

ON THE
HISTORY AND ART
OF
WARMING AND VENTILATING
ROOMS AND BUILDINGS

BY
OPEN FIRES, HYPOCAUSTS, GERMAN, DUTCH, RUSSIAN, AND
SWEDISH STOVES, STEAM, HOT WATER,
HEATED AIR, HEAT OF ANIMALS, AND OTHER METHODS;

WITH
NOTICES OF THE PROGRESS
OF
PERSONAL AND FIRESIDE COMFORT,
AND OF THE
MANAGEMENT OF FUEL.

ILLUSTRATED BY TWO HUNDRED AND FORTY FIGURES
OF APPARATUS.

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ESSAY III.

WHEN Pompey, says Plutarch, was visiting Lucullus, he blamed him for making his villa so delightful in summer, and yet so uninhabitable in the winter. "Think you," replied Lucullus, "that I have less forecast than the cranes and storks, and that I know not, as they do, how to change my habitation with the season." When this rich and extravagant seeker of pleasure admitted being reduced to the same alternative with the fowls of heaven, in order to insure a genial warmth in his brumal retreat, he exhibited the low state of domestic comfort in a Roman community. Yet, change as he would, he had no means in his winter palace, placed any where, of enjoying a summer temperature in the cold weather, without being inconveniently burdened with clothes, and breathing charcoal vapour, rendered perhaps less offensive by impregnation with costly aromatics. It is clear, from the instructions Vitruvius gives in what manner to decorate apartments generally, that discomfort was not confined to the palace. To hide the unsightly stains of smoke, this architect directs the walls of the rooms in which fires or many lights are burned, to be finished above the *podium* with polished panels of a *black* colour, having red or yellow margins round them; and he advises that delicate ornaments should not be introduced into the cornices, because they are spoiled, not only by the smoke of the house, but also by

that from the neighbouring buildings.* The same architect thus describes the construction of the *hypocaust* or stove for heating the *caldarium* or sweating room of a bath.

The floor is made inclining, so that a ball placed on any part of it would roll towards the fireplace, by which means the heat is more equally diffused in the sweating-chamber. The floor is paved with tiles that are eighteen inches square; and on these are built brick pillars, eight inches on the side, and two feet high, and cemented with clay and hair mixed together. The pillars are placed at such a distance, as will allow tiles two feet square to be laid on them to form the ceiling of the hypocaust, and support the pavement of the *caldarium*. The air to the *caldarium*, or room over the hypocaust, is admitted through an aperture in the centre of its roof, from which a brazen shield is suspended by chains. By raising and lowering this shield, which opens or shuts the aperture, the heat of the *caldarium* is regulated.†

For heating the water to supply the baths, there are to be three caldrons,—one for hot water, another for tepid water, and a third for cold water; and arranged

* L. vii. c. 3, 4.

From the description he gives of a method of forming the pavement in Grecian winter rooms, his own notions of comfort do not appear to have been very refined. "These pavements," he says, "are not only economical but *useful*. The floor of the *triclinia* or dining room is excavated to the depth of two feet, and when properly rammed, a layer of brick rubbish, made to slope towards a drain, is spread over it. Upon this is laid a cement of pounded coals, sand, ashes, and lime, half a foot thick. The surface being made flat and smooth, and then polished with a stone, has the appearance of a black pavement. The liquor that is spilt at the banquet, and the expectoration that falls on it, immediately dry up, and the attendants on the guests, though barefooted, do not suffer from cold on this kind of pavement."—L. vii. c. 3. At the present time, drained floors are formed only in the triclinia of cows, horses, and other beasts.

† Vitruvius, L. v. c. 8. In some cases these circular shutters or valves seem to have condensed the vapours with great rapidity, and causing them to fall in showers, kept the pavement under them constantly wetted. The apartment must at all times have been very gloomy, and the darkness must have increased with the rise of temperature.—Gell. *Pompeiana*, vol. ii. p. 121.

so that as the hot water runs out of the lower vessel, it may be replaced from the tepid vessel, and that in like manner replenished from the cold vessel: the arched cavities in which they stand are to be heated by one fire.*

After such minute instructions how to form the stove in which large quantities of wood were to be consumed, it is singular that he should omit to notice in what way the smoke produced was to be conveyed into the atmosphere. From this silence, it has been inferred that he was ignorant of what Anderson calls "the elegant and commodious tube now known by the name of a chimney." It is not, however, a fair objection to his skill in contrivance, that, although sensible of the inconvenience of discoloured walls and smoke-filled rooms, he should nowhere suggest the use of a hypocaust to avoid the nuisance. For this presupposes that the urgency of a want will prompt an invention to supply it, when all experience shows that even the most obvious improvements oftener arise from accident than reflection. It is certain, however, that such structures were sometimes built without chimneys. An ancient bath yet remaining in the island of Lipari has a small opening at one end of the hypocaust, for the admission of firewood, and a similar one at the other end for the exit of the smoke.†

About sixty years after the period in which Vitruvius flourished, hypocausts are first noticed, as being employed for heating domestic apartments. "Many inventions (says Seneca) have been divulged within my memory,—such as windows formed of a transparent plate, also suspended baths, and pipes from hypocausts, so inserted into the walls as to spread an equal warmth through the room, and heat what are beneath, as well as what are above."‡ The apparatus

* Vitruv. B. v. c. x. † Smith. Archæol. vol. xxiii. p. 100.
‡ Ep. 90.

here so briefly mentioned may have been arranged in this way. The hypocaust being constructed in the under story of a building, in the manner described by Vitruvius, several pipes of baked clay were then built into the walls, having their lower ends left open to the hypocaust. These pipes were carried to the height of the first or second story, and had their upper orifices made to open into the chamber that was to be heated. They were closed by moveable covers.*

While green wood was burning in the furnace, and the hypocaust filled with its acrid smoke, the covers were not removed from the caliducts; but as soon as the wood was charred, the upper orifices of the pipes were opened, and the hot vapour from the hypocaust then flowed into the chamber. If, as some imagine, it was used in this manner, it is clear the contrivance had all the inconvenience and danger of the brazier,

* Winkelman, in his *Letters on Herculaneum*, describes the ruins of a villa discovered near Rome that had pipes placed in the walls in a somewhat similar way. "Stoves (or hypocausta?) were found, he says, in the apartments. Below these apartments there were subterraneous chambers about the height of a table, two and two under each apartment, and close on all sides. The flat top of these chambers consisted of very large tiles, and was supported by two pillars, which as well as the tiles were joined together, *not with lime*, but with some kind of *cement*, that they *might not be separated by the heat*. In the roofs of these chambers there were square pipes made of clay which hung half way down into each, and the mouths of them were conveyed into the apartment above. Pipes of the like kind built into the wall of this lower apartment rose into another in the second story, where their mouths were ornamented with the figure of a lion's head formed of burned clay. A narrow passage of about two feet in breadth conducted to the subterranean chambers, into which coals were thrown through a square hole, and the heat was conveyed from them by means of the before-mentioned pipes into the apartment immediately above, the floor of which was composed of coarse mosaic work, and the walls were encrusted with marble. This was the sudatorium. The heat of this apartment was conveyed into that on the *second* story by the clay pipes enclosed in the wall, which had mouths opening into the former as well as the latter, to collect and afford a passage to the heat, which was moderated in the upper apartment, and could be increased or lessened at pleasure." Rooms were sometimes built over the sudatorium to participate in its heat. Cicero, in a letter to his brother Quintius, tells him, that he had removed the seats into another angle of the dressing room; because their stove from whence the fire proceeded was under the bedchambers.—*Ep. ad Frat. l. iii. ep. i.*

without its portability and economy ; yet, if adopted to use the superfluous heat only of the hypocaust after the pavement of the apartment over it was sufficiently heated, the plan might be considered an improvement, by those to whom charcoal vapour was not offensive. But had the upper orifices of the caliducts been kept closed until all the fuel in the furnace was consumed, and had then been opened, the method would have been freed from objection. The current of air entering through the furnace, would have had its temperature raised by coming into contact with the hot ceiling, walls, and piers of the hypocaust, and rising through the caliducts would have flowed into the apartment, and have ventilated as well as warmed it.

Glass must have been long known to the Romans through their intercourse with the Egyptians ; but talc is considered to have been the "transparent plate" that Seneca alludes to as having been introduced as a weather screen within his recollection.* It

* "The want of the thin plates of glass now used for the purpose of glazing windows, only permitted the ancients to throw into apartments a considerable body of light by exposing them at the same time to every inclemency of the weather ; or to protect them against wet and wind by excluding, in the same proportion, all day-light, and contenting themselves with the dim glare of lamps. In general, it caused them to seek a medium between the two extremes of suffering a few straggling rays of light to penetrate athwart the ends of the rafters that lay on the wall, and formed the ceiling ; or by introducing immediately under the shelter and projection of the eaves, a sort of wide low window, which only commencing, for the sake of restricting its perpendicular opening and permeability, high from the floor, afforded no view of external objects. These *restraints influenced the whole of their architectural system*. It caused smaller temples to receive the requisite light through an enormous entrance door always open ; and the larger ones to remain open roofed. It caused the dwelling-house, for seclusion as well as for safety, to shun all windows outside, to have every aperture for light, as for egress, turned inwardly to a vast open court, and only to present to the street, instead of the multifarious windows of modern habitations, an impenetrable dead wall. It even caused so many apartments of every sort to be left, for warmth as well as comfort, entirely destitute of windows or apertures for daylight of every description, that in the baths of Titus, the fine group of the Laocoon was found in a room which, however glittering with precious marbles, depended entirely for the light that made them visible on artificial illumination.

is related of Caligula, that while giving audience to Philo, a rich Egyptian Jew, he attended to nothing but new glazing his windows; and it has been conjectured that they had previously been glazed with talc, which the emperor was replacing with glass, as a more elegant material, and one better adapted to the purpose. Pellucid shutters, whether of glass or talc, quickly became common; and Seneca, who remembered their first introduction, states, that, at the time he was writing, a man was considered to be poor, who had not transparent windows in his dining room; and that glass had grown so fashionable an ornament, that the public baths had their walls lined with crystal and Thasian marble, for decorations.

Since the invention of fire and clothing, the most valuable gifts to health and enjoyment were assuredly glazed windows and hypocausts. Yet these memorable innovations on ancient discomfort—the most indispensable, agreeable, and enlivening among the refinements of domestic life—were, nevertheless, considered to be prejudicial to health. The man, says Seneca, who screens himself from the cold wind by his glazed windows, whose feet are kept warm by wrapping them in folds of flannel, and who never sups but in his stove-heated chamber, is not without danger of illness on the slightest change of the weather.* And live they not against nature, he asks, that long for a rose in winter, and endeavour by apt changes of heat to make lilies and flowers to blow at that season, instead of in summer.†

Indeed it seems to have *influenced the whole domestic system of the ancients*. By diminishing the difference either between the inside or the outside of the house, or between day and night, it caused them to transact much of their daily business in the public place or forum, and at home to make the night, much more the time of their most retired studies or their most convivial meetings."—Hope. *Historical Essay on Architecture*, p. 112.

* *De Providentia*.

† *Epist.* 122.

The excavations at Pompeii have thrown a clear light on the domestic arrangements of this period. The *villa suburbana* had a large bow window glazed with a green tinged glass, and a window in the baths had good plate glass ground on one side to prevent persons looking through it. But notwithstanding these instances, and that transparent shutters were not rare, window glass was not a common material at Pompeii, nor in Italy. Its scarcity and expense, and late introduction, must have confined its use to the wealthy; and even in their houses, to the rooms appropriated to the reception of company; and linen, horn, and talc, were most likely the substances commonly employed to form diaphanous weather screens.* The Italians, like the Egyptians, made their window openings very small. They were considered better for the eyes than larger apertures.† But the preference was, perhaps, established as much from their being easier filled and made weather-tight in the winter, with the transparent materials at their disposal, as from their better excluding heat and light, in seasons when their excess was oppressive. Some windows discovered at Pompeii were not more than 23 inches wide and 3 feet high; they were fitted with lattices, and had shutters that slid horizontally; which not being very well put together, the gaping chinks had been covered by an inside curtain.‡ Upper floor windows had curtains only; and door openings were often closed in the same manner. The doors moved

* Gell. Pompeiana, vol. ii. p. 97.—The accounts remaining of the scarcity of glass among the ancients are very contradictory. Glass ornaments abounded in Italy at this period, and vast collections of bottles, glasses, cups, vases, and other utensils were found at Pompeii. Yet Vopiscus accuses Firmus the merchant, whose riches enabled him to contest the sovereignty of Egypt with Aurelian, of luxury, for having glass windows in his villa. Glazed windows never have been general in Italy. Even now, except in the houses of the great, the lighting of a house in Italy on a rainy or windy day is very defective.

† Cicero ad Attic. l. ii. ep. 3.

‡ Gell. Pomp. vol. i. p. 164.

on pivots, and were sometimes hung to shut of themselves. The Pompeians had carpets, raised bedsteads, mattresses stuffed with Gaulish wool, down pillows, blankets, and carpet coverlets, and these elements of warmth and comfort were probably enjoyed by all Italians. The general method of procuring a warm indoor climate was by burning charcoal, in a brazier on the pavement in the middle of the room, and allowing the vapour to exude at the door and window.*

These braziers and tripods, formed of all sizes, in iron and bronze, occasionally displayed great elegance of design and neatness of workmanship, and sometimes were contrived to heat water. One of this description, in the museum at Naples, is 28 inches square, and has four towers, one at each angle, fitted with a lid that can be raised by a ring. The fire-hearth is placed in the square part in the middle, which is lined with iron, as in the common braziers. The fluid to be heated was contained in the towers.†

It is supposed this *foculare* was intended to "heat water and other liquors, for family uses," as well as to warm the apartment, though it seems far from being either a convenient or an economical apparatus for these purposes. Another use of such utensils has perhaps been overlooked. The cold dry air of an Italian winter and spring was desiccated to a high degree after being expanded by the heat of a hypocaust, or a fire of charcoal; and these braziers appear a very elegant method of diffusing that quantity of

* "In the kitchen of the house of the Dioscuri, the smoke might have escaped by a little window yet existing; no trace of a chimney is visible, yet it seems impossible but that there must have been one. It is certain, however, that in a small shop, and in a chamber of the Temple of Isis, chimneys may be found at Pompeii."—Gell. *Pompeiana*, ii. vol. ii. p. 164.

† Sir William Gell gives a figure of this brazier in his *Pompeiana*, vol. i. Another of most elegant design, is represented in Donaldson's *Pompeii Illustrated*, vol. ii. The bronze brazier that was placed in the *Tepidarium* of the Baths at Pompeii, is described and figured in the *Museo Borbonico*, vol. ii.

moisture in the air of an apartment, that was necessary to make it agreeable and salubrious. Perhaps the evaporation was partially regulated by shutting or opening the lids of the water vessels.

The *caldarium* of the public baths had a hypocaust formed beneath it, and its walls were so constructed that heated air surrounded the apartment on all its

FIG. IV.

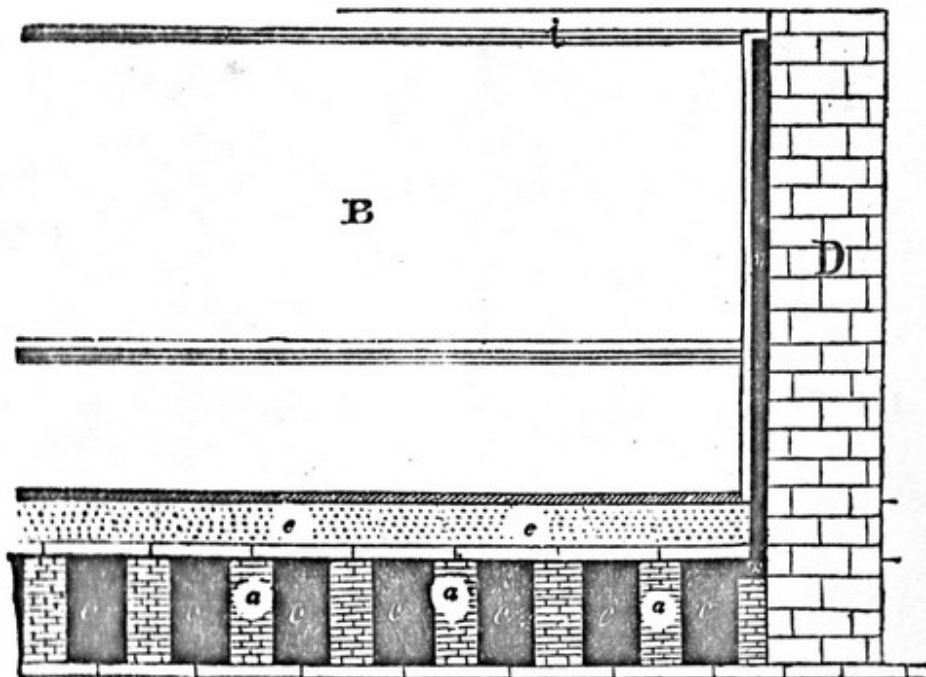
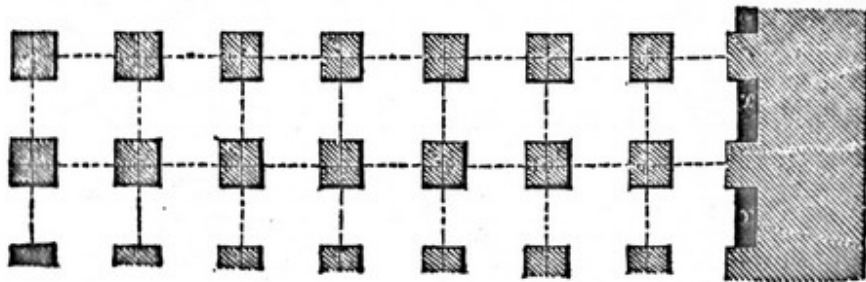


FIG. V.



sides. Fig. IV. is a section showing part of the walls and floor of the caldarium, and Fig. V. is a plan of the same portion.*

A foundation for the floor was prepared by laying

* Museo Borbonico, pl. 51.

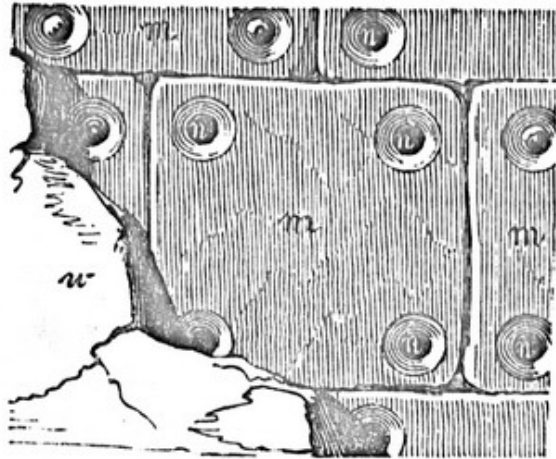
a thick stratum of cement, composed of lime and pounded bricks. On this were built small brick pillars, *a*, about $9\frac{1}{2}$ inches square and 19 inches high; strong tiles, *c*, were then placed on these pillars to form the ceiling of the hypocaust, and over them was spread a stratum of cement, *e*, about 9 inches thick. The surface of this pavement, ornamented with mosaic, formed the floor of the caldarium, *b*.

The sides of the caldarium, as high as its cornice, *i*, were formed hollow, by means of tiles, *m*, $1\frac{1}{4}$ inch thick, placed at a distance of 3 inches from the outer wall, *d*, and firmly attached to it by iron cramps, *n*, passing through holes, made at each corner of the

FIG. VII.



FIG. VI.



tile. These holes appear to have been perforated, after the tile had been moulded, by an instrument somewhat blunt being thrust into the mass while soft, which, protruding the clay, formed a hollow projection, *z*, on the opposite face of the tile. Each tile had four of these hollow projections, through which the iron cramp, *n*, was driven into the outer wall, *d*, of the caldarium.* The hollow knobs thus served as sheaths to protect the cramps, *n*, from the heat, and as

* Museo Borbonico, vol. ii. p. 27.

stays to preserve the space *o*, between the inner surface of the tile, *m*, and the wall, *D*. A substantial stucco was laid over the tiles to receive the decorations appropriate to the apartment, which, filling up the joints, made the casings smoke-tight. The space, *o*, formed between the outer wall and the tiles, communicated with the hypocaust, between the pilasters, under the floor, as is shown at *x*. The furnace was placed in an area at one side of the hypocaust, and the flue by which it communicated with the hypocaust, was placed nearly in the middle of its side.

Figure VI. shows the face of the lining tiles, *m*, on a larger scale, which in Fig. VII. are shown in section. The same letter, in the preceding figures, refers to the same part.

When the hypocaust or stove was filled with the hot smoke from the furnace, the vapour rose into the space *o*, between the tiles and the wall, and formed a column, or rather a lining, of heated air round the caldarium as high as its cornice, by which means the walls, as well as the floor, of the apartment could be kept at a high temperature. In constructing this hollow wall there does not seem to have been an intention of making the hot vapour, that ascended into the space *o*, circulate throughout the interval, although without this circulation much of the effect that would have been produced by this skilful arrangement was thrown away.

Adjoining the caldarium was the *tepidarium*, a room kept at a moderate temperature only. It had a capacious flue, running the whole length of the floor and communicating with the hypocaust of the caldarium, and also with the furnace; but it was heated solely by a large bronze brazier, placed at one end of the apartment. This vessel was 7 feet long, 2 feet 6 inches wide, and lined with iron to protect the bronze from