GOLDEN OLDIES

Fire brigades can be traced back to the Roman Empire. Hero's book *Spiritalia* describes the construction and use of a fire-pump (200 BC). The Emperor Augustus in AD 6 created the Vigiles, a force of some 7000 men comprising water-carriers, pumpmen and men with hooks for pulling down burning buildings.

Appollodorus, architect to Trajan, described how assistance may be given when the upper part of the building is on fire, and the machine called "sipho" (the fire engine or pump) is not at hand, "In this case leathern bags filled with water are to be fastened to long pipes in such a manner, that by pressing the bags the water may be forced through the pipes to the place which is in flames."

It appears that organised fire-fighting in Britain virtually ceased with the collapse of the Roman Empire. London was devastated by fire in AD 798 and again in 982.

Throughout the Middle Ages the onus for protecting the towns from fire rested with the householders. The *Liber Albus* records for the reign of Edward II (1307-27) have orders for each of the great house-owners to provide ladders, iron hooks and, "Of barrels filled with water item, that all persons who occupy such houses, have in summer-time, and especially between the Feast of Pentecost and the Feast of Saint Bartholomew (24 August), before their doors a barrel full of water for quenching such fire, if it be not a house that has a fountain of its own."

A fire squirt in use during the Great Fire of London.

It was not until the 16th century that mechanical means of fire extinction were revived.

Contributed by the CIBSE Heritage Group.

GOLDEN OLDIES

A fire set on a hearth in the main room of the dwelling was used all over Europe, by the rich as well as the poor. The *Beowulf* tale of the eighth century relates that a German King, his family and his followers sat around a central hearth in a large hall.

No outlets for the escape of smoke were originally provided: it had to escape as best it could through doorways and windows, as at Penshurst. At a later stage, an aperture was formed in the roof or gable to allow the smoke to dissipate. The roof opening was surmounted by a turret, often richly decorated.

The central hearth and resulting smoke could have hardly been thought a nuisance, since it survived until the 15th century in Britain, and could be found in Danish farmhouses as late as 1841.

In order to keep the fire alight overnight, the embers were covered with ashes or with a cover which also prevented flying sparks. In Lower Saxony, the cover was of metal, bell-shaped, with small air holes at the top (this is the origin of the English "curfew' from the French "couvre-feu"). A police order in Germany dated October 1618 required, "The fire everywhere at nights, when one goes to bed, is to be guarded by iron or tin doors, cover, lid or stones, so that cats do not lie thereon or in the warm ashes, and scatter the fire onto the straw or hay on the floor."

The central hearth at Penshurst.

It may be supposed that the "curfew" gave rise to the smoke-hood placed some little way above the fire or cooking hearth, and this became common in cottages throughout Europe. These hoods led to the roof and terminated in a lantern or turret.

Contributed by the CIBSE Heritage Group.

GOLDEN OLDIES

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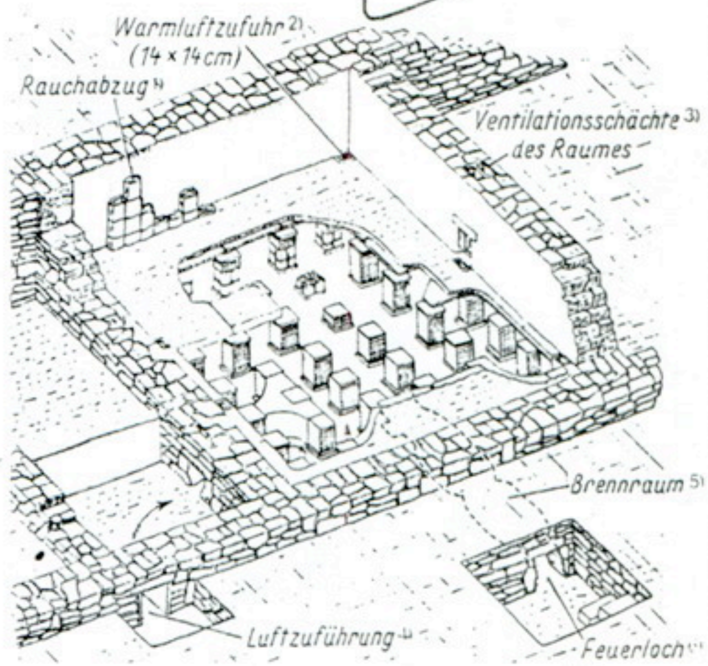
The hypocaust was devised by the Romans, and used from about 80 BC to the end of the Roman Empire in 450 AD in the villas throughout Europe. In the Roman motherland, it was used almost exclusively for heating baths. Only after the destruction of Pompeii in 79 AD did the hypocaust begin to the oust the brazier as a means of room heating.

Some excellent examples are to be seen in Britain at Chester, Bath and Chedworth (Glos) where the boiler was believed to have been made from thick sheet lead supported on massive iron bars.

There were three kinds of hypocaust: floor heating only; heating via floor and walls; and a warm-air system in which the air was admitted to the room through holes in the floor. The latter could be controlled to some extent by covering or stopping the holes as required. The hypocaust structure and floor was warmed by the furnace, which was then allowed to die out, the smoke flues were closed and the ventilation holes opened, so that air warmed by passage through the underfloor space was discharged into the room.

In the earliest hypocausts, the floor of the room was supported on pillars 0·7 to 1 metre high and spaced about 1·3 metre apart. Part of the space beneath the floor served as a furnace chamber, the fire being stoked through a stoke-hole in the external wall. The hot gases circulating beneath the floor warmed it.

Later, tile flues (tubuli) were incorporated in the walls. The furnace gases ascended through these tubes and were discharged to outside just below the eaves. These can be very clearly seen in the Chedworth villa. In the baths of this villa, these wall flues were continued within the barrel-vaulted roof to prevent condensation.



1) Fume extraction
2) Warm air supply
3) Room ventilating
4) Air intake
5) Fire chamber
6) Fire hole

Hypocaust at Saalburg

Contributed by the CIBSE Heritage Group.

GOLDEN OLDIES

It was realised as long ago as the 16th century that certain tasks demanded a higher level of illumination than commonly obtained from a simple candle. Certainly, the use of water lenses or refractors dates from this time, when they were used by lacemakers, by cobblers, and by scholars to aid reading. A spherical flask filled with water, placed in front of the candle flame acted as a condenser lens, producing a small area of relatively bright illumination. The principle involved was described as "a new devised luminary of glasse" by John Rovenzon in his *A Treatise of Metallica* published in London in 1613. It was noted that aqua vite (distilled spirit) was added to the water to prevent fouling by algae. In another, "Encyclopedie" of the 18th century, the Abbe Pluche (in 1732) discussed the distribution of light:

"It is not difficult to increase the amount of light from a candle. One way is to suspend a clear glass globe of water in front of it. Another is to use a shade, which should be so tipped that the rays of light would be concentrated on the work to be performed. The candle tube should be slanted at an angle of from 45 to 60 degrees from the horizontal. The inside of the shade or reflector should be lined with paper having a dull finish but this is dangerous. A copper shade can be given a coating of white lead, which is easily renewed, or plates of quicksilver, which soon oxydizes leaving a non-reflecting surface."

This is probably about the earliest written observations on the intensity and quality of illumination.

A 16th century scholar with his water lens

Contributed by the CIBSE Heritage Group

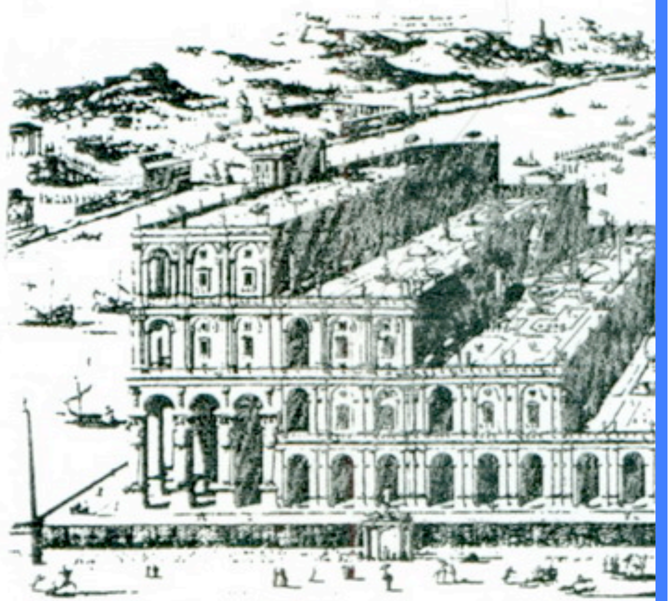
GOLDEN OLDIES

The earliest water supplies were obtained from springs and rivers, surface water, shallow wells and dewponds. The first major developments were in the use of water for irrigation, still the most important use in some areas.

Organised irrigation is at least 6000 years old, dating from the New Stone-Age. A change of climate, with less rainfall, in the Mediterranean and the Near East forced people to move into the river valleys, which had to be drained and cleared. Digging of drainage and irrigation channels could be achieved only by co-operative effort and teamwork; a powerful force towards the formation of nations under central power. This was an important advance towards civilisation.

One of the oldest cities which has been excavated is Jericho, where digging in the 1950's uncovered enormous walled ditches which modern dating techniques have placed as being constructed around 8000 BC. Archeologists examining these easy constructions found large walls which had no opening except a top channel about ·5 metres deep, the channels being full of silt which implies running water. Running water at this height, since some of the walls were probably 4·5 metres high, suggested aquaducts; possibly for purposes of irrigation or sanitation. If this assumption is correct, Jericho had a planned water distribution system in daily use 5000 years before the building of Egypt's pyramids.

The earliest reservoir is probably that recorded at Babylon in 4000 BC where the Hanging Gardens were irrigated by means of a screw drawing water from the river.



The Hanging Gardens of Babylon.

Contributed by the CIBSE Heritage Group.

GOLDEN OLDIES

London obtained its first water supply in 1237: the water was taken from a spring at Tyburn and distributed through pipes to a conduit at Cheapside, where the people could draw the water they needed. The Great Conduit of Chepe (Cheapside) was fed from Highgate, from where the Tyburn flowed down to a waterhead (now Stratford Place, Oxford Street). From here it was channelled through some 5·3 km of leather pipes to a stone basin (the Great Conduit) at the east end of Cheap for public supply.

Other early supplies from springs, wells (hence Holywell and Clerkenwell) and rivers, were the result of private benefactions. The better class families often hired professional water-carriers to bring the water to their homes. In 1496, the carriers formed themselves into a Company of Water Tankard Bearers, which soon had a membership of 4000. They went so far as to impose a toll on those who wished to carry their own supplies.

In 1582, the eastern part of the City of London was supplied from the Thames by a pump near London Bridge. The Corporation granted the use of the first arch of the Bridge for 500 years to a Dutchman, Peter Morice, who installed a waterwheel to drive a pump to raise Thames water into reservoir, whence it was taken by lead pipes to some houses in the City. The Guild of Water Bearers opposed the scheme, but they were eventually persuaded to agree by the Lord Mayor. This machine ran until 1822.

A London water carrier (1572)
Contributed by the CIBSE Heritage Group

GOLDEN OLDIES

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Smoke from burning fuel does not seem to have caused great concern until the introduction of coal. The Industrial Revolution led to a vast increase in fuel consumption in factories and on the railways; and the urbanisation of the population led to concentration of chimneys in limited areas such as the "Black Country".

In 1842 Chadwick noted that:

"The specific effects of an excess of smoke on the general health of a town population has not been distinguished. . . but there is strong reason to think that the prejudicial effect is much more considerable than is commonly apprehended even by medical practitioners".

J F Campbell drew the attention of the 1857 commissioners to the loss of sunlight in the smoky atmosphere of London.

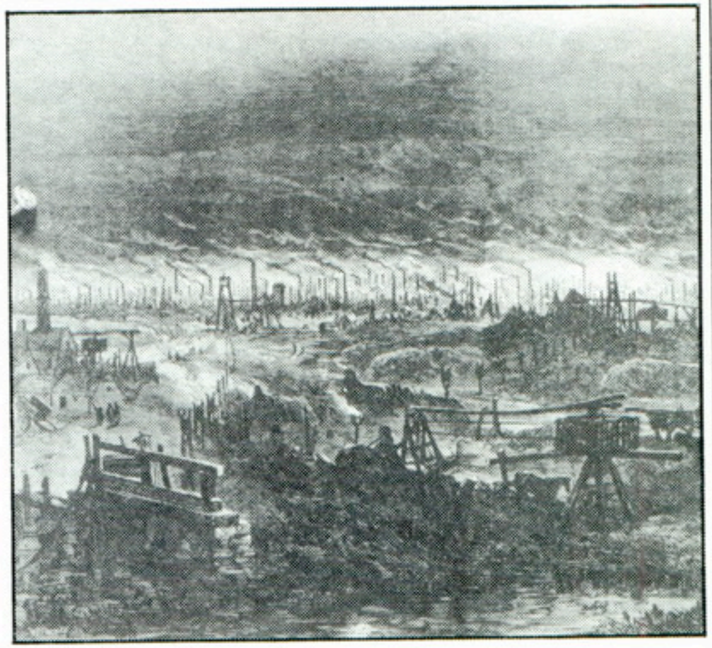
A Private Member's Bill, introduced about 1880 in the British Parliament, proposed:

"by means of a pipe fixed to the highest part of our principal buildings, and with the aid of a fan to bring down the pure air from above and force it into buildings such as St Paul's and the Houses of Parliament, thus displacing all fogs and smoke and all impure air".

In 1890 Edwards put forward a number of suggestions for abating the smoke nuisance, mainly by using smokeless fuels.

An alternative which had been proposed was to use the sewers:

"with powerful chimney shafts at suitable intervals, the smoke to be consumed as far as possible in powerful furnaces burning perpetually at the bottom of each shaft, unconsumed smoke and other products to be discharged in the open air at a great elevation".



Staffordshire in 1866, on the edge of the "Black Country".

It required the London smog of 1952 to produce effective action, and the eventual passage of the *Clean Air Act* of 1956.

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GOLDEN OLDIES

In the 6th century BC, in Greece, baths began to take the place of sea and river-bathing. As in Egypt, sprinkling and showers were important features of Greek baths. A large pedestal basin was employed, and slaves sprinkled the bathers. The "sweat" bath, with shower, appeared in Sparta a little later. Public baths were provided for the poorer people.

Bathing became a well-developed social habit in ancient Rome. The Romans set up, throughout their Empire, the "thermae" or bathing establishments, which served as communal leisure centres. The most famous of these are the Baths of Titus and the Baths of Caracalla, both in Rome. The Baths of Carcalla could accommodate 1600 bathers; the Baths of Diocletian at Split in Yugoslavia are said to have been able to take twice this number.

As the Roman Empire developed and expanded, its baths became larger and more elaborate and also more formalised in their design. This can be seen in Hadrian's Baths at Lepcis Magna on the coast of North Africa, where the building included an open-air swimming bath, a cold room (frigidarium), cold plunge-baths, a hot room (calidarium), and a number of superheated rooms or sweating baths (laconica). Also, wherever the Romans found hot springs they used them, as at Bath.

The Greek and Roman "sweat" bath developed into the Turkish bath and appeared in eastern Europe and Moorish Spain. The Muslim bath (hamman) is believed to be directly inherited from the Classical World, but with emphasis on Islamic concern for both ritual and cleanliness, rather than social and sporting aspects.

The earliest known public hammans date from about the middle of the 12th century. A typical public bath is the Hamman-al-Bzouria of Damascus, containing a disrobing room and fountain, cold, warm, hot and steam rooms, as well as lavatories. In Istanbul, during the Ottoman period, baths were built with separate facilities for men and women.

The Cagaloglu Hamman (bath), Istanbul, Turkey (18th century).

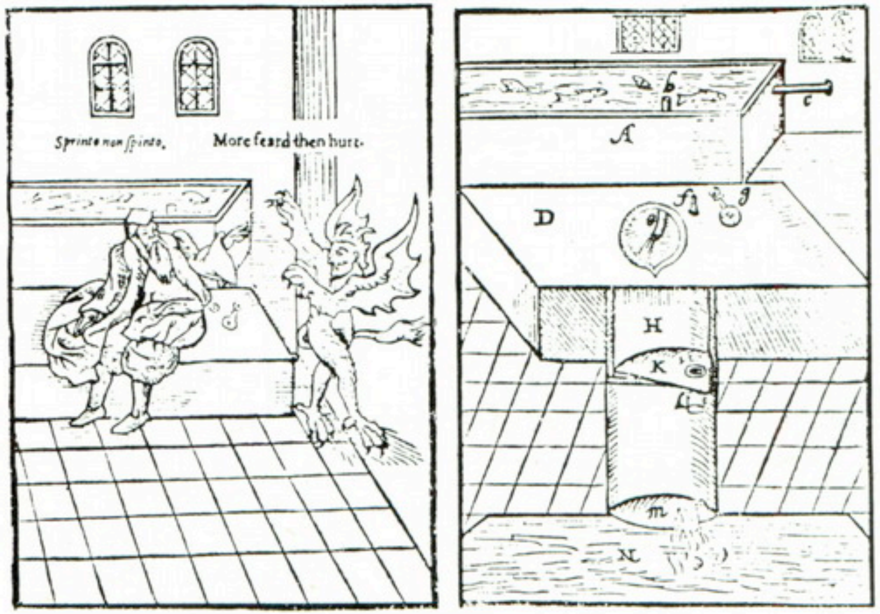
Contributed by the CIBSE Heritage Group

GOLDEN OLDIES

Queen Elizabeth I was considered by her court to be extremely fastidious in matters of hygiene, taking a bath once a month "whether she need it or no". By comparison, her godson, the poet Sir John Harrington, was considered eccentric in the extreme, because he had a bath every day. But Harrington is not remembered for his bathing habits, but because in 1596 he designed the first valve water closet.

He described an odourless toilet in the book *The Metamorphosis of Ajax* (1596). It incorporated all the main features of a water-closet — a cistern with operating lever and overflow, a bowl, flushing pipe, plug outlet valve and a seat. It was flushed from "a barrel of water placed in the room above, whence the water may, by a small pipe of lead of an inch, be conveyed under the seat. . . to which pipe you must have a cock or washer to yield water with a pretty strength when you would let it in".

The bowl was closed by a plate at its base, and contained a few cm of water. After use, the plate was removed, and the contents of the bowl deposited in a drain beneath. Sir John installed one of the closets in the Queen's Palace at Richmond and one in his house near Bath.



Sir John's water closet

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GOLDEN OLDIES

The application of the principle that water finds its own level was described by Vitruvius, but the Romans went beyond using only a direct gradient to convey their drinking water across valleys, for they developed an elaborate system of siphons. But the outstanding examples of Roman engineering works are those to be seen in the lofty single arches of the aquedate between Zaghouan and Carthage in Tunisia (AD 117-138) which ran for 141 km with a capacity of 31·8 million litres/day; in the double-tiered aqueduct at Segovia (ca AD 10); and even the more famous three-tiered Pont du Gard (ca AD 14) which once brought 450 litres/day to each citizen of Nimes.

The Roman water supply was initiated by Appius Claudius Crassus in 321 BC to meet a steadily increasing demand, and in 144 BC the first overhead system, the Aqua Marcia, was built. By the 3rd century AD, the 11 principal aqueducts brought to the city some 200 million litres/day — about 200 litres per person for all purposes including industry, fountains and baths. By the 4th century AD Rome had 11 public baths, 144 public lavatories, 1352 public fountains and cisterns and 856 private baths. At its peak Rome was supplied with something like 1350 litres of water per head of population per day.

In constructing the water supply system, the Romans avoided the use of "high-pressure" pipe, using instead bridges to cross valleys. The incoming supply was taken to three reservoirs, one serving the baths, one the fountains, and the third private houses. Private supply was available as a concession on payment of a fee. Most Roman citizens had

Aqueducts outside Rome.

to rely on water carriers who drew water from the fountains. For distributing the water, pipes of earthenware, lead, wood and clay were used.

An insight into the Roman system is given by Frontinus, who was in charge from 97 to 104 AD. 700 AD personnel — surveyors, inspectors, masons, paviours, labourers, architects and plumbers, and administration staff — were employed.

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GOLDEN OLDIES

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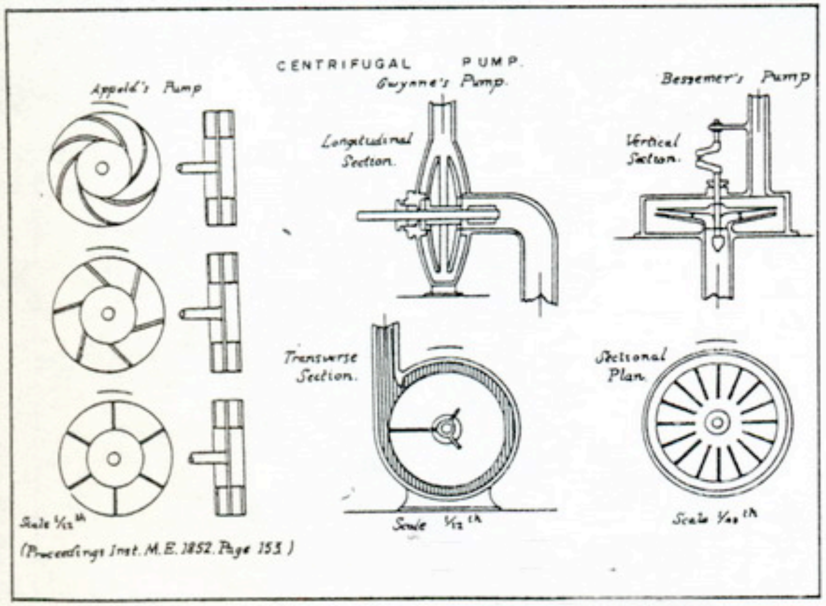

The three pumps at the 1851 Exhibition (by Appold, Gwynne and Bessemer)

In 1500 Leonardo da Vinci sketched a device for raising water by centrifugal force. In 1688 Papin developed his centrifugal pump with two blades rotating in a circular casing. However, the two outstanding mechanical engineering achievements of this period were Savery's pulsometer pump of 1689 and the Newcomen atmospheric engine of 1712. Captain Thomas Savery was granted a master patent in 1698 for an engine for raising water by the impellant force of fire although this may have been achieved some 30 years earlier by the Marquis of Worcester with his "water commanding engine".

In 1732 Kernelien Le Demour published in Paris his description of a "Machine pour elever de l'eau". The illustration of his machine was described as "showing a very crude appliance — designed to raise water by centrifugal force".

The year 1818 saw the introduction in America of what is now known as the "Massachusetts Pump" which showed a return to the original conception of Denis Papin with the creation of a forced vortex within a circular, or spiral, casing by means of blades. Meanwhile, on this side of the Atlantic, the centrifugal pump was also being developed independently by both Appold and Bessemer.

Prior to the Great Exhibition of 1851 much controversy raged between Appold, Bessemer and Gwynne over the merits of their respective pumps. The argument was conclusively settled by the tests conducted by the jury of the exhibition, which gave the following results:

Make	*Water quantity (l/s)*	*head (m)*	*Speed (rev/min)*	*efficiency %*
Appold	94	5·9	788	68
Bessemer	64	1·0	60	22·5
Gwynne	22	4·2	670	19

Gwynne's pump was handicapped by its small size and having only one blade. Bessemer's model suffered due to its very slow speed and its radical blade design. The superiority of the Appold pump is apparent, due to its high speed and the curved vanes on the impeller.

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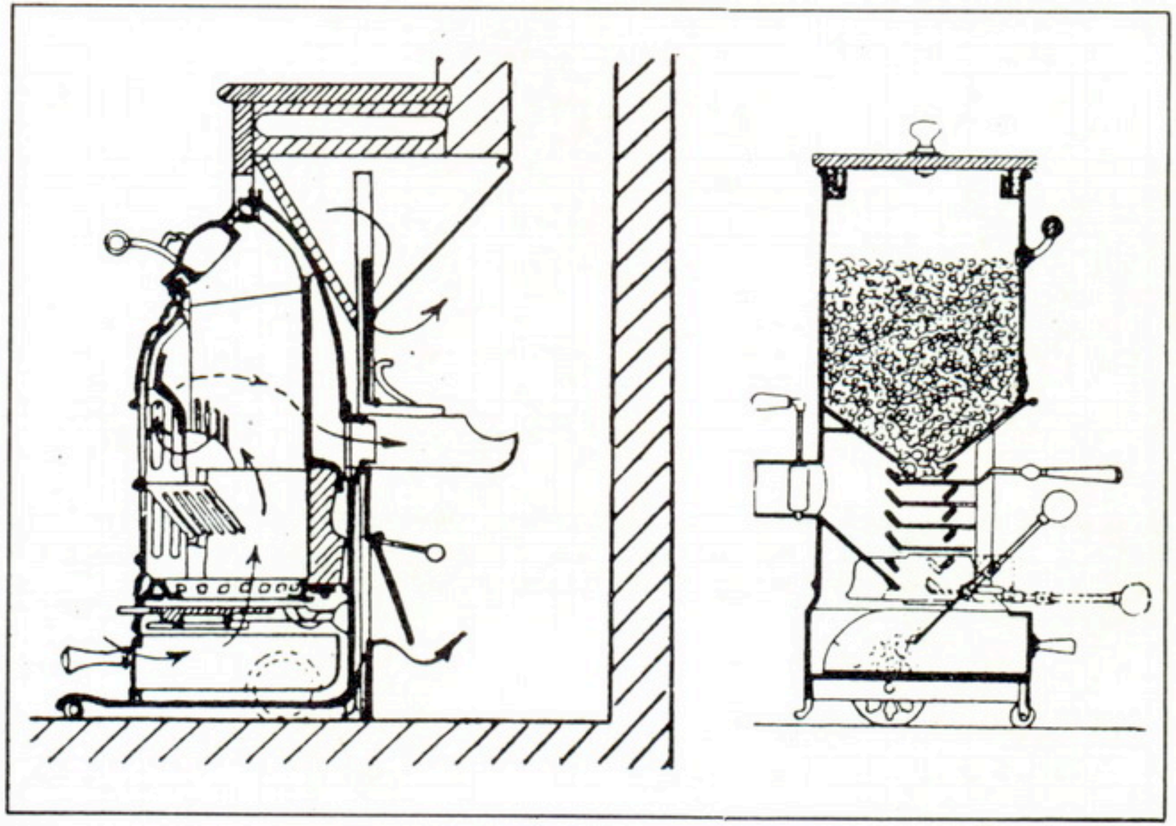
GOLDEN OLDIES

In 1908, Debesson when reviewing heating methods in France, wrote:

"Stoves are, and will remain for a long time, the heating appliance *par excellence* not only for the poor but also for the great majority of the population of the globe, of all those who cannot afford the luxury of living in houses with modern central heating."

He did not, however, approve of their use in schools, believing them to be unhygienic, nor in government offices.

"Let us hasten to say that in Paris and in the country, almost all the schools are warmed by these odious stoves. When many of our provincial towns, and all foreign governments are proud to heat their schools by the hygienic steam or hot water, Paris, City of Light, remains as at the time of Franklin and heats its schools by stoves."



Two portable stoves (slow combustion). Salamander, *left*, and Cade, *right*.

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