

Preliminary report on form and construction of kilns, now used for the burning of clayware / By Mr John Roe, Chief Surveyor. February 8, 1849.

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Metropolitan Sewers.

PRELIMINARY REPORT OF MR JOHN ROE,

CHIEF SURVEYOR,

ON

The Form and Construction of the Kilns now used for the Burning of the various kinds of Clay Ware, with a view to ascertain if any, and what Improvements can be made on them, either as to Economy or Efficiency.

It is proposed to describe the different kilns in use for burning the various kinds of clay ware, to point out the advantages or disadvantages they severally present, and by a general comparison and examination of the whole to ascertain, if possible, whether any improvements in the general arrangement or the details of such structures can be suggested that will enable the manufacturer to burn with less waste and greater economy of fuel than at present, and thus insure to the public an increased supply of a superior character in each class of ware at a reduced price. The general review here contemplated will include notices of the kilns now used for porcelain and other superior ware; but the inquiry will be more particularly directed to the improvement of those used in the manufacture of the coarser kinds of pottery and stone ware applicable to drainage purposes.

It will best serve the purposes of this inquiry to arrange the kilns now in use in the following general classes; viz.—Class 1. The Porcelain or China Kilns, including those adapted to the different varieties of that ware, but all distinguished by requiring two separate and distinct firings. Class 2.—The Stone-ware Kilns; and Class 3.—The ordinary Pottery Kilns.

It has not been considered necessary to carry this classification further, or to include those minor varieties adapted for particular kinds of ware, as for pipe-clay, fire-clay, crucibles, &c.

CLASS 1. THE PORCELAIN KILN.—The manufacture of true porcelain not having been yet naturalised in England, all examples of kilns suited to the firing of that superior ware must be taken from the Continent.

Porcelain, of which the chief constituents are a white, infusible, plastic clay, called kaolin, and a felspathic flux which permeates or saturates the whole mass, requires great and long-continued heat to produce that vitreous body which characterises it. In the firing of this ware two distinct stages or operations are observed: the first is intended gradually to expel all moisture that may exist in the vessels when formed, and raise them to a red heat (in which state it is called biscuit); and the second is to completely bake them with the glaze or flux. The porcelain kiln of Sèvres, near Paris, may be taken as an example of this class; those of Germany and other parts of the Continent differ only in the details, the general arrangement being the same in all. Figs. 1, 2 and 3 show the plan, elevation, and sections of the Sèvres kiln with references to the several parts. It consists of two circular arched chambers, one over the other, for containing the ware, terminated by a wide funnel-shaped chimney. The bottom or floor of the kiln is solid and the flame is admitted to the lower chamber a little above its level; the firing-places are four in number, and the operation of firing is thus conducted:—The space occupied by each firing-place outside the main body of the kiln is filled with red-hot charcoal; the wood is then introduced in small billets from above, and the whole space completely filled; the apertures used for stoke-hole and ash-pit are then closed, and the draught is forced to take a downward direction, and the combustion is augmented by the circumstance that all supplies of air must previously pass through the heated fuel, and thus enter in a rarefied state, producing a long and fierce flame, which is divided into three separate channels, and finds its way into the chamber through twelve narrow apertures or flues around its circumference. This lower chamber, of course, receives the greatest degree of heat, and is used for completely baking the glazed ware, which from its delicacy requires to be protected from the direct action of the fire, and for that purpose is enclosed in cases or hollow vessels of clay ware, called Seggars, fitted to each other and packed in columns (as shown in the section Fig. 3). The whole of the lower chamber is thus occupied, sufficient space only being left between the columns of ware thus packed to allow the free access of heat and flame, which afterwards finds its way through twenty-five holes in the ceiling or dome of the lower chamber into the upper one, where the unglazed or biscuit ware is placed: this of course receives a modified degree of heat and flame, and the residue passes through a smaller number of openings in its arched ceiling into the wide funnel-shaped chimney, the lower part of which is sometimes used for preparing the biscuit ware on the clay seggars or cases. The whole structure is strongly bound together by iron ties, so contrived as to allow for the expansion and contraction consequent upon the great heat to which it is occasionally exposed.

In Figs. 4 and 5 are shown a modified form of porcelain kiln recently introduced in France, and intended for the use of coal, instead of wood, as fuel. The principal

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CLASS, I. PORCELAIN KILNS.

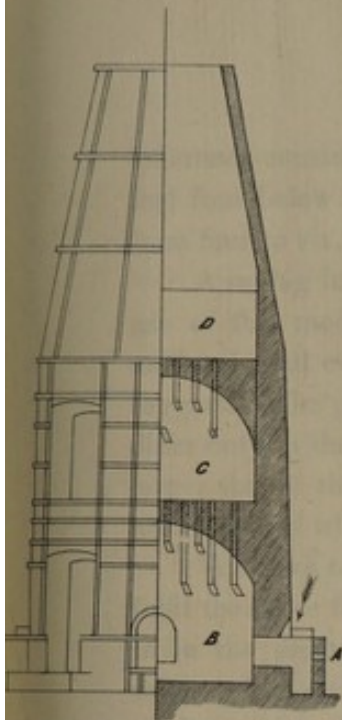


FIG. 1.

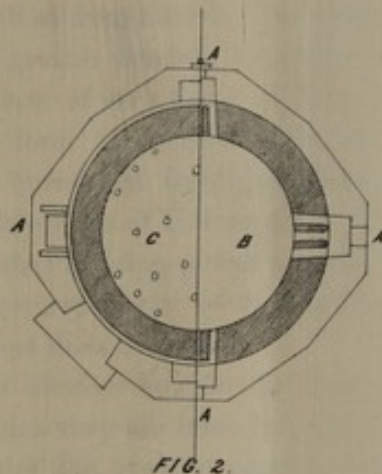


FIG. 2.

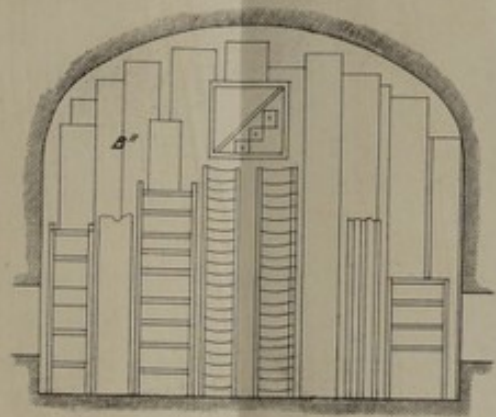


FIG. 3.

FIGS 1, 2, 3. - A. A. A. Firing Places; B. B. Lower Chamber; C. C. Upper Chamber; D. Chimney, B' Enlarged section of Lower Chamber packed with ware.

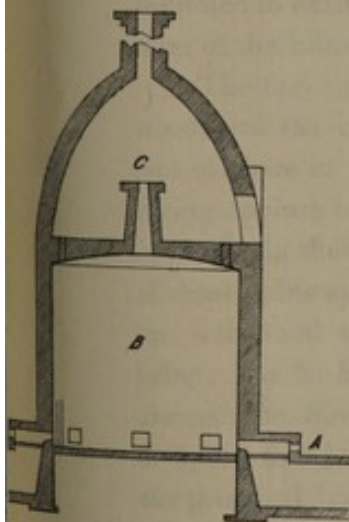


FIG. 4.

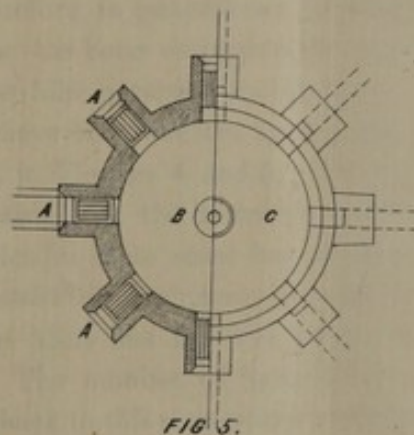


FIG. 5.

FIGS 4, 5. - A. A. A. Firing Places, - B. B. Lower Chamber, C. C. Upper Chamber.

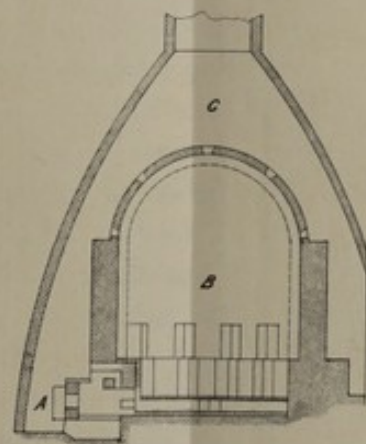
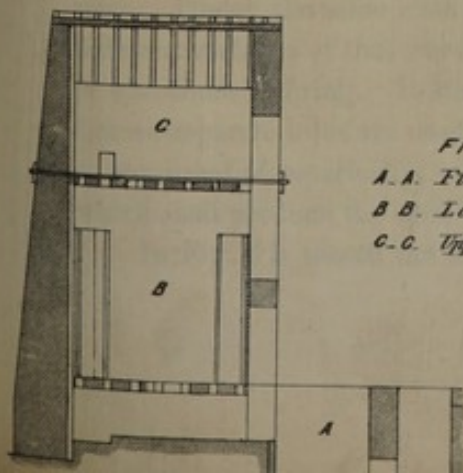


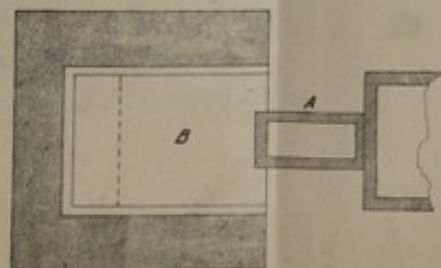
FIG. 6.

FIG. 6. A. Firing Places. B. Chamber. C. Hovel and Chimney.



FIGS 7 & 8.

A. A. Firing Places.
B. B. Lower Chamber
C. C. Upper Chamber



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difference consists in having an inside grate, and allowing the access of air to the fuel from below as well as from above. The number of firing-places is also increased from four to six, or a greater number, according to the size of the kiln.

A saving in the cost of each firing of from 16*l.* to 18*l.* is said to arise from the use of this modified form of porcelain kiln, in addition to the ware being more uniformly and evenly burnt, and less injury done to the lining of the kiln and the seggars. The porcelain kilns of Germany and the other parts of Europe appear to differ only in the number of firing-places (usually five), and in the lesser number and larger size of the apertures in the roofs or ceilings of the chambers, and which are also provided with short flues or bags.

We have now to consider how far the kind of kilns above mentioned appear to fulfil the office for which they are intended, which may be described (as in all kilns) to be the production of the greatest amount of heat and most perfect combustion that a given quantity of fuel is capable of producing, and the proper application of the heat so produced to the greatest quantity of ware. The circumstance of porcelain requiring two stages or degrees of firing no doubt suggested the double vertical chambers, an arrangement which appears well adapted to its purpose: the necessity supposed to exist for a number of firing-places most probably produced the circular form of the kilns, as well as the structural advantages presented by that form.

The fuel heretofore in general use in porcelain kilns has been poplar or lime wood, and the cost has been estimated for each firing at about 10*d.* for each cubic foot of space in the kiln occupied by the ware. As before noticed, a considerable saving appears to have been effected by adoption of coal as fuel, and the modified form of kiln shown in Figures 4 and 5. The principal source of loss and expense of these kilns appears to be the destruction of the clay cases or seggars that enclose the ware, and which in some cases has amounted to between 4*l.* and 5*l.* at each firing. As far as stability is concerned, these kilns appear to advantage, as on an average the Sèvres kilns last for 300 firings, and others have lasted thirty years, or 1,500 firings. The number of firing-places considered requisite appear to be the principal drawback to this arrangement of kiln, as in practice they have uniformly been found to present great difficulties in management from cross draughts or strong currents of air setting in one direction, by which portions of the kiln are overheated, and others not sufficiently so. It would appear that, could the number of firing-places be reduced, and the flame spread more equally by flues or other means, the result would be economy of fuel, and greater certainty of equal burning of the ware. Under the same class as the porcelain kiln may be placed those used for the different varieties of that ware, but all distinguished by requiring the distinct stages or operations of firing. It may be necessary to mention that in the English manufacture separate kilns are used for these two operations; but this cannot be regarded as any proof of superiority, which can only be awarded, *cæteris paribus*, to that form which shall produce the ware in both its stages at one firing.

In Fig. 6 is shown the most usual form of kiln for the varieties of porcelain or

fine earthenware. This consists of a single-domed chamber surrounded by an outer cone or hovel serving both for a chimney and a protection to the outer walls of the kiln from loss of heat by radiation. The chamber is circular in form and resembles a reverberatory furnace. The firing-places (of which there are six or seven) resemble those of the porcelain kiln last mentioned, and are intended to burn coal as fuel: the grate to the firing-places is often omitted. In all cases the draught passes downward, and the flame is carried by a horizontal flue connected with each fire-place under the floor of the kiln to the centre, where an aperture is left for its ingress into the chamber. Communicating with each of these horizontal radiating flues is a short perpendicular one opening directly into the chamber, so that the flame from each firing-place is divided into two parts, and enters the chamber both by the bags or short flues and by the central aperture near the floor.

This arrangement, although somewhat complex, appears well adapted for the equal distribution of the flame and heat; but the objection before taken to the number of firing-places applies with the same force to this arrangement. The hovel, or outer covering, appears to be an expensive expedient, and applied to little, if any, useful end, beyond that of mere protection to the kiln, and the spare heat is in no way economised or made useful for secondary purposes; and this form of single chamber in so far falls short of the double-storied arrangement. An oblong form of kiln suitable for ordinary glazed earthenware, requiring a lower temperature than either of the varieties previously mentioned, and but two firing operations, is shown in Figs. 7 and 8. The whole arrangement is much more simple; the fire-place is constructed for wood, and is connected with a low arch running under the floor of the kiln through apertures, in which the heat and flame find their way into the lower chamber, where the glazed ware is placed, and from thence through holes in the flat ceiling to the upper-roofed chamber, where the unglazed ware is placed, and the spare heat afterwards escapes into the open air. This arrangement may be considered as the simplest adapted to wares requiring two firings; the introduction of the heat and the form and arrangement of the firing-places nearly resemble those in use for ordinary unglazed pottery, hereafter described.

CLASS 2. THE STONEWARE KILNS.—This description of ware requires great and long-continued heat, inferior only to that required for porcelain, with but one firing.

The first description of kilns for this ware that may be noticed are constructed on a different principle to all the previous forms, and are called horizontal from the draught taking a horizontal instead of an upward direction. As the fire is applied at one end, it follows that the portion of the chamber nearest to it receives a greatly-increased amount of heat, so that it will be seen, by reference to the diagrams, that in some two separate chambers are formed by means of a perforated partition placed transversely, and in which two kinds of ware, requiring different degrees of heat, can be placed. In Fig. 9 is shown the simplest construction of kiln on this principle, intended to burn wood, and roughly constructed of rubble walling. It has a sloping

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CLASS 2, STONE WARE KILNS.

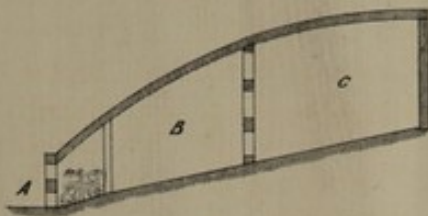


FIG. 9.
A. Firing Place.
B. First Chamber.
C. Second Chamber.

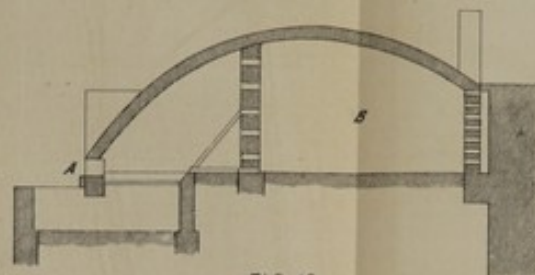


FIG. 10.
A. Firing Place.
B. Chamber.

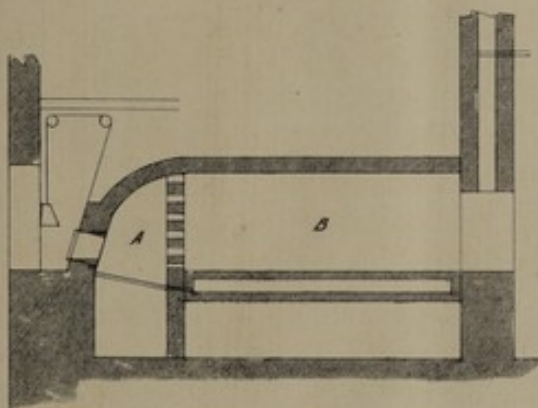


FIG. 11.
A. Firing Place.
B. Chamber.

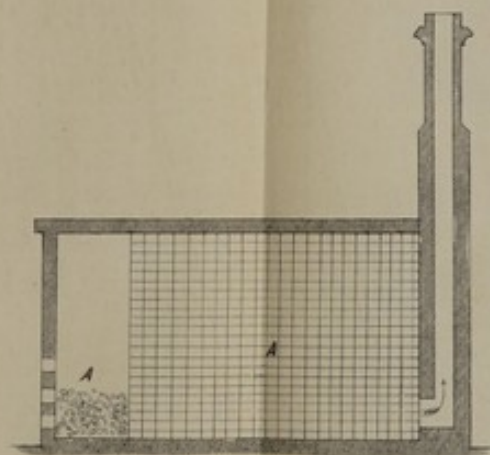


FIG. 12.
A. Firing Place and Chamber.

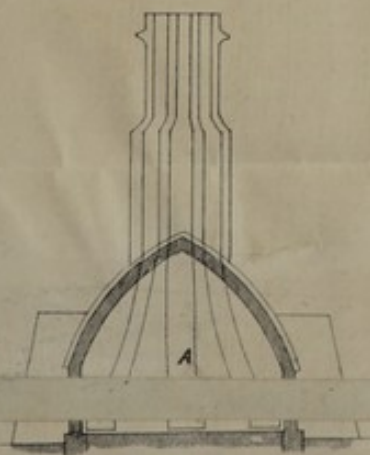


FIG. 13.

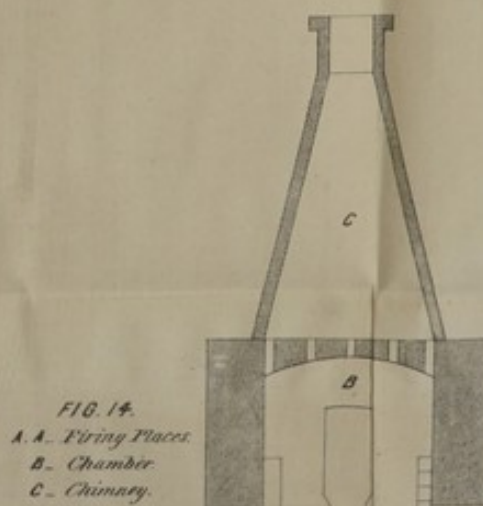


FIG. 14.
A. Firing Places.
B. Chamber.
C. Chimney.

FIG. 14.

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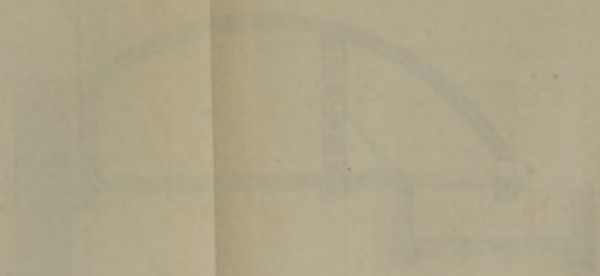


Fig. 1
Side elevation
of the building

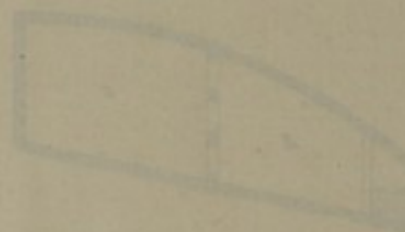


Fig. 2
Side elevation
of the building



Fig. 3
Side elevation
of the building

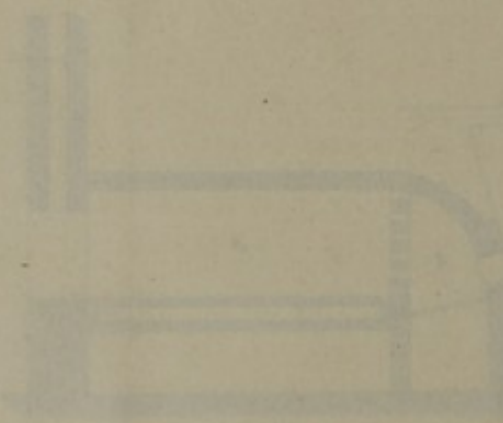


Fig. 4
Side elevation
of the building

sole or floor, and consists of a firing-place and two chambers divided by a perforated partition, covered by one arch of a segmental form.

Fig. 10 shows another of the same general arrangement, but more complete and elaborate in construction, and with a straight instead of a sloping floor.

Fig. 11 presents other modifications in detail of the same general features. In Figs. 12 and 13 is another on the same plan used for burning the Newcastle fire-bricks: this has but one chamber and no distinct firing-place, a portion of one end being temporarily screened off for the purpose. The difficulty to be overcome in this horizontal form of kiln appears to be in obtaining a more even distribution of the heat. The draught in practice has been found to take a direction more or less slanting with respect to the floor of the kiln, and not a completely horizontal one. This has been attempted to be overcome by sloping the floor of the kiln (as shown in Fig. 9). This contrivance to a certain degree answers the purpose, but at the same time presents great difficulty to the proper packing of the kiln. Upon the whole, the horizontal form, although attended with some advantages, yet from its great inequality in the distribution of heat, its confined space, and want of means for the application of spare heat to useful purposes, must yield in excellence to the upright kilns. The most usual form of upright kiln for burning stoneware (of which the Lambeth kilns offer the type) is shown in Fig. 14. They are usually circular, about ten feet in diameter and eleven feet high, with four firing-places, twelve inches wide and three feet long, with grates and ash-pits: a perforated chimney-flue is connected with each firing-place, through which the flame and heat is conducted to the ware in the chamber. The floor of the kiln is solid, and there is but one firing-chamber, with a domed roof, with apertures for the escape of the spare heat into the large funnel-shaped chimney. The greater portion of the goods are exposed to the direct action of the fire, but the more delicate are enclosed in temporary cells. Some of the ware is coated with a glaze of ground glass and clay before being placed in the kiln; and those requiring salt glaze have it introduced in iron ladles through the apertures in the crown of the arch during the process of firing.

In some of the stoneware kilns the form of the firing-chamber, instead of being circular, is oblong with the corners rounded, adapted for the purpose of increased stowage for the ware. These kilns, although undoubtedly capable of producing and maintaining great heat, yet appear from the details of their construction not so well adapted for its equal distribution as the form shown in Fig. 6, with radiating horizontal and chimney or bag flues combined.

The position of the perforated upright flues against the outside wall of the stoneware kiln, instead of being detached from it, may be considered to occasion a loss of heat, as much is expended uselessly (if not mischievously) in heating the outside wall. Although so great a heat is required, a single chamber only is provided, and the spare heat passes off at once into the chimney without fulfilling any other useful office. The number of firing-places, the evils attending which have been previously pointed out, are also another point in the arrangement of these kilns that

seem to require revision. The great importance and excellence of this ware demand that increased pains should be bestowed on everything connected with perfecting and economising its manufacture.

CLASS 3. ORDINARY POTTERY KILNS FOR GLAZED OR UNGLAZED WARE.—In Figs. 15 and 16 is shown the usual form of kiln adapted to this ware. It consists of a single chamber, circular on plan, with an elongated domed head surmounted by a funnel-shaped chimney; it has four firings, each connected with a perforated flue against the outside wall, whence the flame is admitted to the chamber, and in addition has a larger perforated shaft or flue in the centre for the same purpose. There are perforations in the top of the chamber for the escape of the spare heat into the chimney. As this ware requires less heat than the kinds previously mentioned, it might be supposed that the number of firing-places might be advantageously diminished. The same objections as regards the perforated flues against the outer wall again apply, the same waste of heat before remarked again occurs, and the general arrangement seems susceptible of considerable improvement. The elongated form of the chamber, which gives considerable space for packing the ware, might be advantageously combined with a more equal distribution and economical application of the heat.

It is to be regretted that the arrangement and construction of kilns for burning the cheaper kinds of pottery have been comparatively neglected. As good and easily-fused glazes for ware requiring such can now be obtained, and as the progress of chemical knowledge upon this subject promises at no very distant time to insure the production of a sound article from the cheap, plentiful, and easily-burned clays, it becomes of great importance that the kilns adapted for its firing should attain the greatest practicable degree of perfection.

Figs. 17, 18, 19, show the arrangement of a good ordinary kiln (as used in Sussex) for the firing of unglazed pottery, bricks, agricultural drain and roofing tiles. It consists of one chamber of oblong form, with the firing-places connected with low arched flues running longitudinally through the kiln: the flame finds its way into the chamber through perforations in these arched flues, which are in general temporary. The ware is packed upon a temporary perforated floor, and the smoke and spare heat escape from the chimney direct into the open air. This general arrangement is the most usual for kilns of this description, more or less modified according to circumstances.

The number of the firing-places, it will be seen, is here reduced to two, and a species of perforated floor for distributing the heat is adopted. This kind of kiln, it is presumed, might be materially improved, as most of the points before commented on as objectionable are here again reproduced. In the agricultural districts, where the manufacture of drain-tiles has now become of importance, the kilns ordinarily erected for burning them, from their defective construction, waste of fuel, and the unequal character of the material produced, require considerable revision. In many expense has not been spared; but the result is still unsatisfactory, owing to the

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CLASS 3, ORDINARY POTTERY KILNS.

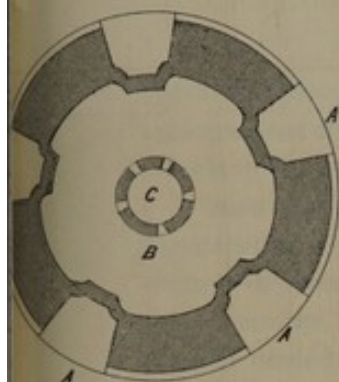


FIG. 15.

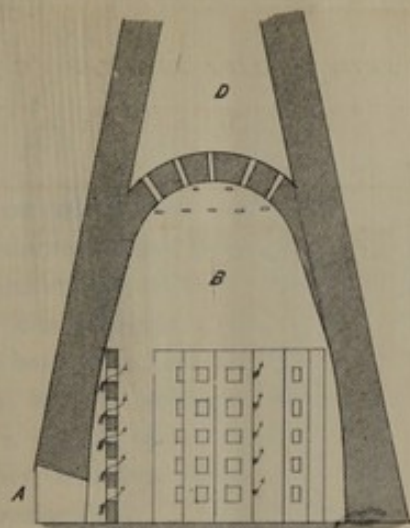


FIG. 16.

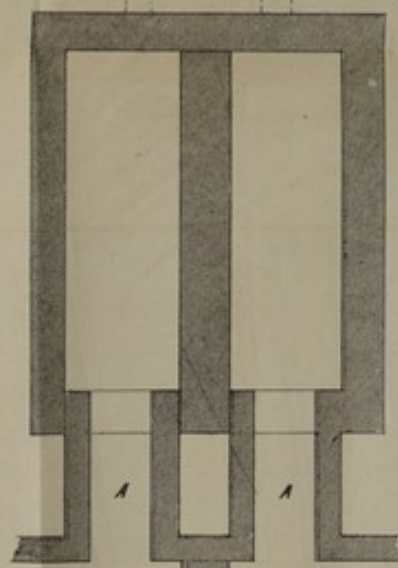


FIG. 17.

FIGS 15 & 16. A.A.A. Firing Places, B.B. Chamber.
C.C. Central Shaft. D. Chimney.

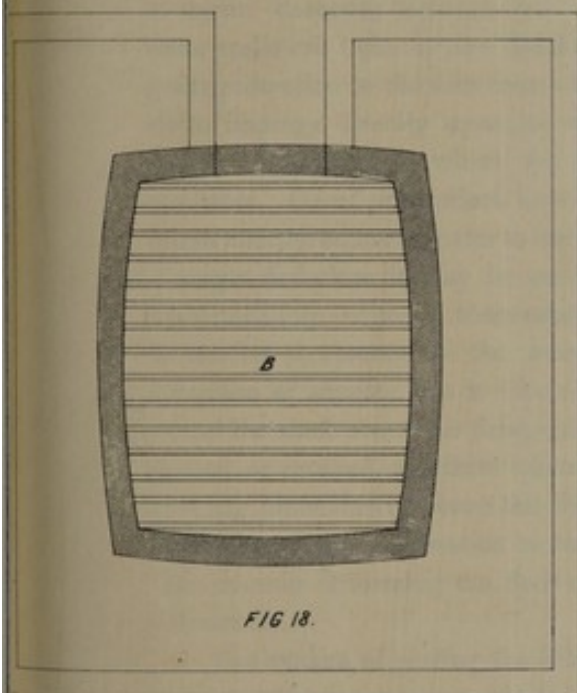


FIG 18.

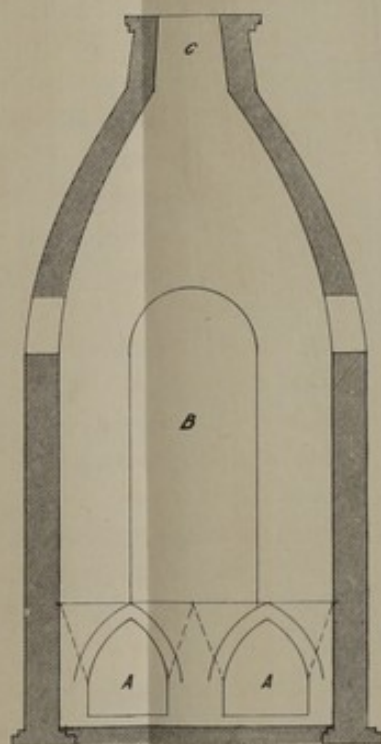


FIG. 19.

FIG. 17, 18, 19. A.A. Firing Places, B.B. Chamber, C. Chimney.

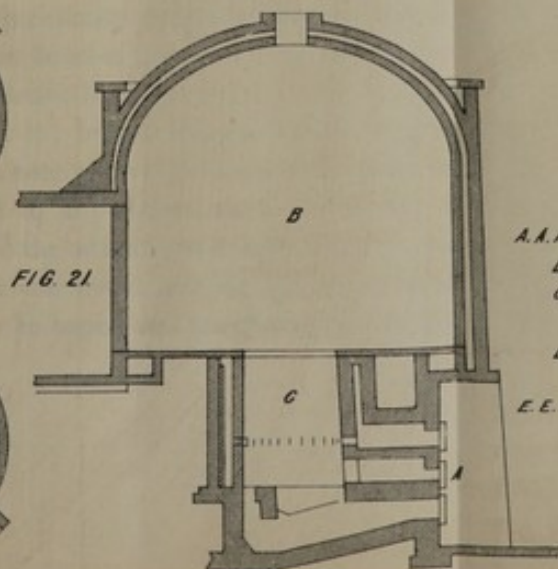
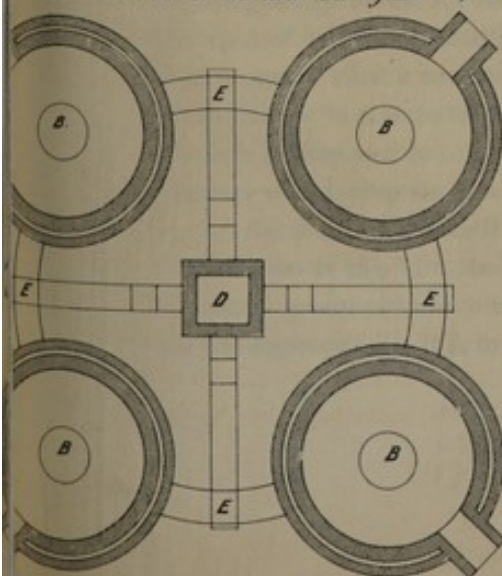


FIG. 21.

FIGS 20-21.
A.A.A. Firing Places.
B. Chamber.
C. Central Shaft
from Fire Grate.
D. Chimney to the
four Kilns
E.E.E. Communicating Flue.

380

defective principles on which their construction has been grounded. The last arrangement of kiln, shown in figs. 20 and 21, is that patented by the Ainslie Tile-Machine Company, and erected at their works, Alperton, Middlesex.

As a whole this kiln presents a great advance both in economic and scientific construction over the best of the same class in previous use. The first distinguishing feature of these kilns is their arrangement in groups of four, or six, or even a larger number, with a central chimney common to all. Each kiln consists of a circular domed chamber, with one firing-place communicating with the centre of the chamber by a circular shaft. The reverberatory principle is completely carried out. The flame and heat first rise from the fire-grate up the short shaft to the centre of the chamber, and through a continuation of the same (built up in a temporary manner either with large ware or otherwise) to the dome of the chamber, where it again descends through the ware packed all round the central shaft. The outer walls are built in two thicknesses with an intervening space, thus offering great protection to the kiln from the loss of heat consequent upon allowing the cold air to impinge directly upon its outer surface, and at the same time obviating the danger of splitting to which the strongest solid walls, although banded with iron, are liable. Great precautions have in this kiln been taken in the formation of the ash-pit and the adjacent parts to insure a perfect command of the draught, and this with a single fire-place it may be considered satisfactorily to have achieved. Another important improvement observable in these kilns, and one hitherto entirely neglected in similar structures, is the means taken to insure perfect combustion and consumption of smoke: this is effected by the simple expedient of providing a chamber round the shaft above the firing-place, in which air is admitted and becomes highly heated or rarefied, and from whence a regulated supply is let in through small slits opening immediately above the firing-place, which has the effect of increasing the fierceness of the combustion to such a degree that the smoke is entirely consumed. The manner of forming the floor of these kilns appears to be capable of some improvement.

The system of placing the kilns in groups seems to be especially commendable, as it not only saves expense in the reproduction of certain parts which they have by this means in common (as the chimney shaft, &c.), but more especially from the advantages it presents for the economical application of spare heat to useful purposes, the want of which has been previously noticed in most of the kilns in ordinary use. In a group of kilns a constant succession may be kept up, as the cooling of one brings its neighbour in a state to receive its full heat; and this is not the only manner in which it is proposed to apply it: in case the spare heat is required to raise the temperature of a drying shed, a hose or air-tight channel fastened to the aperture at the top of the dome will take it to any desired spot. From the skilful and scientific construction of this kiln, and the advantages found to accrue from its use (although the whole group are not yet completed, and the full advantages of it consequently not yet appreciated), it is to be hoped that it will have the beneficial result of effecting

important improvements in the construction of kilns applicable to all purposes. It is not intended to enlarge further on the forms of the kilns used for particular wares, as for pipe clay, fire clay, crucibles, &c., which only present different modifications of those before described. A general review of the arguments in favour of, or opposed to the various kinds of kilns referred to in this paper will now be made with an endeavour if possible to deduce from them some general principles for future guidance in the form and construction of such structures. Upon looking at the comparative forms of the kilns shown in the diagrams, it will be seen that for the burning of all kinds of ware, and whatever other minor differences may exist, they may be divided into upright and horizontal, so called from the direction of the draught or fire stream in either case.

Upon the choice of one of these, as a general principle, practice appears to be pretty uniformly in favour of the upright; and further consideration of their comparative merits appears to justify the choice, taking into account that even in the best-constructed kiln of the horizontal form great disproportion in the amount of heat received in its different parts must always exist.

The upright principle being selected, it now remains to make choice of a general form; and almost universally the circular or cylindrical form appears to have obtained the preference, and not undeservedly so, since it appears to be adapted to all kinds of kilns, and to nearly every manner in which the heat can be applied, to say nothing of its stability in a structural point of view. The selection of any one precise mode as to the application of the firing involves consideration on matters of detail, and would be misplaced in an inquiry only to ascertain general principles. All the kilns described may be placed, as regards the application of heat, under two heads, viz.: those kilns which have a solid floor, and the firing-place at or nearly at the level of the same; and, secondly, those which have a perforated floor formed by flues running in various directions, and the firing-place at some point under the level of such floor. In the choice of one of these general principles some difficulty may exist. The kilns with solid floors, as the porcelain or stone ware, are found to be capable of producing great heat: this cannot be denied; but it is questionable if they can produce an equal, and an equally well distributed heat from the same quantity of fuel, as the kilns which have the hollow flues and the firing-place below the level of the floor. The use of the solid floor almost necessitates a great number of firing-places, the disadvantages of which have been previously enlarged on. The kiln with the hollow floor, and the firing-place below its level, may be taken as offering superior advantages to the other form. The number of the firing-places required for a kiln appears yet to be involved in uncertainty; but one thing may be considered certain, that the number heretofore considered necessary even to kilns where no very great or continued heat is required may with advantage be diminished; and that this can be effected by the hollow in the place of the solid floor, is made manifest by the practice of the Ainslie Company's Kiln, which fulfils its office perfectly with but one firing-place.

There remains to be determined the arrangement to be adopted to insure the economical and useful application of waste heat, and the different methods, in which this has been attempted, either by additional chambers placed above or beside the principal one, has been shown. The adoption of either of these methods will depend, in a great measure, upon the ware to which the kiln is intended to apply. Thus, for ware that requires two firings, the upper chamber would most probably be most advantageous; where one firing only is required, some arrangement of lateral chambers, either adjoining directly or communicating by flues, would be preferable.

Having thus gone through a few of the arguments to be adduced in favour of or against certain forms of kilns and their principal component parts, it will probably best answer the purposes of this inquiry to sum up shortly a few of the requirements of such structures deduced from an examination and comparison of the examples cited, and which there is every reason to suppose could be carried out in future structures of a similar kind.

Thus it appears that kilns for firing the various kinds of clay ware may be most advantageously constructed as follows:—

- 1st. With the upright in contradistinction to the horizontal draught.
- 2nd. Of circular or spheroidal form.
- 3rd. With hollow in contradistinction to the solid floor.
- 4th. With means for the consumption of smoke.
- 5th. With an arrangement for the economical application of the spare or waste heat, either by vertical or lateral communicating chambers, according to circumstances.

Were the attention of practical and scientific men directed to these points, it can hardly be doubted but that very improved forms of kilns would result, as well as great saving in the cost of manufacture and improvement in the quality of the ware.

The inquiry into this matter set on foot by your Honourable Board will lead to the most beneficial results, not only with regard to the districts over which you have control in regard to cost of material, but, by diffusing a better knowledge of the subject generally, immense benefits will result to the community at large.

JOHN ROE.

February 8th, 1849.

Metropolitan Sewers.

PRELIMINARY REPORT

ON FORM AND CONSTRUCTION OF

KILNS,

NOW USED FOR THE

BURNING OF CLAYWARE.

By MR JOHN ROE,

Chief Surveyor.

FEBRUARY 8, 1849.