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. 3. *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. 1. † Smith. Archæol. vol. xxiii. p. 109.
‡ 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 Quintus, 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 hypocanst 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 struggling 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 slided 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.

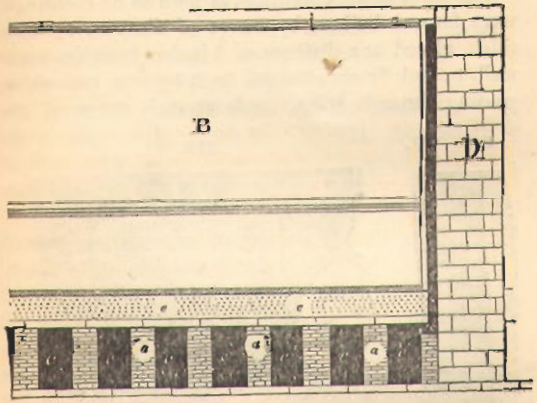
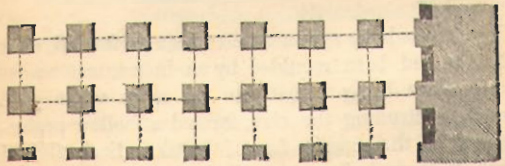


FIG. V.



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

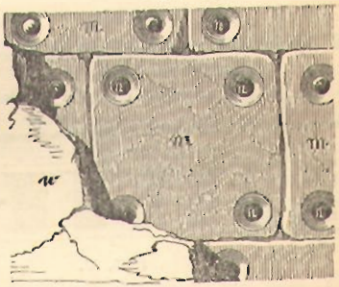
* Museo Borbonico, pl. 51.

a thick stratum of cement, composed of lime and pounded bricks. On this were built small brick pillars, *a*, about 9½ 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*, 1¼ 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

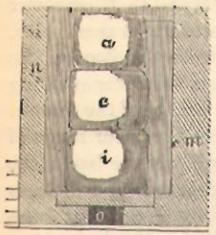
the action of the fuel; and the bars at the bottom were of brass, on which bricks were placed to support the pumice-stone for the reception of the charcoal. The introduction of this brazier into the tepidarium shows the force of prejudice in favour of the common mode of warming by a pan of charcoal. In the caldarium a much higher temperature was necessary than in the tepidarium, and this was obtained from the hypocaust and hot wall, without the room being filled with the fumes of charcoal; a comfort that might also have been enjoyed in the tepidarium by means of the flue formed under the pavement. It is not quite certain, however, that the suffocating vapour was at all times excluded from the caldarium itself, notwithstanding its great surface of hot floor and hot wall, that under modern management would have sufficed not only to "diaphorise, but to bake the Pompeians." Gell observed a stone in its floor that was moveable, and was probably placed there to be occasionally lifted to permit a current of hot air from the hypocaust to enter the caldarium.*

The form and proportions of the caldrons that heated the water for the bath are given in Fig. VIII. from the impression very visibly remaining in the bed of the mortar in which they had been fixed. The caldrons were arranged one above another, and set in a kind of oven, without flues running round them, and were named, like the chambers, according to their temperature and use; the lowest, next the fire, *i*, was called the caldarium; the next, *c*, was the tepidarium; and *a*, the upper caldron, was the frigidarium: *m* is the wall of the bath; and *n*, a wall enclosing the boilers; *o*, the flue of the furnace. By means of a syphon, when boiling water was drawn off from the caldron of boiling water, *i*, it was

* Gell. Pompeiana, ii. vol. i. p. 120.

refilled with warm water from the middle one, *c*; and this vessel in its turn was replenished with colder water from the uppermost boiler, *a*, into which cold water flowed from the cistern.*

FIG. VIII.



The matrice or bed of one column only of caldrons was found; but, as it was seldom necessary to have more than one fire in the baths to warm both the rooms, and the water; it is thought that three columns of boilers (nine vessels) were placed over the same fire in one oven.†

Where a large quantity of water was wanted, heating it in boilers on this plan, would appear to be nearly impracticable; and the magnificent baths at Rome, it has been conjectured, were heated in another manner.

A series of hypocausts was constructed after the method described by Vitruvius; and similar to the stove under the caldarium in the baths at Pompeii. Upon these stoves ranges of substantial vaulted stuccoed water tight chambers were built one above the other, into the walls of which were inserted earthen pipes, that communicated with the hypocausts beneath.

The vaulted roof of the tier of chambers was formed into a shallow reservoir, that was left open to the air; and into this cistern the water from the public aqueduct was conducted to have its temperature raised as much as possible, by exposure to the sun, before it was allowed to fall into the water chambers beneath it.

* Gell. Pompeiana, vol. i. *pl.* xxv.
† Ibid. ii. vol. i. p. 120.

If both ranges of chambers, and the reservoir forming their roof, be supposed filled with water, and fires made in the hypocausts, the floors of the lower range of chambers will be heated, and the smoke rising through the earthen pipes from the hypocausts heating the walls, the water contained in these lower chambers will have its temperature raised also. This will then communicate heat to the floor of the second tier of chambers, and warm the water standing on it. The operation is the same as that of the caldron apparatus. As the hot water from the lower range of chambers is drawn off for the supply of the baths, the tepid water in the second range descends and replaces it; and, at the same time, the water that has been slightly warmed by exposure to the sun in the shallow reservoir on the roof, falls into the tepid water chambers.

FIG. IX.

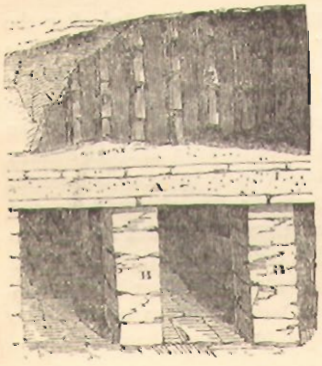


FIG. X.

Figure IX. is a section of a portion of one of the hypocausts. B B, the piers; A, the floor of the hot water

chamber. The way in which the pipes were placed in the walls, is seen at C, a part where the stucco had fallen down, when Piranesi made his sketch from which the figure was taken.*

One variety of the earthen pipes that were built into the walls is represented in Figure X. They were about 1¾ inches thick, and fitted into each other with a sort of spigot and faucet joint that lapped about 2 inches. Another sort was cone-shaped, and, when placed in the wall, the narrow end of the one was inserted about 2½ inches into the wide end of the other. Some were made cylindrical, others were parallelopipedons, and, when used in the building, their ends were merely placed in contact. The drains that conducted underground the hot water from one part of the bath to another, were sometimes formed of these earthen pipes cased with bricks; and to prevent the water being cooled as it flowed through them, the drain or conduit was surrounded by a flue, that led from and communicated with the hypocaust, or, when it had one, with its furnace. They were thus enclosed in the centre of a hot funnel, and could by this means be heated before the water entered, and have their temperature preserved, while it was running from the caldrons.

In some ancient baths that stood where is now the church of St. Cecilia in Trastevere, the same end was attained by another method. To diminish the dispersion of heat by radiation, the copper tubes that served for flues or pipes were gilt at those parts where they were exposed to the atmosphere.†

Cameron, who considers the method of heating water in chambers of masonry to be feasible, gives some illustrations drawn from the remains of the baths of Caracalla. In these magnificent *thermæ*, he

* Cameron. Baths of the Romans.
† Ibid. p. 26.

height, and it was a more manageable and compact apparatus than a hypocaust, if erected on an upper floor.

A figure of the draco copied from an ancient painting, agrees nearly with the preceding description,* and a diagram of it given by Castel a century ago seems to have been the type of a meritorious modern revival of the ancient apparatus.†

The ignorance of a salubrious and effective system of warming apartments among the Romans, is well exemplified by the solicitude shown by the younger Pliny, to turn to profitable account a source of heat that is neglected in modern buildings, as one which no ingenuity could make adequate to the lowest want of domestic comfort.

The villa Laurentinum was situated on the sea coast, about seventeen miles from Rome, and although not extensive, it was large enough to afford every desirable accommodation. From the station, and taste of its owner, and being built for habitation during the winter months, it most likely contained all the conveniences for heat and ventilation that were to be found in the houses of men of the highest rank in Rome.

From a plain porch, says Pliny, you enter a portico of the form of the letter O, which includes a small but agreeable area. This affords a pleasant retreat in bad weather; as it is not only enclosed with windows, but sheltered by an extraordinary projection of the roof. From the middle of the portico you pass into a handsome hall, that has folding doors and windows on every side. On the left of this apartment lies a large drawing-room, and beyond that a second of a smaller size, having one window to the rising and another to

* Cameron. Baths of the Romans, p. 42.
† Castel. Villas of the Ane. p. 56.

the setting sun. The angle that the projection of the hall forms with this drawing-room, retains and adds force to the heat of the sun. To this warm corner, continues Pliny, my family resort in winter to perform their exercises; for, sheltered from all winds, except those which are generally attended with clouds, nothing renders this spot useless but what, at the same time, destroys the fair weather. Contiguous to this is a room that juts out and forms the segment of a circle; the windows of which are placed so as to receive the sun the whole day.* From hence you pass into a bedchamber, through a passage which, being boarded and suspended, as it were, over a hypocaust beneath, tempers the heat which is emitted, and conveys it to all parts of the bedchamber.

In the opposite wing is a room ornamented in a very elegant taste; adjoining is another room that, though large for a parlour, makes but a moderate sized dining-room. It is exceedingly warmed and enlightened, not only by the direct rays of the sun, but also by their reflection from the sea. Beyond is a bedchamber with its ante-room; its height renders it cool in summer, and being sheltered on all sides from the wind makes it warm in winter. To this a similar apartment is joined by a party wall. From thence you enter into a handsome and spacious cooling room belonging to the bath, contiguous to which

* A room constructed in this form, and for the same purpose, was discovered at Pompeii.

"The *cubiculum*, with the bow window, was doubtless the principal one in the villa; having the ends towards the country circular, it continued to receive the full influence of the sun from the dawn to the close of the day. When the shutters were closed, light was admitted by bull's-eyes over the windows. The alcove in the middle of the chamber was enclosed by a curtain. On one side is a recess hollowed out of the solid construction. This was probably the toilette, as it contained several vases which apparently had contained perfumes and unguents."—Donaldson. Pompeii Illustrated, vol. ii. p. 39.

is the perfuming room, then the sweating room, and next to that the furnace which conveys heat to the bath; adjoining are two small elegantly fitted up bathing-rooms, and next to them is a warm bath, wherein one may swim, and at the same time have a prospect of the sea. Near it is the tennis-court, that lies open to the warmth of the afternoon sun. From thence you ascend a sort of turret, containing two entire apartments below, as there are the same number above, besides a dining-room, which commands very extensive prospects. At the other end is a second turret, in which is a room that receives the rising and setting sun. Behind this is a large repository, and near it a gallery of curiosities; and underneath a spacious dining-room, where the breaking of the waves is heard but faintly. From the banqueting-house in the garden an enclosed portico extends, which has a range of windows on each side; but on that which looks towards the sea, they double in number those next the garden. These are all thrown open when the weather is fair and serene; but if it blows, those on the side the wind sets from are shut, while the other remains open without inconvenience.* The portico itself is coolest when the sun is most scorching, that is, when its rays fall most directly upon its roof. By setting open the windows, the western breezes have a free draught, and prevent the enclosed air from stagnating. At the upper end of the portico stands a detached building, which I call my favourite. It contains a very warm winter room, one side of which looks upon the terrace. The other has a view of the

* Ventilating by opposite apertures seems to have been well understood. Varro, De Re Rustica, l. i. c. 5, tells us how several cities in Greece were preserved by Hippocrates during a pestilence, and of great cures done by himself in a parallel case at Corcyra, by no other knowledge than that of rightly disposing the apertures of the houses.

sea; and both lie exposed to the sun. Adjoining this is a bed-chamber, which neither the voice of the servants, the murmuring of the sea, nor even the roaring of the tempest, nor lightning, nor the day itself, can penetrate, unless you open all the windows. Annexed to this is a small hypocaust, from which, by opening a little aperture, the heat is let out to warm the bed-chamber to the degree required, and beyond this lie an ante-chamber and chamber that also enjoy the sun, though obliquely, from the time it rises till the afternoon.*

Thus far Pliny, who, it is manifest, made warmth a principal consideration in the construction of his villa, and delighting in warm apartments, took all opportunities to have the benefit of the sun both within doors and abroad, as much and as long as possible. To enjoy his beams the whole day, he formed one end of his dining-room like that curve which he thought the glorious luminary made in his course round the world, and when obliged to make projections in his building, he contrived them so as to form a warm corner for his family to take exercise in, since no fires were made in the house, except in the kitchen, and in his own apartments. His sleeping-room was placed to have the benefit of the morning sun; and to remedy the inconvenience of its being situated in a cold corner in the winter, he warmed it from a hypocaust under a small room adjoining, as being more convenient for a servant on the outside of the chamber, to admit what heat was necessary, without disturbing the person that was asleep, than if it had been made under it. He shows no care to heat any other room in this winter villa, except his bed-room in the garden-house, as if he chose rather to keep himself warm by

* Ep. l. ii. ep. 17.

additional clothing, or by exercise, or by retiring to those rooms which were warm by their position, than by the heat of a hypocaust. Our ignorance of ancient manners, and deep-rooted prejudices imbibed during that period of our lives when we generally read the classics, have taught us to think very highly of Roman magnificence, and luxurious enjoyment; but, in this instance, Pliny himself admits that real comfort could only be found in his little bedchamber in the pleasure-house in the garden, a room that would now be considered most dismal in the winter by a modern domestic, for its small window was closed with wooden shutters only.

It may here be observed, that, in general, the arrangement of a Roman house was such that the sun could shine through the *compluvium* or the opening in the roof of the *atrium* or hall; and being commonly only one story high, and rarely exceeding two, it must have been warmer and drier than houses of the present day, that preserve something of the ancient form, but where the court is usually darkened and rendered damp and chilly by the greater height of the surrounding buildings. In town houses, however, the rooms must have been very gloomy, as the only light they could receive entered through an aperture in or over the door, and even this light was often borrowed. Under these circumstances the ventilation must have been most imperfect; and in spite of their use of talc, glass, and linen shutters, and of curtains, carpets, and braziers, still the want of fires generally, and chimneys entirely, must have reduced the ancient inhabitants of Italy, as it does the modern population, to endure, under additional clothing, that state of discomfort and cold damp which is always produced whenever the sky is overcast between November and April. Yet no people are

more sensible of the slightest variation of temperature than the Italians; and none make a more plentiful use of warm clothing. They also know the use of chimneys; but popular as well as professional prejudice prevents their introduction; and people who follow the rules of their physicians, *avoid* them, and live in rooms warmed by pans of burning charcoal set on the middle of the floor, or under the table at which they sit, without a funnel of any sort to carry their fumes out of the apartment,—but such has been the custom in Italy from the most ancient times.

In the cold and changeable climate of Britain, the Romans adopted a more economical and healthful method. Almost all the remains of their houses that have been discovered, show that the means of heating them by hypocausts and flues were provided at the erection of the building, not for one or two rooms only, as in Pliny's Laurentine villa, but for every apartment designed for habitation by the family.*

These hypocausts are of two kinds. The first con-

* The hypocaust at Withington was 27 feet 6 inches in length, and 19 feet wide. The piers were formed of brick, 8 inches square, and the average distance between the piers was 14 inches.—Archæologia, vol. xviii. p. 112.

At Caerleon, the piers were built of circular bricks, 14 inches in diameter, "piled on each other like cheeses."—Roy. Military Antiq. p. 197. Arch. vol. ii. p. 6.

The pillars of the hypocaust at Wroxeter were formed of fragments of columns of granite that had before been used for some other purpose, 14 inches diameter. There was much irregularity both in the distance and placing of the pillars. In the same villa two other hypocausts had pillars 8 inches square, 2 feet distant from centre to centre.—Phil. Trans. No. 306. Arch. vol. ix. p. 326.

The hypocaust at Cirencester was 32 feet long, by 24 feet wide, and had pillars 8 inches square, with tiles for bases and capitals, 11 inches square, on which rested tiles 2 feet square, and on them others of the same size to receive cement for floor; pillars 2 feet 3 inches asunder. —Arch. vol. vii. p. 407. A plan and sections of this hypocaust are given in Carter's Ancient Architecture, p. 7.

Roman house at Rodmarton. Piers of the hypocaust were 21 inches high, and 8½ inches square; spaces between the piers from 7 to 10 inches. They were of brick, and the mortar joints were ¾ of an inch in thickness.—Arch. vol. xviii. p. 115.

In the remains of a Roman building on the river Eske, five out of the seven rooms had hypocausts under them, constructed in the

structed with flues running under the floor of an apartment, and heated from a fireplace made on the outside of the building; and the second kind formed like a low chamber, having its ceiling supported by small pillars as described by Vitruvius, or by dwarf walls, and sometimes having flues leading from them under other apartments. The hypocaust discovered at Lincoln will explain this variety, of which Figure XI. is a ground plan, and Figure XII. is a section. The same letters on both Figures refer to the same part.*

The hypocaust was 24 feet 6 inches long, and 9 feet 6 inches wide. It contained four rows of brick pillars, *a*, *a*, *c*, *c*, two of which were square, and two circular. The square pillars, *a*, *a*, were 8 inches on the side, and about 9 inches apart; the circular props, *c*, *c*, were 11 inches in diameter. Each pillar had a projecting brick or tile about 11 inches square for its base, and another tile of the same size that formed a capital, making its height, and that of the heating chamber, about 26 inches. Large bricks, *e*, *e*, varying from 16 to 20 inches square, and 2 inches thick, were laid on the pillars to form the ceiling of the hypocaust. On these were placed courses of tiles, bedded in mortar, and on them a layer of stucco, to form the floor of the room, *z*, to be heated; the entire thickness of the floor being about 10 inches. The fire-hearth was at *i*; and the flame and smoke

usual manner with flues, and heated from the outside.—Roy. Mil. Antiq. pl. 46. King. Munimenta Antiqua, vol. ii. p. 182.

In the Villa Rustica, adjoining the villa at Bathorne End, the flues of the hypocaust were 18 inches deep, and 14 inches wide. At the extremity of every flue, within 3 or 4 inches of the top, a brick funnel was placed in the wall.—Rooke. Arch. vol. ix. p. 205.

Hypocaust at Chester. Had thirty-two pillars, 2 feet 10½ inches high, 18 inches distant from each other, standing on a mortar floor, spread on the rock.—Pennant. Tour in Wales, p. 2.

At Dover, the pillars of a hypocaust were 20 inches high, 9 inches square, and 15 inches apart.—Arch. vol. v. p. 327.

The pillars in an ancient bath at Lipari were 2 feet high.—Arch. vol. xxiii. p. 100.

* Vetusta Monumenta, vol. i. pl. 47.

passed through the arched cavity, or throat of the furnace, *e*, into the hypocaust. Two flues, *m*, *n*, opened into the hypocaust. The flue, *m*, that pro-

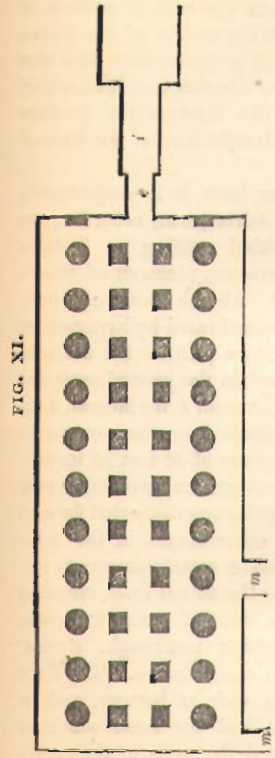


FIG. XI.

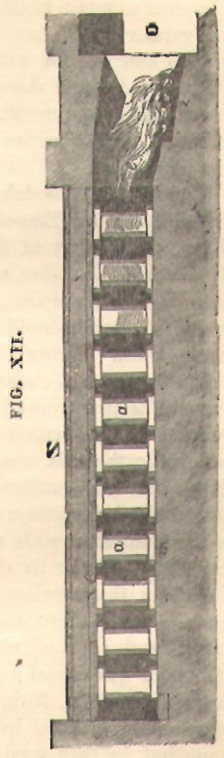


FIG. XII.

bably conducted the smoke under some other apartment, was about 6 inches high, and 14 inches inside. Its bottom was raised about 2 inches above the floor

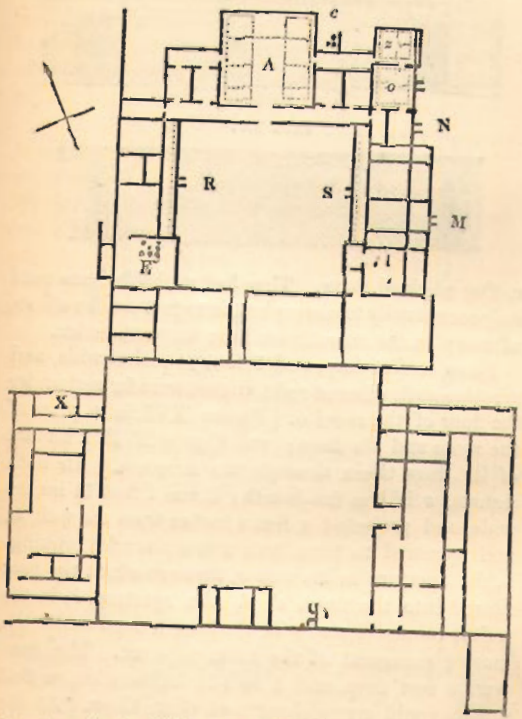
of the hypocaust. The flue, *a*, was about 6 inches square, and placed as much under as above the floor of the hypocaust. This seems to have been a smoke flue. The position given to these flues was, perhaps, designed to retain at all times the hottest portion of the vapour in contact with the ceiling of the hypocaust; and in the want of a contrivance like our furnace doors and dampers, this was an effective and ingenious arrangement. The floor of the præfurnium, A, was 18 inches under the level of the floor of the hypocaust.

The villa at Woodchester, built, it is conjectured, by order of the Emperor Adrian, was, according to King, the noblest of the kind existing in Britain. It contained sixty-five apartments, nineteen of which were of good proportion.* All the rooms and passages in the main building were heated by hypocausts, or by flues. Figure XIII. is a plan of the walls of this villa, and will clearly explain the general arrangement of its apartments.† The room A, the largest, and, judging from its beautiful mosaic floor, the most magnificent in the villa, was a square of 48 feet 10 inches. It opened into smaller chambers on two sides, and on the third side into a corridor or gallery that formed a communication with the other rooms in the main building. Under its elaborate mosaic pavement ran four flues, that are shown by the dotted lines, crossing each other at right angles, built of stone, and plastered, and covered with thick unwrought stones. The floor was coated with a coarse tarras. The flues were 4 feet high, 23 inches wide at bottom, and in the middle of their length had the same width at top; but as they approached the walls of the apartment they gradually diminished at top to a width

* Monumenta Antiqua, vol. ii. p. 188.
† Lysons. Roman Antiquities at Woodchester, pl. vi.

of 6 inches. The flues that ran from front to back had brick funnels placed in the walls at their extremities. These funnels were 13½ inches wide, 4½ inches broad on the outside, 18 inches long, and

FIG. XIII.



about an inch thick. They were deeply furrowed on one side with lines made with a toothed instrument when the clay was moist, and were most likely intended to make the mortar adhere more firmly to

them. It was remarked that these flues, (shown in Figs. XIV. XV.,) were not discoloured by smoke, and could not, therefore, have communicated with the hypocaust,

FIG. XIV.

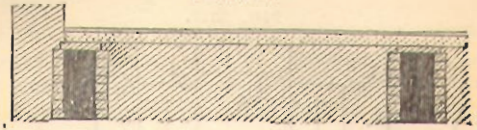
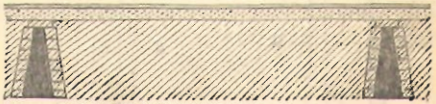


FIG. XV.



c, that adjoined them. They had probably been used only occasionally to convey hot air to prevent the effects of damp on the magnificent floor they ran under.

Flues, 4 feet deep, and 1 foot 11 inches wide, and crossing each other at right angles, were formed under the floor of the room o. Figure XVI. is a plan of the room and its flues; and Figure XVII. a section of its flues taken through the fireplace. In both figures, *a* is the fire-hearth; it was 1 foot 11 inches wide, and projected 4 feet 2 inches from the wall, c, and appeared to have been also a place for cooking. *b*, the aperture in the wall c, through which the heat flowed into the flues, *d*, *d*. An aperture, *h*, in the wall *l*, communicated with the flues formed under the mosaic pavement of the room adjacent. The flues were 4 feet deep, and 1 foot 11 inches wide, so that a man could creep along and clean them. At the extremities of the flues, tile funnels, generally having oblong holes in their narrowest sides, were placed upright in the wall to convey the heat upwards. The holes, in adjoining ranges, being placed opposite to

each other, allowed the hot vapour to circulate through the series of tile pipes.

A hypocaust was formed under each of the rooms

FIG. XVI.

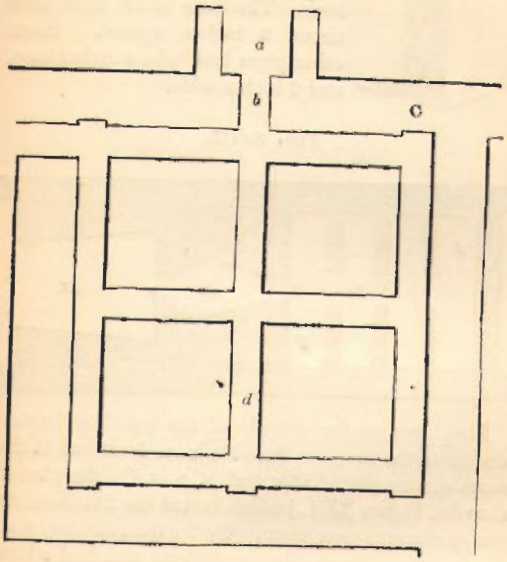
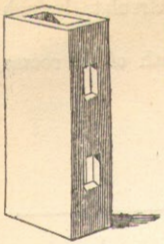


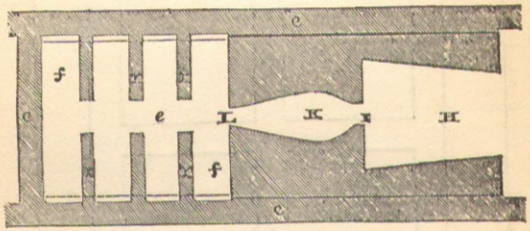
FIG. XVII.

E, I, (Fig. XIII.,) with brick pillars 11½ inches square and 9 inches asunder; and the heat from both appears to have been conveyed into the adjoining apartments.



The figure represents one of the funnels that had two holes in one side, and one hole in the opposite side. They were 7 inches wide, and 5 inches broad, and 15½ inches long. The three lateral holes were about 2 inches square. Some other pipes had holes 4 inches long, and 2 inches wide.

FIG. XVIII.



Fireplaces on the outside of the building formed similar to the fireplace that has been described in the room O, were placed at M and N, R, S, (in the plan of the villa, Figure XIII.,) which heated the flues beneath the apartments near them. Under the galleries, R, S, the flues ran close to the foundations, and had others crossing at right angles.

The situation of the warm air or vapour bath, was at X, in the general plan of the villa, (Fig. XIII.). A ground plan or horizontal section taken a few inches above the floor of the hypocaust, is given in Figure XVIII. H, is the *præfurnium* or porch of the furnace. I, the furnace or fire-chamber. K, the *focus* or hearth on which the fuel was burned. L, the throat or aperture at which it communicated with the *hypocaust* or stove. The furnace was 7 feet long, and 17 inches

in width at its mouth, which increased to 28½ inches at the hearth, and thence diminished to 13 inches at the throat. It had the same height throughout, and its floor was level. The hypocaust was 9 feet 10 inches in length, and 8 feet 10 inches wide. The six piers *x*, *x*, were pyramidal with the narrow end for their base. Figure XIX. is a section of the hypocaust in the line of its width, and Figure XX. a section in the line of its length. The piers were partly

FIG. XIX.

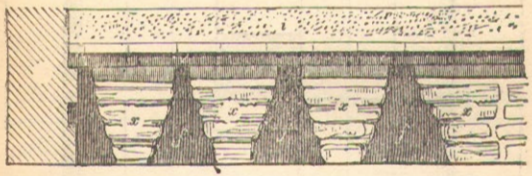
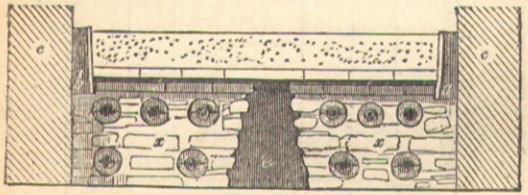


FIG. XX.

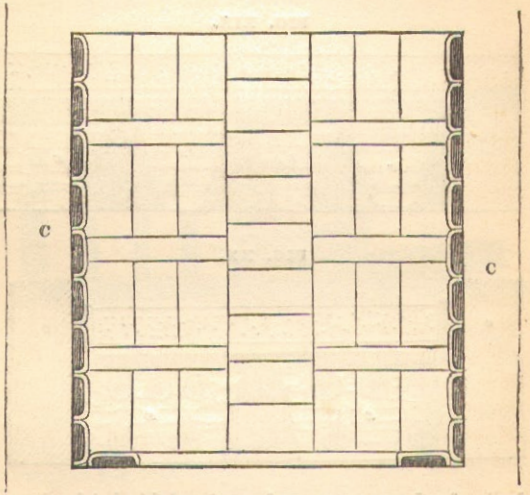


built of unhewn stone, and partly of thin bricks, in a very rough manner, and their wide joints were filled with a reddish sort of clay. They had a number of perforations, *o o*, formed by two curved or ridge tiles laid so as to form a tube, or by a ridge tile laid on a flat tile. They seem to have been formed with the view of allowing the hot vapour to disseminate itself more equally through the hypocaust; no flue was observed for the exit of the smoke. The longitudinal

flue *e* formed by the piers was 21 inches wide at bottom and diminished to 7 inches at top, the 8 spaces, *t t*, were 18 inches wide at bottom, and decreased to 6 inches at the top.

On these piers were placed bricks, *i i*, 2 inches thick, 12 inches wide, and 24 inches long, that formed the ceiling of the hypocaust, and on which was laid

FIG. XXI.



the tiles and cement, *h*, 8 inches thick, that made the floor of the sudatorium, *l*, of which Figure XXI. is a ground plan. C, is the walls of the chamber. A row of curved tiles, that form a series of perpendicular brick funnels extended along two sides of the sudatorium. Their lower ends were open to the hypocaust, (see *a b*, Figure XX.,) and the upper edges of the first row rose about 1½ inch above the floor.

Other rows of funnels were placed on these, and a thick coat of stucco laid on them made the casing smoke bright. They serve the same purpose as the tile lining of the caldarium of the baths at Pompeii.

FIG. XXII.

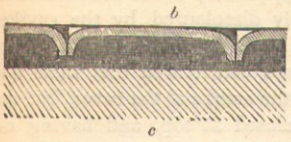


Fig. XXII. is a section on a larger scale of these curved tiles; *w*, the curved tile about 18 inches long and 13 inches wide; *s*, the space in which the smoke from the hypocaust circulates between the tile and the wall, C.

The walls of the villa remained entire for a few inches only above the floor, so that no notion could be formed of the height to which these funnels were carried. But from the large size of the hearth, and the moderate area of the floor of the sudatorium, it is probable that it was not found necessary to carry them as high as the ceiling to acquire the necessary temperature, and they may have terminated at the second or third row.

The sudatory of the villa at Northleigh had the walls lined with *square* brick funnels, which went through the floor into the hypocaust.* They were 18 inches in length, and the internal opening was 4½ inches by 2 inches; the pipes were set perpendicularly on each other, so as to form a close range of upright flues, between which there was a continued lateral communication by means of small corresponding

* Hakewill, in Oxonia Restaurata, p. 12. The square brick funnels found in the hypocaust at Dover were each made of four tiles. They were fixed together with four cramps, and had lateral holes of communication.—Arch. vol. v. p. 327. The ancient bath in the island of Lipari had two rooms lined with vertical square clay tunnels. At Faro Point, Sicily, one of the rooms over the natural warm baths was lined in the same manner; and a hypocaust on an exactly similar construction was found in the remains of some ancient baths in Catania.—Arch. vol. xxiii. p. 100.

apertures on the sides of each funnel. *Behind* these rows of funnels (or caliducts), six other separate ranges of funnels, of the form of those that are shown in Fig. XVIII., with an opening of 4¾ inches by 4 inches, were built in the walls. These also communicated with the hypocaust; but it was remarked that they were entirely discoloured by the smoke, while the square tile pipes in front had hardly a tinge of it; from which it was conjectured that their use might be to discharge the smoke at the eaves, but the outer funnels, being closed at top, and having no draught through them, contained the air that communicated its heat to the room.

The villa at Bignor exhibits a peculiarity not elsewhere found in Roman buildings. In using open fires, it is not probable that it was always convenient to place the hearth in the centre of the apartments. Two rooms in this villa had their hearths placed against the wall, and enclosed with jambs like a modern fireplace. One of them was 21½ inches wide in front, 17 inches wide at the back, and 8 inches deep, with a hearth formed of bricks; another room had a similar fireplace, but 19½ inches wide in front. The sloping jambs of these fireplaces were placed as in the stove recommended by Count Rumford. It could not be ascertained whether they had chimneys.*

* Lysons. Arch. vol. xiii. p. 209.

Were the Romans as ignorant of chimneys as the Greeks? (see page 35). Vitruvius does not mention a chimney even to carry off the smoke of a furnace, (see page 41). When the Triumviri caused the proscribed to be sought for by the military, some of them had, says Appian, De Bellis Civil. lib. iv., hid themselves in the chimneys, or rather in the smoky apartments of the upper story under the roof, inhabited only by poor people, as Beckmann explains it. The roofs of kitchens were to be made high and arched, that their timbers might not catch fire.—Columella. De Re Rustica, lib. i. c. 6. This precaution would have been unnecessary, had chimneys been known. Horace describes an accident of this kind when the landlord of an inn was making a large fire to get some birds cooked in a hurry for Mæcenas and his company: Lib. i. sat. 5. He, as well as Juvenal, talks of smoky houses, which shows that people suffered for the want of chimneys. The word *atrium*, or hall, had its rise from the walls of these places being blackened by smoke.—Isidorus, xv. 3. The habitations of people not of the lowest ranks are represented as black with smoke-stains and smoky. Columella speaks of the "*soot* which adheres to the *roof*." De Re Rustica, lib. i. c. 17; that could only be in apartments without chimneys. Pantries for flesh and wine are to be made near the kitchen or oven, and also coops for fowls, that they may partake of the smoke: De Re Rustica, lib. viii. c. 3.; but articles spoiled by smoke were to be kept at a distance from the kitchen: Columella, l. 6. 20. Quintus Curtius says, that Alexander, in his march to Gabara, encouraging his soldiers, "showed them *smoke* that rose from roofs afar off, advising every one to take the nighest refuge."—Lib. viii. c. 4. Montfaucon says, "from the Latin word *Caminus* is derived *chiminea* of the Spaniards; *camino* of the Italians; *cheminée* of the French; *kamin* of the Germans;" and *chimney* of the English; and with the name was transmitted the invention. Beckmann observes, though the derivation be just, the conclusion is not so. An ancient name has been transferred to a new invention. "Even if we should conclude that the ancients were acquainted with the art of constructing elevated funnels for conveying off smoke, when we consider the many proofs that we have to the contrary, they were, at any rate, extremely rare." —Hist. of Inventions, vol. ii. p. 88. Sir William Gell observes, that chimneys were certainly found in two instances at Pompeii, (see page 46); and that they certainly existed at all times in the South of Italy: Pomp. ii. vol. ii. p. 140; but he quotes no authority for his observation. The point is yet to be explained how the smoke could be conducted from such immense furnaces as those of the hypocausts of the public baths, without the aid of chimneys. Kitchens were sometimes 140 feet long.—Moule on Villas of the Ancients, p. 176. If the fires were large in proportion to the size of the apartment, without a chimney the smoke must often have been uninhabitable.

* Libri dell" Architettura, l. iii.

Similar hearths, it is thought, are alluded to by Palladio, where he says that "The ancients made their chimneys or hearths in the middle of the room, with columns or modiglions that supported the architraves, upon which was placed the pyramid of the chimney whence the smoke issued. One of these hearths was to be seen, in his time, at Baiæ, near Nero's piscina, and another near Civitta Vecchia. Where the ancients were not desirous to use chimneys, they built, in the thickness of the walls, some tubes or pipes, through which they conveyed the heat of the fire that was under the rooms, and which came out of certain vents or holes that were made in the top of the pipes.* One of the methods of heating described in the preceding passage, we have seen, was employed

by the Romans. We know that in the fourteenth century, fires were made in the houses at Rome, (that were then very low and thatched,) on a hearth or in a hole in the middle of the floor, and without a chimney.* The fireplaces seen by Palladio, were not, therefore, mediæval structures, nor vestiges of a mode of heating that had become obsolete only a little while before Alberti and himself introduced elegance and comfort into Italian buildings, and established the use of recessed hearths with smoke flues. Palladio considered them to be ancient, and much authority is due to his great knowledge and judgment of Roman building. On this much litigated question it were not, however, becoming here to decide. The necessity for chimneys, it is true, backed by the remains at Civitta Vecchia, and by the chimney in the Temple of Isis at Pompeii, and by the second row of tiles in the villa at Northleigh, give fair and strong ground for believing that the Romans occasionally conducted smoke from a hearth by pipes in the walls, and also in the manner still seen in some parts of Holland, where the fireplace, made in the middle of the kitchen, has a canopy or pyramid over it that extends to the ridge of the roof for the escape of the smoke. On the other hand, it must be admitted, that the total absence of mention or vestige of the contrivance in ancient writings and buildings, is certainly greatly in favour of the popular opinion, that the Romans were ignorant of a comfort daily enjoyed by the meanest among ourselves.

Hypocausts constructed in the manner of those described, seem to have been used in other northern countries where the Romans established themselves; and the house in which Julian lodged in Paris, was probably warmed by a hot floor and flued walls.

* Muratori. Script. Rerum Ital. vol. xvii. p. 46.

"The winter," says the emperor (in his *Misopogon*), "was then uncommonly severe, and the river was frozen; and being more boorish than usual, I would not suffer my servants to warm the chamber in which I slept, though the cold increased, and grew every day more intense. Lest it should draw the damp out of the walls, I only ordered some lighted brands and a few live coals to be carried in and placed there. These exhaled so much vapour from the walls, that my head being oppressed, I fell asleep, and narrowly escaped suffocation. But being carried into the air, and by the advice of my physicians disgorging the food that I had just swallowed, though I did not disgorge much, I was immediately relieved, so as to pass an easy night, and next day I was again fit for business."

It is not easy to comprehend how the damp that excited Julian's apprehension could be exhaled from a flued wall. His objection, however, shows that some inconvenience was usually produced by that particular kind of apparatus, and which, in all probability, arose from the insensible transpiration of carbonic vapour from the hypocausts, through imperfect joints into the sleeping chambers. Yet it is doubtful from his account, whether the brands that occasioned the accident had been placed in the hypocaust, or whether they had been burned in a brasier in the apartment. In either case, the effect in a close room would have been the same. The danger of the practice did not, however, lead to its discontinuance. Ammianus Marcellinus states that his successor Jovian was accidentally suffocated by the vapour of a charcoal fire that had been lighted to warm his bedroom.

From the preceding examples it will be apparent that the modern method of heating by flues is different from the ancient; with us a large mass of fuel is burned in a capacious furnace, constructed in such manner, that

all the air entering the heating flues must rise at a high temperature from the incandescent fuel; and a great extent of flue is heated by one fire. There is no means of equalizing the heat at different points of the same length of flue, and the parts near the furnace are constantly overheated, while those more remote are comparatively cold. The Roman practice, as exhibited in the villa at Woodchester, is more judicious. Each apartment has its own fireplace, and flue, or hypocaust; and can be warmed, independently of another apartment, to the particular temperature required, without the waste of fuel that takes place when many apartments must be heated when a part only is wanted: by burning the fuel at several points, the danger of accident and destruction of the apparatus, that is occasioned by one great fire, is avoided. The nature of the fuel, and form of the fireplace also, were advantageous. The furnace not being enclosed, the hot gases that rose from the wood were greatly reduced in temperature by mixture with the air, and the hypocaust was filled with vapour at a comparatively low heat. This being spread over a very large surface, and more equally diffused than is practicable in the modern method, the warmth produced in the building was more uniform and genial.