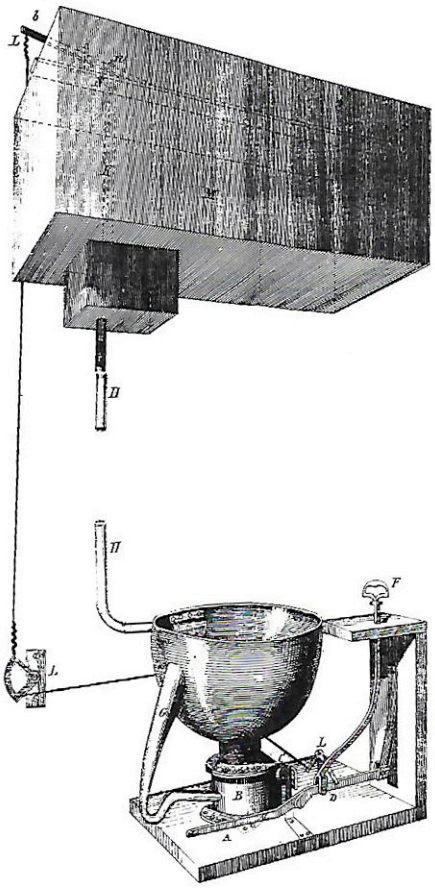


The principle was the same: a lever beside the seat operated a leather-covered valve at the bottom of the bowl, and at the same time water from an overhead tank was released through an opening in the side of the bowl.[12] Beneath the water closet itself the waste drained through the "stink-trap," an S-shaped bend in the waste pipe that retained sufficient water to seal the pipe and prevent odors entering the toilet room (fig. 9.2). Until rubber valve seals were introduced, the fit of valves quickly deteriorated, and there was little to prevent entrance of smells from the system.

Various adaptations of the basic design were developed. The most influential of these was the first patent of Joseph Bramah, a London cabinet-maker who later invented locks and many other devices (fig. 9.3). Bramah fabricated cabinets to surround valve water closets, and he turned his mind to improving the closets. Three improvements contributed to the popularity of Bramah's design, as compared to that patented by Cumming only three years before.[13] First, a metal flange was set in front of the opening through which water entered the bowl, deflecting the flow to cover much of the bowl's interior surface. Second, an overflow pipe bypassed the valve in case of stoppage. The third improvement was in the valve itself. Cumming's valve, the "slider," had moved horizontally to close or open the bottom of the bowl; Bramah's was hinged and pivoted when the lever was pulled. Thousands of such water closets were manufactured by Bramah. For about a century the Bramah valve closet was in general

use, until in 1870 the British firm of Dent and Hellyer introduced their "Optimus" improved valve closet. Almost a hundred years later this model was much like Bramah's design, except for its having a flushing rim and improved mechanics that quieted its noise and made chain-pulling less frustrating. In alphabetical order from "Optimus A" to "Optimus P," models of this closet were produced until World War II.[14]

The pan water closet was probably introduced almost as early as eighteenth-century valve closets, and the difference between them was slight. Instead of the flat face of the valve closing the opening at the bottom of the bowl, in the pan closet a shallow metal dish was hinged beneath the opening. An 1829 British patent provided a leather ring to seal the edges of the pan against a flange of the bowl, and water in the pan further sealed against odors.[15] Leather gaskets were not usual in the many pan closets available during the middle half of the nineteenth century, but one would assume that water seals at the pan and in the "stink-trap" would have been sufficient. Nevertheless, leaks in the entire assembly of pipes and fixture often defeated the purpose of these water seals. Pan closets were widely used, but there were constant complaints about them. Even with the addition of a flushing rim around the upper edge of the bowl, the design was not considered satisfactory. A nineteenth-century plumber commented: "I consider this closet a very unsanitary piece of mechanism, and totally unfit for its intended purpose, inasmuch as in a short time the internal parts become besmeared, and consequently become offensive."[16] The pan closet persisted as a basis of negative comparison for other designs, "as bad, or worse, than the pan-closet."[17] Toward the end of the nineteenth century the pan closet was sometimes still in use in Chicago, although it was not admired:



9.3 The Bramah valve closet was operated by pulling the handle (*F*), which opened a hinged valve in the chamber (*B*) and pulled the wire (*L*) that opened a valve at the bottom of the water tank. As with all valve closets, a tight-fitting valve was needed if any water were to be retained in the bowl. (British Patent no. 1177.)

> The pan-closet of twenty-five years ago was identical with the pan-closet of today. The old pan cistern-closet was defective in structure in two particular things: First, the supply pipe to the closet bowl was far too small for a proper flush; one-half inch pipe was not sufficient. Second, the closet bowl, especially the French [round] bowl, was defective in principle. The swinging of the water around the bowl in a whirlpool-like shape was not enough to cleanse the bowl nor remove the soil from the trap, or clean the trunk of the closet or wash out the soil pipe.[18]

Not much better was the hopper closet, which dispensed with valve or pan. It consisted of the hopper, an inverted cone placed directly over the

"stink-trap," and an ineffective trickle of water that spun around the sides of the bowl. The sole advantage of the hopper closet was its extremely low price. In 1849, 18 hopper closets were shipped from New York to St. Louis for installation in the Planters' House Hotel, but a few years later the installation was improved when the hopper closets were replaced with the repugnant pan closets.[19] In general, it could be assumed that hopper closets would be provided for servants and workers, because they cost about a fifth as much as more sophisticated and efficient models. At any time every country used a variety of designs, cost being the major factor in selection. So many hopper water closets were manufactured so cheaply that an English sanitary reformer suggested abandoning use of the hopper and selling the unused earthenware cones to gardeners, who could use them to protect rhubarb from spring frosts.[20]

Although the plunger water closet was used at the same time as valve, pan, and hopper closets, few improvements in its design were patented until the latter part of the nineteenth century. The mechanism was simple, though clumsy. At the bottom of the bowl, instead of a valve or pan, there was a plunger, which, when lifted by raising a handle, opened the passage between the bowl and the trap. Some plungers were simply cylinders, but others were hollow and contained a valve that opened under pressure to prevent the bowl's overflowing. Two major problems of the plunger closet were the tendency of the plunger to make an imperfect seal, even when provided with a rubber gasket, and the fact that concealed portions of the mechanism were quickly fouled. An advantage was the quantity of water retained in the bowl, about half its capacity, and this feature was kept in many later designs of water closets.

The valve, pan, and plunger water closets had provided a bowl within which feces might fall into water and a means of conveying the feces and water into a drain in which there was a trap, but the more fastidious classes required a closet that was more sanitary, although it might also be much more expensive. The washout water closet had its outlet located at the back side of a shallow bowl. Waste and water flowed through this opening into the trap, leaving an inch or two of water in the bottom of the bowl. Its principal fault lay in the fact that the water seldom had enough force to cleanse the bowl properly and eject the wastes. A variety of designs attempted to make improvements by changes of the flushing rim and the surface of the bowl, but they were, on the whole, unsuccessful.

The washdown water closet was little more than a hopper closet with its S-trap at a level so high that the water in it filled much of the water-closet's bowl. A variation of the washdown closet was the siphonic closet, which used different water inlets and amounts of water to cause a siphon action with two or three sequential flushing actions.

Earlier water closets, like the other bathroom fixtures, had required cabinetwork to conceal the inelegant connections between parts made of earthenware, cast iron, and enameled iron. Makers of the ceramic portions of fixtures had long resented the fact that their portion of the final product was priced far below the pipes, traps, and valves that were made of metals. After the introduction of the flushing rim, the skill in manufacturing extremely intricate shapes of earthenware grew year by year (fig. 9.6). One of the advantages of the washout and washdown water closets was the pos-

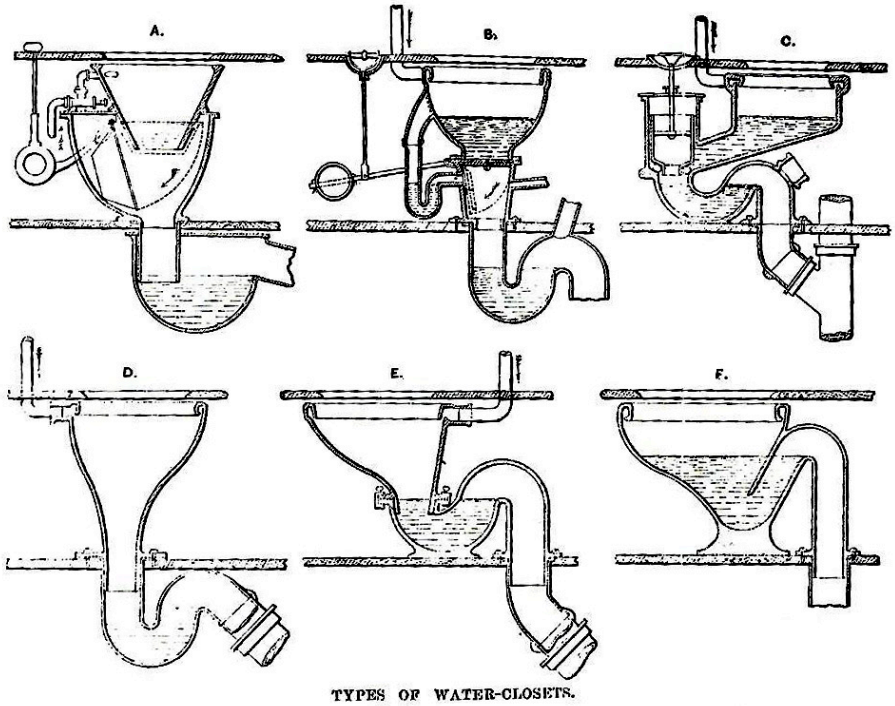
sibility of making them from a single smooth material, earthenware, using complex shapes to replace the complicated mechanisms of earlier models. The shapes of the fixtures were made visible in bathrooms, where they shone bright and clean. Decoration could be added to their surfaces, plants and animals shaped in bas-relief and colored patterns added with sanitary glaze.

After cholera first struck England in 1831, a physician in the industrial city of Leeds began compiling studies showing that mortality rates were higher and epidemic disease spread more rapidly in the working-class areas of the city. A later investigation proved that most of those who died in London from the cholera epidemic of 1849 had drunk water from a single public pump. With repeated epidemics in Europe and the United States, cholera came to be respected as "the great sanitary inspector of nature."

Typhus, typhoid fever, and smallpox added to the death rate in nineteenth-century slums, but the frequency of children's deaths probably was largely the result of their increased susceptibility due to malnutrition. A London laboring-class family of five in 1841 is reported to have been fed for a typical week with five pounds of meat, twenty of bread, forty of potatoes, and little else.[21] Although the dispersed squalor of farmworkers' hovels was little better, the slums of large cities attracted the attention of reformers. Friedrich Engels in 1845 described *The Condition of the Working Class in England*, and 16 years later Henry Mayhew in *London Labour and the London Poor* dramatically recorded the lives of the city's impoverished. Prior to both these books, a commissioner of the English poor laws, Edwin Chadwick, published the *Report on the Sanitary Condition of the Labouring Population of Great Britain*. A hard-working and cantankerous man, Chadwick combined a massive compilation of questionnaires to physicians, police, builders, and others with the tabulation and mapping of the vital

9.4 The basic types of water closets in the nineteenth century: *A*, pan closet; *B*, valve closet; *C*, plunger closet; *D*, long hopper closet; *E*, short hopper closet; and *F*, a washdown closet. (W. P. Gerhard, *House Drainage and Sanitary Plumbing*, 1882.)

9.5 Later water closet designs: left, the washout closet; center, the washdown closet; and right, the siphon closet. (W. P. Gerhard, *Water Supply, Sewerage and Plumbing of Modern City Buildings*, 1910.)



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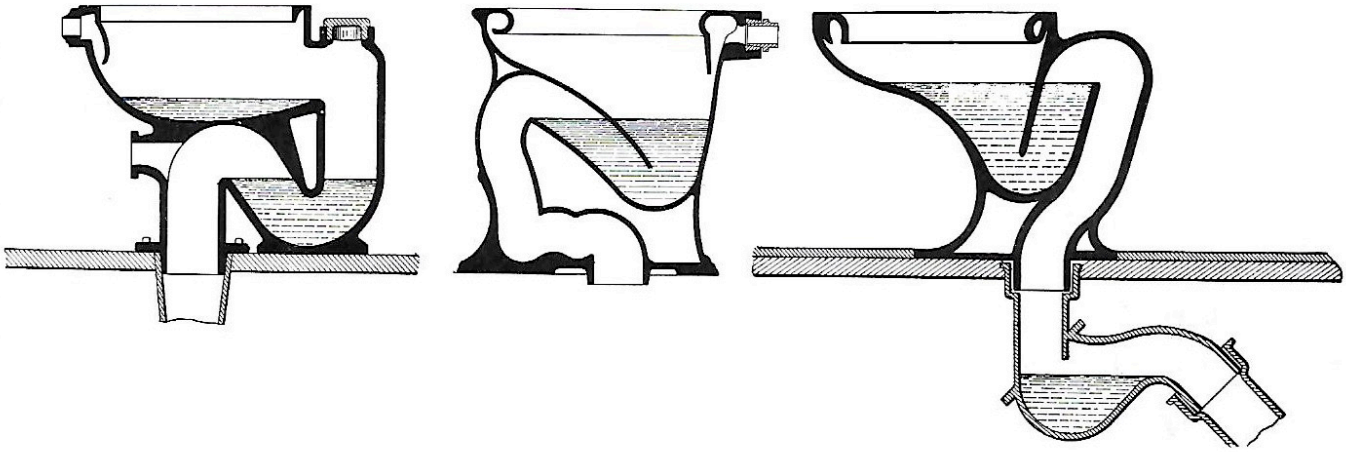
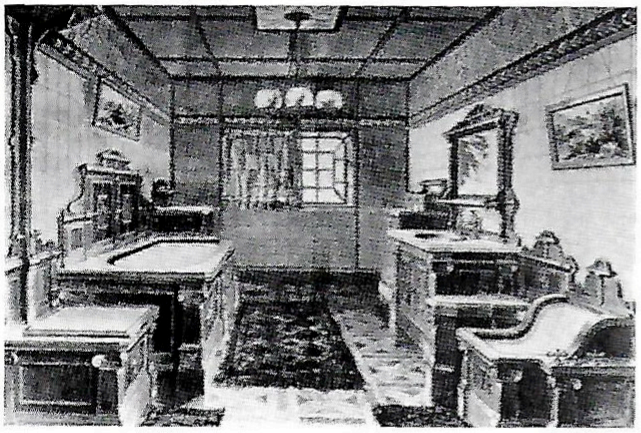
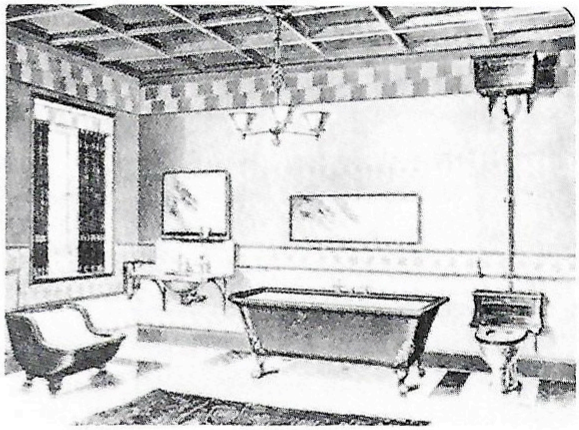


statistics available at the time. Over 10,000 copies of "Mr. Chadwick's Report" were sold, an extraordinary demand for anything published as a government document.[22] A series of boards and commissions contributed to the preponderant evidence that insanitary conditions were closely associated with the occurrence of disease and early death. Although not everyone was alarmed by the facts as they were reported, the righteous impulses of Victorian England were aroused. An exception was Thomas Carlyle, who declared that "if paupers are made miserable, paupers will needs decline in multitude."[23] Unfortunately Hamburg, Paris, and other cities were to make major improvements in their sanitary conditions before the political and business interests in London would permit such construction.

By the middle of the nineteenth century an increased portion of housing for English workmen was built with an alleyway behind, supplanting the back-to-back construction that had opened only at the front. Privies, often shared by several houses, were situated in rear yards, and the alleys permitted nocturnal removal of the privies' contents, which was sold to farmers as fertilizer. In some cases, instead of cesspits being emptied, other holes were dug and the previous pit merely covered, a practice that greatly increased the likelihood of polluting wells. Later the increased number of water closets installed resulted in larger amounts of fecal material entering streams, because it was no longer available for agricultural use.

Problems of building sanitation, while more prevalent in slums, were forthrightly disrespectful of rank. In 1844, 53 overflowing cesspits were found beneath Windsor Castle, providing an explanation of the frequent ailments suffered by the royal family's servants at the castle. The Prince Consort ordered the installation of water closets and a sewage system. Seventeen years later Prince Albert died of typhoid fever, and a decade afterward the Prince of Wales fell ill of the same disease. Such events brought the attention of the English public to bear upon the need for improved household sanitation. The





Prince of Wales, after recovering from his nearly fatal fever, was said to have declared, "If I were not a prince, I would be a plumber."[24] But progress was slow. In 1882 the Duchess of Connaught, wife of Victoria's third son, was dangerously ill, and the ailment was attributed to her newly built residence, Bagshot Park. The duchess's doctor and a civil engineer inspected the building and reported: "Offensive smells had long been perceived about the house, and had been a common topic of conversation; but no one had suspected their origin or had realized the dangers they were likely to cause. Many of the inmates, however, had suffered from various forms of indisposition, such as sore throats, diarrhea, and a general sense of heaviness and malaise, and these generally affect new comers."[25] *Lancet*, a medical journal, commented that the plumbing system of the building appeared to have been designed "by a Machiavellian policy which would seem to be the pastime of modern builders."[26]

In Great Britain the first legislation on sanitation, enacted in 1848, had little effect because it gave permission for improvements without requiring that any action be taken. A succession of later acts established standards and required compliance with them. As legislation advanced, the training of inspectors improved and their numbers increased. In 1864 Dublin had only one sanitary officer, but about 30 years later the city employed a corps of 50.[27]

A reform movement in New York, led by concerned businessmen, in 1864 conducted a survey of sanitary conditions within the city, using procedures that had been developed in England. Their report of shocking conditions and the threat of cholera led to passage of the Metropolitan Health Law two years later. Used as a precedent for many sanitation laws of other cities in the United States, the Metropolitan Health Law and subsequent stricter legislation were particularly directed toward the control of tenement construction.

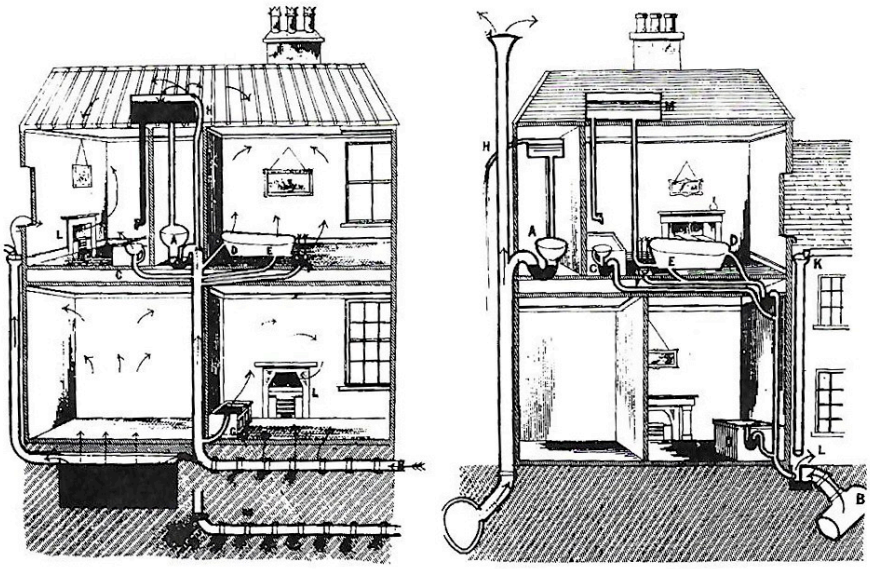
9.6 Bathrooms of the well-to-do in the United States: During the 1880s (left) it was deemed necessary to encase all fixtures in wooden paneling, a requirement no longer present in the 1890s (center) when open fixtures were given decorative treatments. By the start of the twentieth century (right) a shower over the bathtub was standard. The presence of sitz baths and bidets in these catalog illustrations indicates the enthusiasm of the manufacturers of plumbing fixtures more than the common practice of the times. (A. M. Maddock, *The Polished Earth*, 1962.)

One of the most important factors in protecting the public health was the provision of a safe water supply. In 1829 sand filter beds were installed by the Chelsea Waterworks in London, and about 20 years later all water companies in the city were required to do the same. At the end of the century there were in all almost 15 acres of sand filter beds in London. At the same time techniques of filtering water in the United States proved so effective that sanitary engineers recommended that municipal authorities invest only in water treatment, because, as one engineer put it, a dollar spent on water treatment "would do as much as ten dollars spent in sewage purification."[28] There was, of course, a sharp difference of opinion between the citizens of a small downstream town and those of the upstream metropolis. However, it was discovered in Lawrence, Massachusetts, that sand filtration reduced the incidence of typhoid fever by 79 percent.

Early pipes, those of the ancient and medieval periods, were made of earthenware, lead, or wood. For drains made of fired clay it was simple to taper or enlarge tubular shapes in order to provide a firm joint between lengths of pipe. Sheet lead was obtained by spreading the molten metal on a sand-covered surface and beating the sheet until the desired thickness was attained. An oval cross section resulted from bending the sheet lead and making a soldered joint; a teardrop cross section resulted when the metal was folded and crimped for a joint. Wooden pipes have been found in several early medieval English installations, notably monastic complexes. Early in the seventeenth century, when the first large-scale water supply system was available in London, water was brought from the north into the city by an open stream 38 miles long, and from a reservoir it was distributed to users through mains made of elm trunks and fastened together with iron bands. Branches of the trees were often used to form Y's and T's needed for water mains. In spite of the development of metal pipe, the use of wooden mains for the supply of water and gas persisted into the last decades of the nineteenth century. The American Pipe Company of San Francisco in 1878 advertised sections of fir and pine 8 feet long, which were bored, steam-treated, wrapped with iron bands, and coated with asphalt.[29] Wooden pipes must have done their work well. In one of the company's advertising brochures a testimonial letter reported the excellent condition of wooden water mains in Manhattan that had survived more than 75 years of use.

Metal pipes for water supply were later made by the same methods employed in manufacturing gun barrels. In fact, many early installations for water supply, gas lighting, and steam heating utilized inexpensive gun barrels, those that were a manufacturer's surplus or were judged unsatisfactory for the sudden pressure of firing a rifle.

The principal concern in plumbing systems was the piping of drainage systems that carried away the waste, and tell-tale odors were ample indication that the drains were not satisfactory. A major factor in the public's anxiety about drains was the fact that the "miasma theory" of disease's ori-



9.7 A publication of 1879 shows "a house with every sanitary arrangement faulty" (left) and "a house with faulty arrangements avoided" (right). Arrows within the dwelling at left show the possible circulation of sewer gas leaking from fixtures and seeping from beneath the floors. (T. P. Teale, *Dangers to Health*, 1879.)

gins and transmission persisted in the minds of the public and many physicians long after the conclusive experimental determination of the "germ theory." Unseen microorganisms were recognized as the source of disease by the 1880s, but only among those of advanced scientific background. Most of the population continued to associate the spread of sickness with the presence of identifiable foul odors.

Sewer gas leaked into toilet rooms primarily through early water closet installations (fig. 9.7). "The odor of their memory, or the memory of their odor, still lingers with us."[30] An almost endless number of ailments were attributed to the presence of sewer gas. In addition to its supposedly causing specific sicknesses, there was a more general claim that sewer gas deprived "men of ambition and women of beauty." As late as 1901 William Paul Gerhard, a leading sanitarian in the United States, told a gathering of knowledgeable health officers: "Modern German sanitarians are nearly united in being opposed to the so-called 'sewer-gas theory;' they claim that the researches of Von Pettenkofer, of Pasteur, of Dr. Koch and others have established, almost beyond a doubt, the fact that every infectious or zymotic disease requires the presence of a specific microörganism or pathogenic bacterium to cause it, and that the gases of putrefaction *per se* cannot cause the disease."[31] Another authority considered that sewer gas, while not a cause of specific disease, made one susceptible because it produced a condition of general ill health.

The primary defense against sewer gas entering a building was the trap, which was intended to seal drains by means of the water retained in a downward bend of the pipe. There was a danger, however, of water in a trap evaporating when buildings were closed for a long period, but hardly so great a danger as imagined by Chicago plumbers who in an 1888 issue of the *Sanitary News* recommended filling such traps in vacant buildings with glycerine or oil, or even draining out the water and packing the trap with salt.[32] A more realistic danger was that downrushing quantities of water in the main drains might create a vacuum and draw water out of a trap. The solution proposed was venting each trap by extending a pipe from the down side of the trap through the roof, and so providing air to relieve any vacuum (fig. 9.9). A Chicago plumber remembered that he first saw a major vertical drain extended through the roof in structures after the fire of 1871.[33] In the previous decade he had seen vents installed in connection with water closet traps, but they had been meant to avoid pressure developing within the major drains rather than to protect the seal of traps. By the end of the century regulations often called for back-venting traps. This requirement, still in force, was debated with great fervor. The opposition was formidable and outspoken.

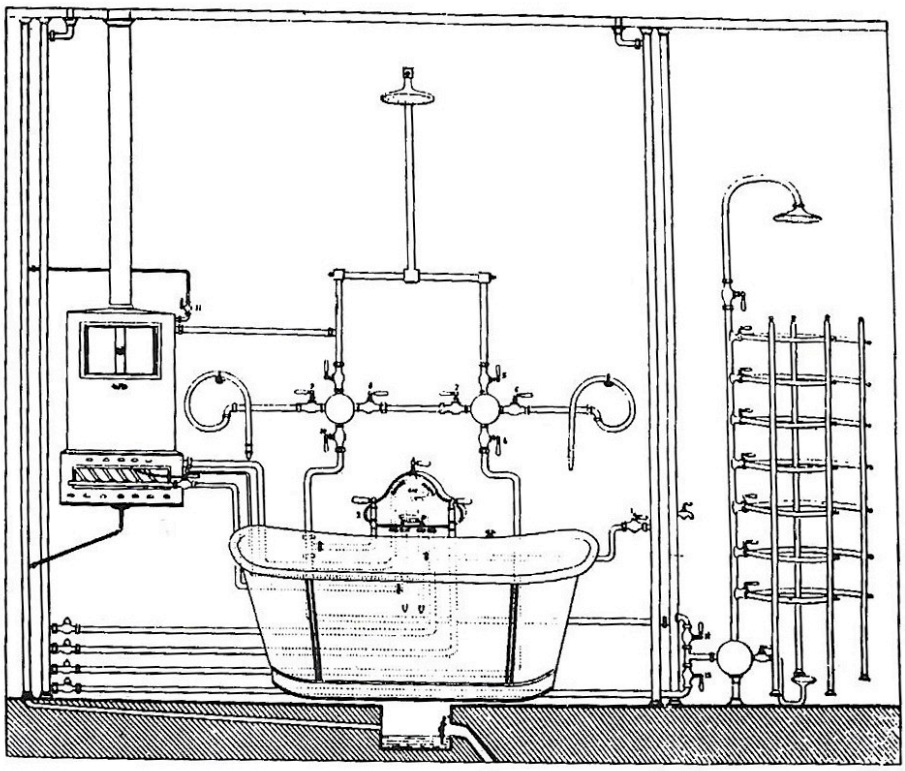
J. Pickering Putnam, a Boston architect: "One of the most unfortunate and burdensome building-laws ever inflicted upon the people, and an imposition upon the public."

George E. Waring, the famous New York City sanitarian: "Does more harm than good, that is to say, that a trap is more likely to lose its seal if it is back-vented than if it is not."

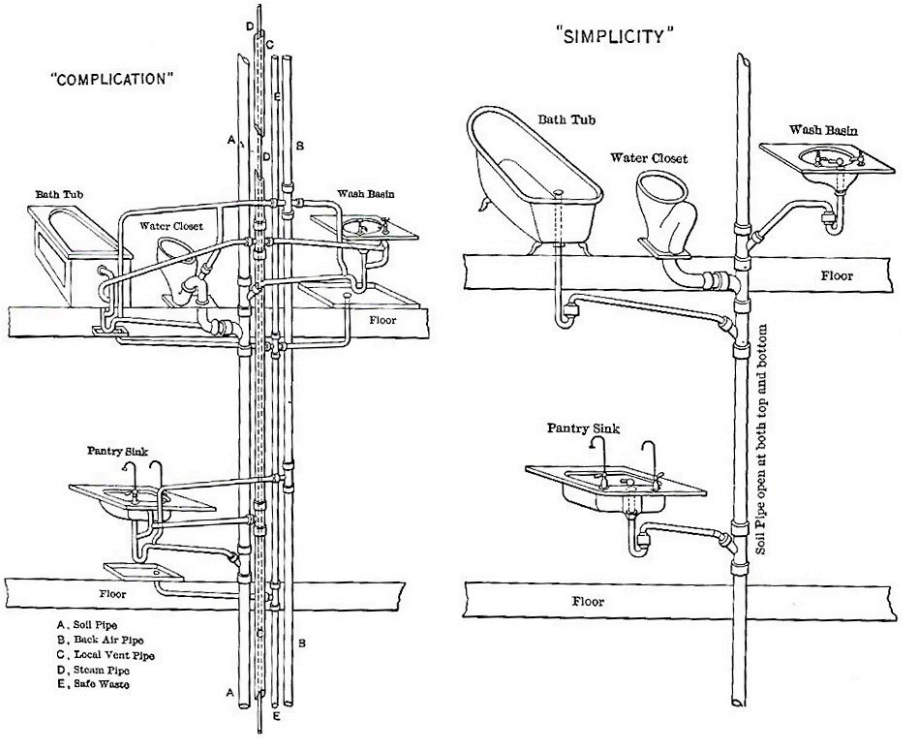
An "English expert on drainage:" "A diagram of house-plumbing, protected by ventilation-pipes as prescribed by most American authorities, a bewildering nightmare of complicated ingenuity."[34]

In 1892 the *Northwestern Architect*, a Minneapolis publication, queried

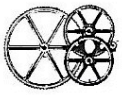
9.8 In commenting on this 1890 bath arrangement displayed at the Palais de l'Industrie, *La Construction Moderne* said, "This system is perhaps extremely ingenious but less than practical." The journal's illustration bore 21 lines of caption explaining the ways of achieving different bathing effects. (*Construction Moderne*, 20 December 1890.)



9.9 Diagrams at the turn of the century suggested eliminating "back air pipes" by care in the provision of special traps. Such precautions permitted simplification of the piping required. (R. Sturgis, *Dictionary of Architecture and Building*, 1901–1902, vol. 2.)



architects and plumbing contractors on the matter. Plumbers were about evenly divided on the subject of back-venting. The architects gave varying replies, but all were convinced that traps of greater depth than customary would provide as much protection as back-venting. This point of view was echoed by Dankmar Adler, the respected Chicago architect, who added, "I am glad to see that you are moving in the cause of reform in a matter which is of vital interest to the entire community."[35]



Since ancient times the disposal of wastes has been accomplished with the use of water. Water closets, by definition, consumed large amounts of water, and even the filth thrown into streets was washed into rivers and lakes. There were few exceptions. The "night-men" who gathered the contents of cesspools, privy pits, barrels, and buckets sold them to farmers when cities were so small that a short trip outside the city would be profitable. When the distance was too great, the excrement was usually deposited in a single large pit or, more likely, taken to the river. The construction of metropolitan sewage systems and the increased number of water closets unfortunately meant only that an even greater portion of the waste went into the river.

"No more pipes, no more cesspits, no more unhealthy odors, absolute cleanliness." When a writer for *La Construction Moderne* read those claims for the earth closet invented in 1860 by the Rev. Henry Moule, he accepted the first and second claims, questioned the third, and rejected the last.[36] Lime, ashes, and sand had long been periodically dusted over the contents of privies (fig. 9.10). In the Moule earth closet, fine, dry earth or sand was kept in a hopper above and behind the seat. After each use a lever released a layer of earth from the hopper and, if ashes were used, gratings retained the cinders. One version of the earth closet automatically activated the hopper whenever a user rose from the seat, but the contraption appears to be have been noisy. "In sick rooms, this method of distribution of earth may be found objectionable, as more or less vibration follows the rising and this is apt to disturb the nerves of a patient."[37] The earth closet enjoyed a limited popularity, and there were nine designs patented in the United States between 1872 and 1882. Much of this interest in what now seems an improbable solution to the problem came from cold regions in which water pipes were liable to freeze. In addition, it should be recalled that the earth closet may have offered a relatively inexpensive alternative at a time when about 95 percent of New York City's population still depended on privies or chamber pots.[38]

The earth closet was a short-lived invention. Chemical toilets containing liquids of high alkalinity have become the most common solution for toilets in temporary locations, and pit privies remain a characteristic of isolated and primitive locations. The discussion of methods for disposing of human wastes has in recent years been related to discouraging forecasts of the future water supply. Toilets employing bacterial decomposition, incineration, and oil as a flushing agent have received attention, but almost all modern systems are fundamentally based on Harington's design made at the end of the sixteenth century. The water closet of that time has been improved in operation and appearance, but little has been done to confront the fact that water-flush systems are manifestly inappropriate in our time.

9.10 Earth closets scattered soil, sand, or ashes over the wastes deposited in a box beneath the seat. (G. E. Waring, *Earth Closets and Earth Sewage*, 1870.)

9.11 Systems of sanitation that avoided the use of water were particularly fitting for northern areas, where frozen pipes were a constant problem. For the Smead Dry Closet and Cremation System, a chamber was constructed beneath the floor of a school toilet with air going over a heater at one side (right) and up a flue on the other side (left). According to an 1889 catalog, over a hundred of these systems at that time had been installed in schools in Minnesota and Wisconsin. (Catalog of Ruttan Warming and Ventilating Co., 1889.)