passed through the arched cavity, or throat of the furnace, c, into the hypocaust. Two flues, m, n, opened into the hypocaust. The flue, m, that probably 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, $n$, 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 prefurnium, $\Lambda$, 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 $\Lambda$, 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, pi. 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 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.**

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**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 15 1/2 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 $a, a$, 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.**

![Diagram XIX.]

**FIG. XX.**

![Diagram 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 the tiles and cement, h, 8 inches thick, that made the floor of the sudatorium, i, 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 $1\frac{1}{2}$ 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. 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 4\( \frac{1}{2} \) 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 passages.

* 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. 109.
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 4¼ 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 jams 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 jams of these fireplaces were placed as in the stove recommended by Count Rumford. It could not be ascertained whether they had chimneys.*

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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 Triumvirs 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 Mecceus 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
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 modillions 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 Baiae, 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

walls of these places being blackened by smoke.—Istidorus, xvi. 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. c. 20. Quintus Curtius says, that Alexander, in his march to Gabara, encouraging his soldiers, "showed them smoke that rose from roofs afar off, advising everyone to take the highest refuge."—Lib. viii. c. 4. Montfacon says, "from the Latin word Caminus is derived chiminea of the Spaniards; camino of the Italians; cheminée of the French; kam in 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 49); 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 145 feet long.—Moulins 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’ Architectura, i. iii.
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.

"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.