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SANITARY ARRANGEMENTS

FOR

DWELLINGS

INTENDED FOR THE USE OF OFFICERS OF HEALTH

ARCHITECTS, BUILDERS, AND HOUSEHOLDERS

BY

WILLIAM EASSIE, C.E. F.L.S. F.G.S. &c.

AUTHOR OF 'HEALTHY HOUSES' ETC.

LONDON

SMITH, ELDER, & CO., 15 WATERLOO PLACE

1874

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PREFACE.

THE following pages include an account of the most ordinary sanitary defects in dwelling-houses and public institutions, in respect to drainage, water-supply, ventilation, warming and lighting. It sets forth also what, after a long practical experience and painstaking investigation, I believe to be the most simple and effective means of *preventing* or *remedying* such defects. I have described in the text, and have illustrated by minute but correct drawings, all the most approved appliances. These papers were first prepared at the request of the editor of the 'British Medical Journal,' and have appeared in substance in its pages.

The reception with which they met from eminent members of the medical profession, and the request of many who read portions of them in the serial form, have decided me to collect and revise them in the shape in which they are now issued.

WILLIAM EASSIE.

Child's Hill,
Finchley Road,
London, N.W.

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SANITARY ARRANGEMENTS

FOR

DWELLINGS.

CHAPTER I.

INTRODUCTION.

MANY causes are now combining to draw the attention of the householder towards sanitary matters, but into these causes I need not enter. I may, however, point out that in former times the householder paid little or no attention to the requirements of health, as far as regarded his house. The chief interest of proprietor, architect, and builder alike, was concentrated upon the outside elevations and inside fittings, and the drainage and foundations were generally left without a tithe of the care which they ought to have received. As a consequence of this, many public and private buildings are badly drained, unprotected from dampness, insufficiently ventilated, and incompletely warmed and lighted. In the majority of town and country houses planned by our forefathers, no serious attention was paid to these vital questions; and if the evils have not been remedied, such houses are consequently inhabited at considerable risk. It may be said that our ancestors erred through ignorance, and their posterity err through neglect.

If the bulk of the houses which were built—say three score and ten years ago—are examined, the chief nuisances will be found to arise from rotten brick drains of large diameter, from old disused cess-pools, from the infiltration of sewage into wells, from the want of dry areas, damp-proofing, and the like. Many of our modern-built habitations are, however, not much better off in these respects. The drain-pipes are too large or too small, not laid to proper fall, badly jointed, connected direct with the sewer, and without any ventilation whatsoever. The waste-pipes act as mere conveyances for the sewer-air, the cisterns yield tainted or putrid water, and from the damp basements arise chilliness and rheumatisms. Indeed it would be safer, as a rule, to inhabit the old house rather than the new.

In building, two errors are possible and ever recurring—the erection of a bad house on a good site, and of a good house on a bad site. If the latter mistake be made, the dwelling, however well constructed, may not be the safer of the two to reside in.

The natural disadvantages of soil and aspect may counteract many of the benefits expected to arise from the excellent arrangements of the architect; and, although not very much can be said by way of pointing out what to avoid in the choice of a site, beyond what would appear commonplace, and what ought to be axiomatic with every one about to build, there are two or three precautions which certainly deserve to be kept prominently before the builder and the future dweller.

A bad house in town or city may be said to be one which contravenes any of the chief rules of the Building Act. This Act, however, allows very much to be done that is inimical to health, and does not quite put a stop to crowding and other evils. It will not allow the builder to fall into many sins of commission; but the sins of omission in reference to material, ventilation, drainage, &c., are patent to any one who has leisure to watch the running up of a house in the more thickly populated parts of London, where land is of high price. The result is a close atmosphere in courts and back-yards, an imperfect supply of pure air to the house, and dark rooms where one cannot perceive the obnoxious and disease-spreading dust. Some of the model lodging-houses are bad enough, and would appear much worse if the collected statistics informed us how many were removed from them just in time to die in the work-houses and hospitals. In the better class of streets there is the same tendency to cover over every available inch of backyards and atmospheric cells, or to overhang them with verandahs and conservatories. A wit is reported to have said that the pauper with us often lives better than the free labourer, and the thief better than the pauper; and he might almost have added that the servants of some of the West End mansions, as far as regards the necessary requirements of space, light, air, and sun, are housed worse than either.

One is often enough reminded that, if his house be a castle, it has an unpleasant resemblance to some of the characters of a moated grange, and that in a climate peculiarly damp. Our builders have singularly failed to afford us the required protection. This is especially the fault of modern builders, and of the brick-built houses of this century and of this country. Culpable carelessness is often shown in the selection of site, and in dealing with it, further errors are committed. Many houses are sepulchrally erected upon a humid subsoil, and instead of being fenced off by dry areas and similar contrivances, are banked up with damp earth. Even if the rising damp be arrested by what is technically called an impervious damp-proof course, it will be frequently found that this is built in the wall too near the ground-line, so that the heavy rain bespatters the ground and splashes above it. As time rolls on, the surface of the ground also becomes elevated, and this damp course is soon lost to sight. Attempts have been made to remedy the evil of damp walls by the adoption of the hard blue bricks of Staffordshire; and then it may often be noticed that the wet has only struck, sailor-like, across the mortar-joints and chequered the inside walls like a tartan plaid. Many walls are at places only one brick thick; and if even made of non-absorbent material, and bedded not in badly mixed lime and mud, but in cement, the moisture still streams down the inside of the house at every sudden fall of temperature. The walls abstract the warmth, and, as the heat of the room subsides, a cold dew covers them. Often enough the garden around is at a higher level than the house. In such cases the subsoil-wet percolates unseen underneath the basement floor, and the kitchen fire and the octopus branches of gas-chandeliers, when in full heat, draw up the moisture. If the cellars be deeper than the drain, or a leakage occur in the latter, this moisture will rise up in an almost visible fever-sheet.

It is not unwise to doubt the dry condition of a house which has just been 'put to rights' after an expired lease. It would often have been better for the incoming tenant of a suburban house to have himself made the repairs, or to have given an architect *carte blanche*. For a time all goes well, and there are a pleasing neatness and a whitened cleanliness. Very soon the papers strip in occasional patches, and reveal half a dozen ancient paperings beneath, with their festering layers of perished paste; the plaster cracks, and here and there falls off in scabby patches. In rainy April, drops of water race down the glass to the window-sill; and in icy December the panes are radiant with crystals. The doors perspire as if seized with a sweating sickness, and the iron and steel obstinately rust. Botanically interesting mouldiness seizes the cases of the books left unwiped upon the library-shelves, and the papers in the cabinets and the very wall-prints suffer from rheum.

It is astonishing how many different neglects will suffice to cause a feeling of dampness. Perhaps the rain-water spouts are filled to overflow, or the pipes cracked, permitting the water to soak into the wall and saturate the basement; or some one has tampered with the cistern fittings, and the reservoir runs over. Perhaps the exodus of the rain-water from the roof is not sufficiently quick, and the leads are leaky. The tap and pipes belonging to the cistern are, it may be, accessible to frost, and occasionally burst; or the water supply pipe near the house is laid in too shallow a trench, and the same evil occurs on a larger scale. The scullery is paved with bricks, porous and open-jointed, when in that place of slops, the floor should have been formed of thick stone flagging with the fewest possible joints. Or some other of the legion of commonplace proprieties known to the builders may have been neglected. The unwary householder may be warned that he must look for himself. Rheumatism and all its allies are curses for which we are largely indebted to speculative builders.

There is, however, a yet worse and putrescible dampness, such as ensues when the soakage from a broken drain finds its way secretly under the cellar pavement. What shall also be predicated of the thousand and one houses which district surveyors have permitted to be erected upon the top of heaps of 'soft core' and other dust refuse? Here there is, in fact, only a two-inch flag or a three-inch brick intervening between the unhappy householder and the lately shot-down rubbish, which rains had ample opportunity to saturate. There a mushroom-like fungus has been known to spread underneath the paving-stones of a house, and actually lift them out of their bed: and the dampness of the basement, though visible to the eye and chilling to the marrow, is often passed over as only concerning the servants. Nearly all the cases of dry rot in the timbers of a house can be traced to dampness and wetness in its foundations or surroundings.

It is very humiliating for a nineteenth century man to inspect, in the course of a holiday ramble, the walls of an old abbey or an ancient castle, and to notice how free from dampness they still appear. The stones were apparently chosen by a body of master-builders sitting in solemn conclave; and the execution of the works does not disgrace the masonic craft-marks everywhere to be found upon them. The bricks completely shame those of the present day. As a consequence, the suckers of the ivy appear, during the centuries, to have done no harm save somewhat to loosen the hydraulic mortar, and the roots of the cryptogamia are but skin-deep. The game of speculation was then unknown. Houses were not then built to last the term of a short lease, with intermittent compulsory patchings. The knight or the abbot ruled supreme over the materials, not the builder or the lessor. Compo and stucco were luckily unknown.

The desire to get the largest amount of house-room for the smallest outlay is natural, but shortsighted. Modern tenants will do well to remember that a roomy cottage, well built, is in the end more convenient than a badly built mansion, though fitted with boudoirs and smoking and billiard rooms. And skilled as we are becoming in surmounting the difficulties brought upon us by the scarcity of impervious building material—rich as we are becoming in asphalte layers, terra cotta intercepting courses, silicate paints, and impenetrable washes—it would be wiser still to choose proper materials, and to build hollow walls. Many of our present popular makeshifts might then be consigned to the shelves of our economic museums.

A matter of first importance is the ventilation of the dwelling. Every now and then, as if by sound of trumpet, the attention of newspaper readers is drawn to the condition of the houses which they inhabit; and but for this periodical marshalling together of sanitary warriors, it is not to be doubted that disease would be more rife amongst us. The different captains deliver their separate messages to the community, and then fall back into the ranks. The crusades of Polignac in 1713, of Franklin in 1745, and of Arnott in 1838, will in such cases especially recur to the mind. And it is beyond dispute that the best fireplaces and stoves of the present day—those which best radiate, reflect, and conduct heat into the room—are based upon the patterns recommended by these writers. The systems for heating our monster buildings are in some sort also derived from the ancients. We have but added the chimney with which most of them were unacquainted, and also some smoke-consuming economics arising from our wholesale possession and extravagant use of coal.

A perusal of the many systems of ventilation advocated in the daily press during the past year would be sufficient to prove that we are very far from being unanimous in opinion as to what plan is best for even an ordinary sitting-room. In the Patent Office lie over seven hundred schemes for the ventilation of houses, shops, ships, and mines, the monopoly fees of which, joined to the necessary cost of previous experiment, would represent a very large sum. If each patent system had been accorded a trial at some public institution, we should, perhaps, have long ago hit a plan that would be universally accepted. Many scores of small improvements we should be sure to have for all time; but we would not be found wrangling at the present day as to the very alphabet of the science.

A plain code should be laid down by which we can secure a thorough withdrawal of the air vitiated by respiration and gas-burning. Warming is in as bad a plight as ventilation; for, in five-sixths of the houses now springing up in our towns, as anyone can see, no provision is made for supplying the fires with fresh air from without. Draughts therefore prevail. Householders suffer, but can do little or nothing. The majority are in the position of a magistrate who has to consult, in the absence of the experienced clerk of the court, a hundred bewildering precedents in Common Law. There are nearly two hundred different descriptions of grates, stoves, and other heating goods in the market at the present time; and the chance is, that the householder chooses a pattern which has been repeatedly condemned by science and experience.

The exhibition of cooking contrivances lately held at Kensington has edified many thousands of people. But these dissolving views are speedily forgotten by the public and the old race goes on, in which the greatest advertiser of his goods wins the day. What is needed is a building where all that appertains to health and house-comfort can be exhibited, seen in use, and studied in detail. Such an edifice, under proper *surveillance*, could be made useful in instructing our but half-educated servants, and would prove self-supporting. Such a structure would also afford an admirable lecture-room, for the lecturers would have before them, in illustration, the very things which have proved commendable. There are at the present time in our metropolis several bodies, such as the Social Science and the National Health Societies, which could easily combine and take the conduct of so truly a patriotic move in the right direction.

Perhaps there is too fatal a facility for patenting things, for very often the showiest arrangement pushes the more deserving ones to the wall. Considerable discomfort is often due to the practice of incoming owners reserving to themselves the purchasing of the grates and chimney-pieces—the architect offering no remonstrance. In many other cases the site or the outside of the house has swamped the major part of the capital, and the interiors, particularly the domestic fittings, have been parsimoniously treated. Mistakes, too, have been made in foolishly introducing untried novelties into so important a section of the domicile.

Many of these evils would, we repeat, die of inanition, if our chief towns possessed institutions where the best contrivances could always be seen in working order. We have a few economic museums, it is true, but they lack the notoriety which accompanies national support; and, if not carefully watched by their philanthropic promoters, these otherwise excellent places are apt to degenerate into mere advertising pantechnica. A permanent sanitary temple, on the principle of that inaugurated at Leeds in 1871, in Norwich last year, and in Salford and Kensington this year, is what is wanted in every industrial centre. Paris had an exposition of this kind in 1873.

The purpose of this small work is to point out in the plainest language what ought to be done in order to render ancient or modern houses healthy. I will eschew all extraneous matter as much as possible, and will not fall into the common practice, better honoured in the breach than in the observance, of heading the chapters, or interlarding the matter, with lines from the poets. I shall briefly describe under each head of my subject, the special appliances which can be used with advantage, and where possible to do so, will give the reader a choice in the contrivances required. Drainage will, first of all, receive a moderate attention, and proper means of disconnecting, ventilating, and disinfecting the drains will be pointed out. The correct uses of traps will be set forth, and the illusions which have surrounded them explained. Some practical rules will also be offered respecting water-closets, and several earth and ash closet systems will receive notice. Old cesspools and brick drains will also be dealt with. A few necessary remarks upon dampness, upon warming and ventilation, and upon gas and water supplies, will conclude the series.

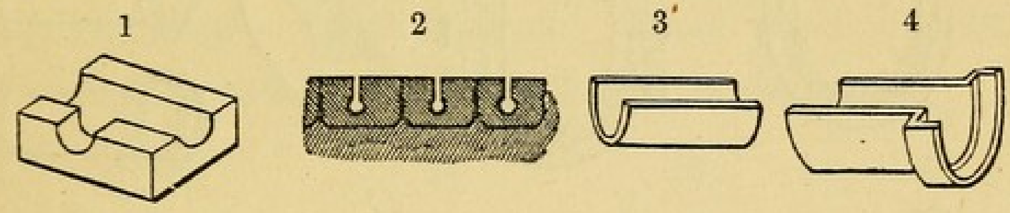
It is due to the medical profession to state that its members have ever been foremost in pointing out the danger of many practices which were unwittingly prolonged by their architectural brethren. The uselessness of water-sealed traps when the air of the sewers is in a compressed state ; the necessity of ventilating house-drains ; the danger of trusting to well-waters, except under certain circumstances ; the reduction of phthisis consequent upon a well-ordered system of water-drainage—these are a few instances of their watchfulness. In all probability, but for the plain speaking of our physicians and surgeons, our habitations would be in desperate plight The professions of medicine and architecture are in no way rivals. Both sciences are necessary to the realisation of a perfect piece of architecture, be it cottage, mansion, school-house, theatre, or hospital.

When, however, a dogma of hygiene has been promulgated by the professors of medicine, the means of its mechanical enforcement are left to the architect and engineer. Thus very often, the appliances which have been invented to carry out his own beneficial ideas are unknown to the medical man. Indeed, the descriptions of them are only to be found in architectural works or in price-lists. I shall therefore in the following pages endeavour to bring under the eyes of my readers illustrations and descriptions of the best sanitary goods.

CHAPTER II.

DRAINAGE.

By the term *draining* is meant the collection and the conveyance to some suitable place, of all the wastes of a building, and it will be necessary to describe in some detail the articles devised and sold for the purpose.



Drain-pipes.

What are known as open channellings are frequently found to be very useful. Fig. 1 represents the ordinary blue Broseley channel brick, much used in asphalte flooring, and in garden guttering &c. Fig. 2 shows a kind of pavement gutter-brick, suitable for backyards or similar places. Bricks like fig. 1 are also made with an enhanced number of side indents so as to receive the water delivered by the pavement bricks, and covers are also made for these channel bricks. The use of the open drain-tile, drawn at fig. 3, is chiefly to convey the wastes from wash-basins and the kitchen slop-waters away to the garden, on the earth-drainage system. In such cases the joints should be kept one inch and a half apart, and when one portion of the garden has been sufficiently treated, these surface pipes can then be laid in another direction. Fig. 4 illustrates a half-pipe with socketed joints, such as will be invaluable in the conveyance of these wastes and slops to some distance from the house, when they can enter the drain or sewer. It will also serve as a good garden gutter.

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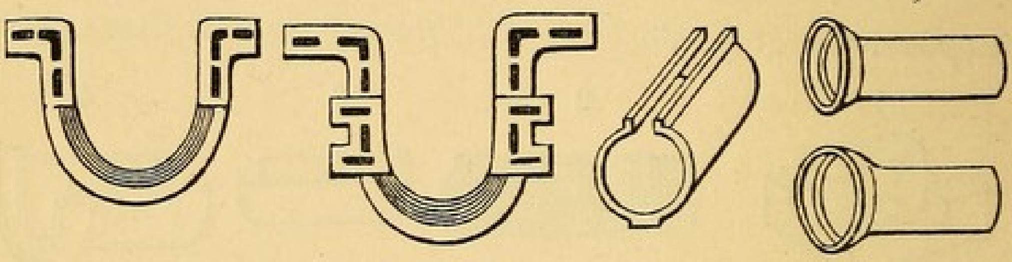

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The open channels, figs. 5 and 6, are those manufac tured by Messrs. Doulton of Lambeth, as sewage-carriers in irrigation farms. Any depth of trough can be got by the introduction of the insertion-blocks seen at fig. 6, and, if necessary, one side can be made higher than the other, which would prove a boon in yards and in lawn-borders. A pipe with a continuous slit, to allow the overflow of the sewage-tank contents upon the land, is exhibited at fig. 7. This would make an excellent pipe to convey the house-drainage, soil excepted, to a trap leading into the drain, and so disconnecting the house from the sewer. In this case it should be surrounded by concrete; and, when the pavement is laid down, the longitudinal aperture will afford means of clearing away any obstructions.

Fig. 8 presents a view of the common circular drain-pipe, and fig. 9 a view of the oval drain-pipe; both have socketed joints. In common with nearly all sanitary pipes, they are made either altogether of pipe-clay, or with an admixture of fire-clay. Sometimes they are salt-glazed, sometimes glass-glazed. Both kinds of pipe, and both systems of manufacture, are alike good, and it is not necessary to be particular as to which is used. These pipes are made from two inches to thirty-six inches in diameter.

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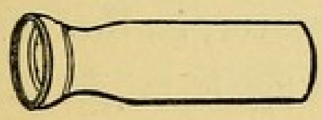

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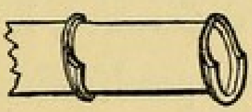

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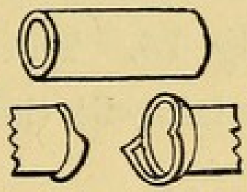

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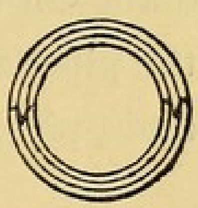

Fig. 10 illustrates a diminishing or enlarging pipe, the use of which is obvious; and fig. 11 what is called the half-socket pipe, which is often used where it is necessary to frequently examine the drains. Another method of achieving this is to drop what is called a butt-pipe between two pipes which are constructed with half-sockets at each end, as shown at fig. 12. A pipe made up of two half-pipes, with a **V** joint running along on each side, is made for a similar purpose, and this is drawn at fig. 13.

Amongst the first and best systems of affording access for the inspection of drains, is the socket and pipe saddle-cover drawn at fig. 14. A *cap* of somewhat

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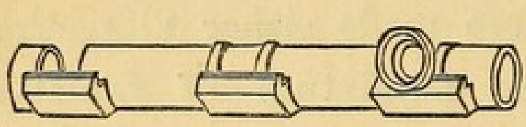

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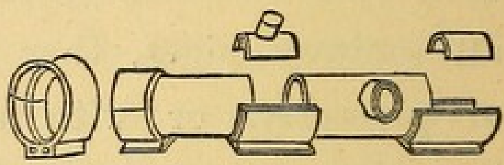
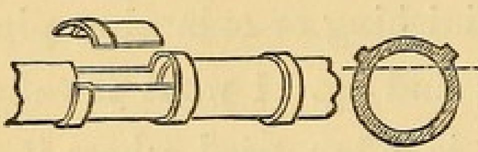


similar arrangement is given at fig. 15, and here the broad base upon the foot of their bottom chair gives greater solidity to the line of drain.

An opercular, or lidded pipe is drawn at fig. 16, and, by the adoption of this pattern, the whole interior of a drain can be opened up ; the same might be done with the pipe, fig. 15. The difference, however, is, that the drain-pipes laid with the pipes drawn at fig. 16 might still

16



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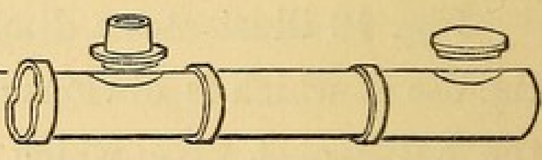
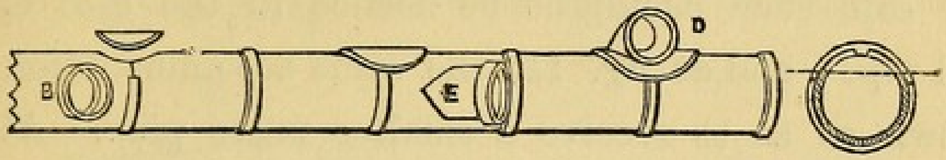


remain almost full and allow no escape of their contents, whilst the latter will overflow at the height of half their diameter. The other pattern, drawn at fig. 17, is extensively used in the North.

The last access-pipe which we need describe is the capped one of Poole, Dorsetshire; see fig. 18. The security of a flange is here given to the socket-piece.

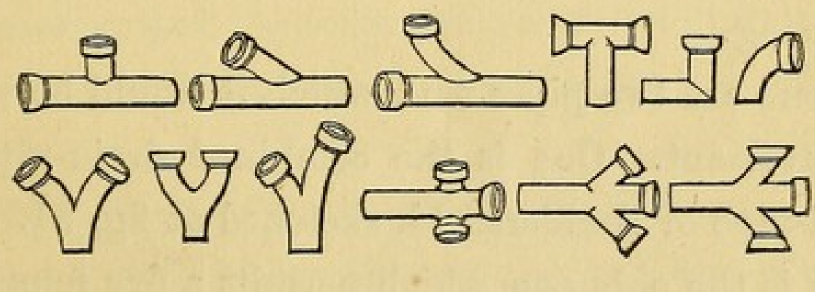
18



The foregoing represent the best of their respective classes, and might compare equally well with each other. Illustrations have been given of Surrey, Yorkshire, and Dorset specimens, merely for the benefit of readers residing near to these chief drain pipe-making localities, as the laying of Lambeth pipes near Poole, or Poole pipes near Leeds, would be a waste of money.

When making junctures to such pipes as those drawn at figs. 8 and 9, it is usual to insert a length of pipe having cast upon it the kind of juncture wanted. These are represented at fig. 19.

19



In the case of the pipes yielding means of inspection, the junctions are differently made. At fig. 14, a large tributary pipe is joined to the saddle and delivers above the running sewage. At fig. 15, and at B, fig. 18, a small inlet is shown in the body of the pipe. At fig. 17, a delivery is sketched directly through the cap, such as might be needed in the case of a soil pipe; and at fig. 15, the same accommodation is shown so as to receive a smaller waste pipe. At D, fig. 18, a right or left hand delivery is seen to take place altogether above the pipe; and at E, fig. 18, an acute-angled junction receives a smaller pipe in the direction of the flow of sewage. Any one of these varied systems will equally well serve their purpose.

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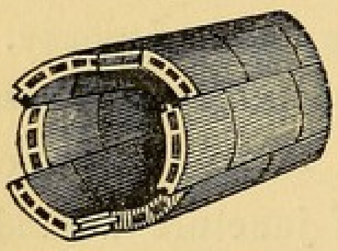

There is an article now in the market called a segmental stoneware sewer, and it is made up of blocks, after the manner shown at fig. 20. A sewer of this kind can be easily put together, and unlike most drains composed of brickwork, it is practically imperishable; great care will, however, be required in jointing.

There are two pipes with which it would be well to be conversant. One is the combined drain-pipe and subsoil-pipe of Huddersfield, sketched at fig. 21. This system is the only one which permits a dry foundation for drainage-pipes in swampy ground. The subsoil water enters at the loose joint of the retort-shaped pipes underneath, and can be collected at intervals and used in flushing the drain-pipes above. The other pipe, which is drawn at fig. 22, is the only method extant for carrying sewage through water or across a river, and shutting out such sewage from the purer

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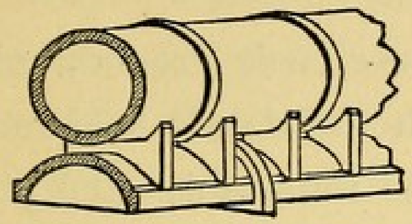

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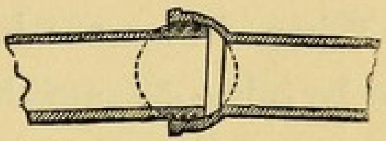

element. The dark filling in between the ends of the pipe represents a packing of lead poured in whilst molten, and the cup-like shape and the absence of bolts make the joint quite flexible.

Memoranda on Drainage.

Drain-pipes, whatever pattern be chosen, should be bedded in proper clay, and have the joints well luted; for if the joints be badly made, the liquid drainage will escape, and the sediment which is left behind may collect to such an extent as to choke the drain altogether.

If any drain-pipes be laid inside the house—and in crescents and streets this is unavoidable—the pipes should in that case be laid upon a bed of concrete, and covered over with a few inches of the same material.

Where the drain-pipes pass through the walls, it is wise to turn a relieving arch over them; for, if a settlement should take place in the building, the superimposed weight will in all likelihood crack the pipes, and cause the drain to leak at a most dangerous place, or perhaps break them, and cause the greatest annoyance.

When drains are laid in new-made ground, unless care be taken to ram the earth sufficiently hard round about them—and this is next to impossible—the pipes will open at the sockets, and sodden the ground in their neighbourhood to a dangerous extent. It is best in such a case to rest the pipes upon boards laid upon occasional piles, or what is better, upon piers of brickwork.

It will sometimes happen that drain-pipes are laid in ground which may afterwards be penetrated by the roots of trees, shrubs, and strongly-rooted weeds. A cure for such an invasion of the pipe joints, which will infallibly lead to choking the drains, has lately been pointed out by Mr. Mechi, and that is the coating them over with coal tar, since roots will persistently turn away from this material.

The only kind of drain-pipes to use is the glass-glazed or salt-glazed earthenware pipes. All others present a roughness inside which gathers 'fur,' and engenders a vegetation sufficient in time to impede the passage of the sewage and other wastes.

A matter of paramount importance is the declination which is given to the pipes. If this be inadequate, stagnation will ensue, and a costly and troublesome flushing be repeatedly necessary. Inside a drain in use, everything should be in gentle motion. If laid too flatly, the heavier effete matters are deposited and clog the way; and if the incline be extravagant, the water will hasten away and leave the solid wastes behind. In a late work, a writer states that too great a fall cannot be given to a drain; but when the fall of the tributary drain has been in excess, that part of the main drain which received the contents of such house drain will be found almost choked up. Some authorities formerly recommended a quarter of an inch fall to each foot, but the best practice is to allow a fall of $2\frac{3}{4}$ inches or three inches to every ten feet.

Drain-pipes can be too large. Some people use nine-inch pipes throughout a house, and think it commendable; whilst the reverse of this rather would be true. A four-inch drain-pipe for sinks, backyards, and basements, is ample. Even the closet-drains in a house need not be more than six inches in diameter. Six-inch pipes well laid will suffice for the largest house, and in the hugest mansion nine inches will not be required until it is sought to carry the sum total of the smaller sized drains away in one channel to the sewer or manure-tank. Drain-pipes of too large diameter are incompatible with that steady onward movement of the sewage which every addition to the contents of the drain beneficially increases.

The junctions of the drain-pipes should never be of the right-angled kind; and an obtuse-angled or curved junction should be used; in other words, the sewage should be delivered in the line of the flow of sewage. A T or L shaped delivery is very apt to cause a deposit at that particular part of the drain.

It is considered wise to give the drain a little extra dip wherever a bend or a junction occurs in its length, in order to counteract the effects of friction. A very small amount of dip will usually suffice.

In laying down a system of drains to a house, &c., it will often prove beneficial and save much expense on some future occasion, if what is called a dummy junction be here and there laid in the march of the drain. The orifices of these junctions should, however, be stopped up with the disc-plugs sold for the purpose.

A large pipe should never deliver into a smaller pipe, or even into one of the same diameter. There should be a difference of three inches between the larger pipes, and of two inches between the smaller ones: for instance, twelve-inch pipes can deliver into fifteen-inch pipes, nine-inch into twelve-inch, six-inch into nine-inch, four-inch into six-inch, and two-inch into four-inch pipes.

Where a diminishing of the drain-pipe is found requisite, the proper tapering pipes should be used; any other contrivance is at the best unworkmanlike.

A certain number of access-pipes will be often found useful, if laid in a length of drain, say one to every ten of the socket-sealed pipes. Some pattern or another of these pipes with a movable cover might wisely be inserted close to all angles, bends, and junctions, and a well-hole built round them to facilitate inspection.

The pipes should be so laid in or about a house that the human ordure may enter nearest the sewer, or, what is the same thing, nearest the point of delivery of the house-drain or the disconnection arrangements. The wastes from the sinks should enter the house-drain between the closet delivery and the house; and the rain-water—if not stored—should enter nearest to the house. By this means a persistent movement of the sewage is better obtained.

A flap-trap should be affixed to the end of the house-drain at its connection with the sewer or manure-tank, so that if the sewer be surcharged at any time it cannot flow up the tributary pipes. This contrivance will also tend to prevent a return of foul gases.

The communication with the sewer should be made with additional care, and is most durable if cement be used instead of common mortar.

From the disconnecting trap on to the sewer, at least where the distance is great, an egg-shaped drain-pipe should be laid. This section secures the maximum speed of flow, and the minimum chance of any solid deposit.

When pipes of the proper kind are well and sufficiently laid with proper fall, the best means of occasionally flushing them should be provided for. Drains should be flushed at least once a quarter, and the outlet, an access-pipe opening, or the point of disconnection watched to see that the flow is unimpeded. Some people flush the drains by removing the sink-trap and allowing a cistern to be emptied through the water-tap into the drains; but this is for the most part useless, and the very term 'flushing' means the imparting of a rushing action to a body of water—at least that is the only effectual method of cleansing underground channels. To provide an efficient quantity of flushing material, the rain-water may be stored in an upper or underground cistern; and when the drain is opened, the water having been caused by flowing or pumping to fill a large tank above such opening, one side of the tank should be made removable so that at a given moment a thorough scour may be insured. Proper openings for this purpose should be left in the drain both below and above the point of disconnection; but these should never occur inside the house, as is but too common, for, as the water runs down, the foul gases levitate and invade the house. Sometimes a cheap disinfectant such as Cooper's Salts may with advantage be added to the flushing water. After this flushing, in all likelihood any syphon-traps in the line of drain will be emptied, and it is necessary to pour a small supplementary supply of water gently into the drain before leaving it.

Should the drain from some cause be stopped up, which will be readily ascertained, a series of swivel-jointed rods, such as are used by chimney-sweepers, but with a roller at one end, or a series of Malacca canes screwed together, should be pushed up the drain. It is here where the access-pipes perform excellent work, since if the rods or canes cannot reach the matted obstructions at one place, they can do so from another point.

A correct drainage plan, showing the different size of pipes used, the positions of bends and junctions, the site of syphon-traps and access-pipes, the depth from the surface, and the nature of the ground, should always be prepared when the drains are first laid down. This may save much future inconvenience and outlay.

No reliance should be placed in old brick-drains. If in the house, they should be removed or opened up, the site disinfected, and filled with concrete. The portions outside the house should be dug up, as they otherwise harbour rats and other vermin.

As a rule, no brick-drains need be laid down inside private grounds or residentiary estates, as this material is now chiefly confined to the main sewers of towns. Earthenware-pipes are manufactured up to thirty-six inches in diameter, and will be found cheaper and better.

Should it, however, for some reason be imperative to build brick, barrel, or egg-shaped drains or culverts, the old-fashioned square drain with flag-cover should never be used, but rather the circular or egg-shaped pattern. The bricks should, moreover, be moulded to the proper radii; and if invert blocks of earthenware or grouted bricks be not adopted, the bottom portion of the drain should be laid in cement. The inverts of different sized brick-drains should never be laid upon the same level, but the difference in height should act as a fall for the lesser drain. Ventilating arrangements will also be found indispensable, and perhaps deodorising media in addition.

Where drains of any kind are subjected to tidal influences, it will be prudent not to rely upon ball-valve traps to resist the evils of backwater and any compression of the gases, but to break the connection of the outlet-drain or sewer above the high-water line.

Ventilation and Disconnection of House-drains from the Sewer &c.

Supposing any of the drain-pipes mentioned in the former article to have been carefully laid, and with proper fall from the sewer up to the outside of a building, the next question to consider is, how best to convey into them the various effete matters of the household. The common practice is to run the pipes into the house, and join the waste-pipes directly into them ; but the consequence of this is, that the sewer-air, when compressed from any cause, forces the hydraulic seals of the traps, and disperses itself over the house. One safe plan, therefore, is to disconnect the drain-pipes inside the house from those outside the house by building over the channel of conveyance, somewhere close to the exterior side of the wall, a grid or grating, and so opening the drain at that point to the light of day. By such a procedure, the passage of the sewer-gases into an establishment is effectually prevented.

A simple system of disconnection is the constructing of a small and shallow square well at the side of the house, as drawn at fig. 23, and the fixing between it and the drain proper of a syphon which will prevent the exit of the sewer-air. If sewer-gas should bubble up and escape, it would soon be dissipated in the open air. At about a foot or two above this well-hole, the rain-water pipes, and the sink, bath, and lavatory wastes are made to deliver their contents ; and it is immaterial whether a grating be fixed to the top of the well or not. It is found in practice, however, that an open drain-ventilator of this description very close to a house sometimes proves a nuisance. Another method of achieving the same end, and avoiding this, is to terminate these pipes about the same height from the ground, and cause them to spout their contents over such a trap as that drawn at fig. 24. This trap is furnished with

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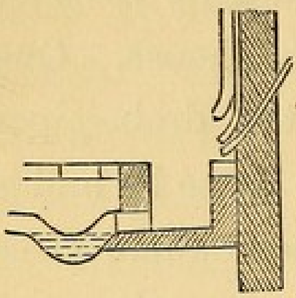

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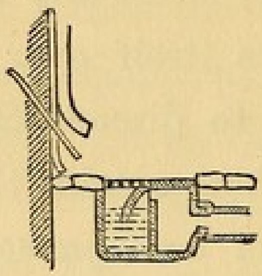

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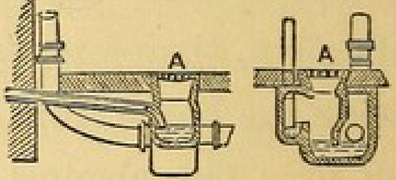

a water-seal; that is, a small body of water is interposed between the air of the sewer and the respirable atmosphere.

There is a ready-made article, which comes sufficiently near, for most practical purposes, to what is wanted; and this is sketched in section and elevation at fig. 25. For instance, a sink-pipe is made to terminate over a small trap on an upper shelf of the main body of the trap. The drain-pipe from the sewer leads into a lower and larger trap; and opposite this is a ventilating pipe, of about four inches diameter, which runs up the side of the wall to the top of the house, and takes away any excess of sewer-gas which may be in the drains between the trap and the sewer. Should, however, the sewers become overcharged by the tide or by heavy rainfalls, and any sewer-air force this lower water-trap, it will at once rise to the open grating at A, which is over the space between the drain-pipe and the sink-pipe or other waste-pipe, and be scattered abroad. This ventilating medium is to be trusted to, provided that the rain-water pipes are not made to act as the sole ventilators. The pipe which enters the trap is needed for ventilation alone; and, if the rain water be required to enter the same gulley, the whole trap, which is of earthenware, should be bodily lowered just so much as will allow the rain-water pipe to be bedded in the pavement as far as the grating over the central chamber of the trap. It is a fallacy to rely upon the rain-water stack-pipes to properly ventilate the drains; for when most wanted—viz., after a storm—they are performing their own specific duties.

There has been lately invented a trap which is worth a description, as it is about the only other article in the market which carries out this kind of drain-ventilation. A sketch of this arrangement is given at fig. 26. Here the rain-water pipes and smaller waste-pipes and overflows empty themselves so as to run through the grating at A. The fouler sink and scullery wastes are supposed to be brought into the drain by the pipe B. The sewer-air is prevented from entering the sink-pipes and so passing into the house by the water-trap; and even if this water-seal were forced, owing to a sudden change of temperature in the main drains, or any like cause, the foul air which escaped would rise through the large

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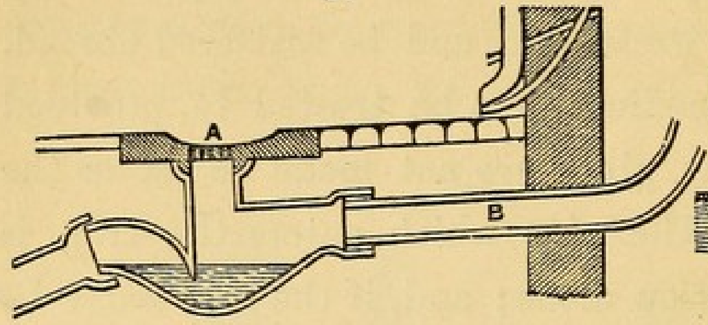

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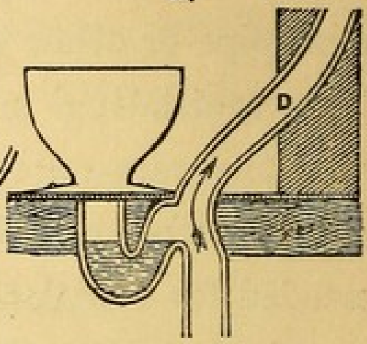

grating at A, and be harmlessly distributed. Fig. 27 exhibits this method of ventilating the soil-pipe of the water-closets. A sigmoidal bend is attached to the base of the closet as usual, and from this there rises up an air pipe of wide diameter D to a few feet above the eaves. This pipe ventilates the drain inside the point of disconnection.

Fig. 28 gives a representation of the ventilating traps devised by Professor Reynolds. He constructs a syphon trough in the line of pipe-drain, and over it

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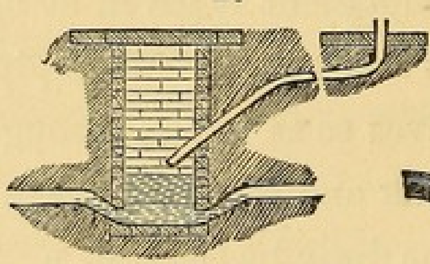

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forms a man-hole as shown. The wastes deliver over the open trough, and the influx of gas into the house is thus prevented. Fig. 29 represents a simpler arrangement upon the same principle; for instance, the rain-water or clean wastes would enter at the short junction near the top of pipe, and form an hydraulic trap. As in the other case, the upright shaft is open at the top or covered with a grating, thus ventilating the drain. Several other kinds of disconnecting traps have lately been brought out, but the above will serve to explain their general working.

Some sanitary engineers have specified the house-drains to be ventilated into the chimney shafts of the house; but I do not consider this a plan to be recommended, as our flues are at times subject to great down-draughts. Systems are also in practice for ventilating the house-drains by leading a junction from the drain-pipe to the back of the fire grates or kitchen ranges, at which places a fire-brick chamber is formed, where the air can be rarefied, and then taking a metal pipe from this chamber up to the house-top. But I have endeavoured to show that the house-drains should rarely, if ever, be allowed to run under the house; and schemes such as these rather recommend this very practice. Depend upon it, the house-drains can be properly ventilated without any such complicated arrangement.

Memoranda on Disconnection and Ventilation of Drains.

The house-drain should be disconnected from the main drain or sewer in some efficient manner, as already pointed out.

The point of disconnection should be made as near to the house as is convenient, as foul gas will generate wherever sewage is diluted with water.

There should be only one disconnection between the sewer and the house. All house-drains should lead into one main collecting pipe on the house side of the delivery into the sewer or sewage-tank.

All waste-pipes or overflows from closet-trays, bath-trays and wastes, cisterns, or lavatories, and all rain-water pipes, should be made to deliver above ground.

Where a proper disconnection cannot be carried out, as is the case in many town houses, an efficient ventilation of the drains should be provided; and the safe rule is to fix an upright tube with easy bends—if bends be unavoidable—at the head of every drain and at the end of every ramification of the drain. The ventilating-pipe should be at all events equal to half the sectional area of the drain. *An inch-pipe is quite inadequate to the work to be performed.* If a sink or wash-basin must perforce communicate with the drain, a ventilating-pipe should be carried from the underside of the trap out to the open air and to the top of the roof.

Rain-water down-pipes are sometimes solely relied upon as ventilators; but this is wrong, for such pipes often terminate under the sill level of dormer windows, and, when most needed, are performing their own duties in clearing the water from the leads and gutters. Besides, they should never be connected with the drain.

The soil-pipes of closets should in all cases be well ventilated below the trap, and the pipe carried to the highest part of the exterior. It might in some instances be well to ventilate the trap of the closet itself.

Where there is any danger that the ventilators of a house on a lower level may taint the atmosphere of a house or building at a higher level, the evil can be averted by fitting to the top of the ventilator a finial containing trays of charcoal or other disinfectants. (See figs. 30 to 32*c*.)

If the ventilating-pipes do not terminate in a properly shaped column containing deodorants or disinfectants, the top should be protected from down-draughts and rain by some sort of hood.

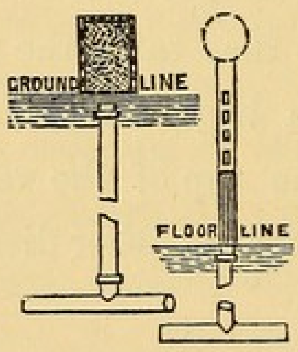
Deodorization of House-drains.

Sufficient has been said concerning disconnection; but, as cases will continually occur in which the escape of any smell whatever would prove noxious, it will be necessary here to point out how the house-drains can be deodorised as well as ventilated.

An excellent plan would be to fix somewhere above the line of drain-pipe between the sewer and the place of disconnection, a square perforated box containing charcoal, which would purify the mephitic gases as they were formed, and prevent them reaching the house, or even the backyards of the house. A protruding ventilator of this description is sketched at fig. 30.

In the case of shelving terraces, or of houses built

30 31 32



at different levels, it would not be difficult to understand how the ventilating continuations of the soil-pipes of the lower placed houses might taint and perhaps dangerously infect the atmosphere of the houses above. To avoid this, the top of the ventilating pipe could be fitted with a ventilating shaft, such as is shown at fig. 31, which is a hollow column provided with gratings, upon which are placed canisters of charcoal or other disinfectants. The above two methods of deodorising the drains have been lately patented by Dr. Taylor.

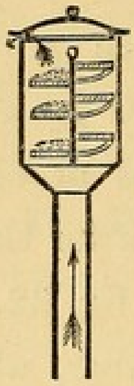
It must be understood that, as Dr. Stenhouse did not in 1854 protect by letters patent the use of charcoal for this purpose, patents which provide for the slow combustion of the sewer-gases by charcoal, can simply monopolise peculiar methods of exposing that material. Another registered design for the end of the soil or ventilating pipe is given at fig. 32. The space around the central perforated chamber, which is equal in diameter to the ventilating pipe, is packed with charcoal, and, in consequence, the ascending air of the drains is purified before it can emerge into the exterior atmosphere.

A more complete ventilation for the end of a soil pipe, or for the disconnecting upshaft of a house-drain is given at fig. 32*a*. The cover is represented at the top and there is also a spiral tray (similar to that shown at fig. 34) containing charcoal.

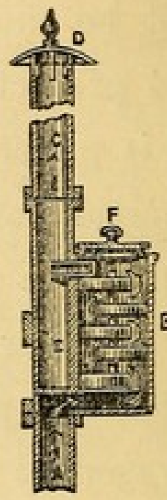
But the most elaborate and perhaps the most perfect contrivance for the disinfection of sinks or closets is drawn at fig. 32*b*. The pipe A will here represent the soil pipe ; B, the cylinder containing trays with wire-meshed bottoms, upon which the charcoal is laid.

The outlet of the air from the drain into the ventilating pipe C is at the top of the cylinder, just underneath the cap F, fitted with indiarubber joint. The ventilating

32 *a*



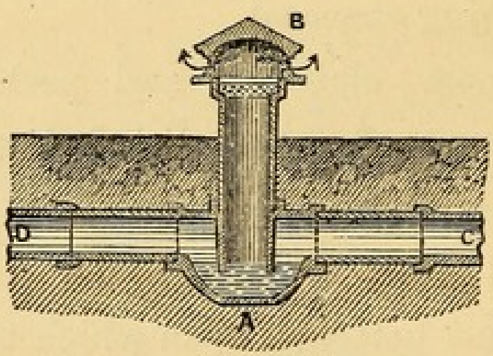
32 *b*



pipe at roof top, or wherever it may terminate, is furnished with a cover D, and in case any condensation might take place in the ventilating pipe C, a receptacle for such water is provided at E, where it may be withdrawn at intervals.

It sometimes happens that it becomes desirable to ventilate the drain on its way to the sewer or cesspool,

32 *c*



and in such cases it is well to insert a syphon with an outlet as at A between the house side C, and the sewer or cesspool side D of the drain, fitting it up with an upright pipe to a few inches, or it may be feet above ground, and terminating it with an earthenware cap with charcoal tray under as at B; see fig. 32*c*.

Again, as for instance in the grounds appertaining to a large public building, where from the very length of the drains there must be a generation of some foul gas, a ventilating pipe and deodorising arrangement become in most cases necessary; such a contrivance is sketched at fig. 33, which is a view of a drain-pipe ventilator largely adopted—especially in the north of

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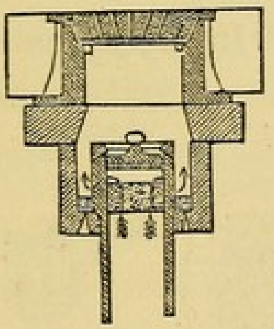

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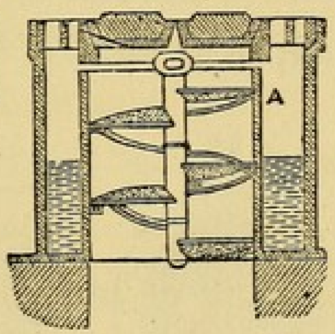

England. A much larger ventilator, suitable for erection over a square shaft, and very well adapted to the larger drain-pipes, is given at fig. 34, and here the charcoal is laid upon a portable spiral tray. The rain or road-water enters in at the annular gratings outside, and when the grit box is full, i.e. as high as A, it runs away down the small square trough underneath the shelves of tray, and so into the sewer. All the gases rising from the sewer are compelled to pass these charcoal barriers. It is impossible also for water to get at the charcoal and so expel the oxygen there. This spiral ventilator was invented by Mr. Latham, and is also manufactured so as to allow of fixing upon the summit of any ventilating pipes. (See also fig. 32*a*.)

Sewers.

Very little need be said concerning sewers, as they are under the especial charge of duly constituted authorities, but it might be useful to say that sewers are formed either circular in shape, as drawn at fig. 36, or egg-shaped, as at fig. 37. In both cases it is usual

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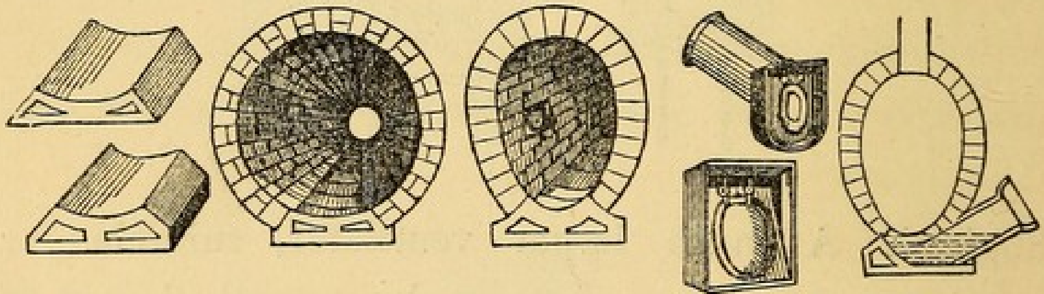

to lay in the bottom with what are called inverts. These are sketched at fig. 35, and are shown in their places at figs. 36 and 37. Where the drain-pipes of a house enter the main sewer, flap-traps similar to fig. 38 are fixed in the sewer-walls. A square one, for instance, is shown in the sewer at fig. 37. These flaps swing open to allow the house-drains to empty themselves, and close again to shut out from the drain-pipes the foul air of the sewers, or at least will do so if kept in proper order by the sewer men. A walk along some sewers will prove how ineffective flaps sometimes prove, and I believe that Dr. Hardwicke has so reported.

A patent mode of ventilating the sewers, and one largely adopted in Birmingham, is drawn at fig. 39. A peculiarity of the system is, that the earthenware drain-pipes lead into the sewer at the bottom, and not half way up, as is usual. Moreover instead of a flap-trap, there is a water-trap. The ventilating pipe is a very good feature in the arrangement, whatever might be said about the liability to choking up at the entrances to the tributary drains.

Sewers may be ventilated in many ways. For instance, they may be connected by pipes with the furnaces of boilers &c., in order that the latter may draw upon the sewers for the air necessary for combustion, and so decompose the sewer gases present there. Some of these schemes would require the most influential syndicates in order to test, and the hugest Limited Liability Companies in order to bring them into practice. Vertical pipes have also been led up the houses, or separate shafts constructed, and the services of archimedean screw-pumps brought into requisition. The simplest and best methods, however, are those just described.

It might be useful to explain that when two sewers join together in the direction of the flow of the sewage, as they should always do, what is called a *bell-mouth* is formed with a ventilating shaft up to the roadway. One description of these junctions is drawn at fig. 40. There are also side entrances into the sewers; and one of these flights of steps, which are arched over, is exhibited at fig. 41. Two sections also of a common roadside gully are given at fig. 42. These

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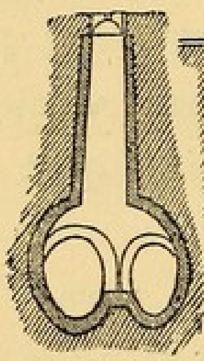

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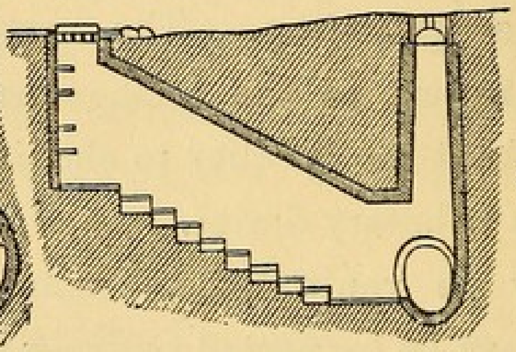

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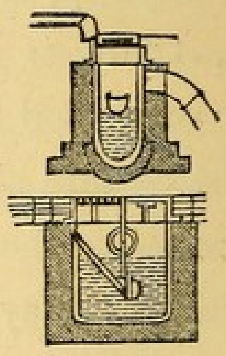

are fixed in the road beside the kerb of pavement, and, as will be noticed, are so constructed that they will intercept the road-grit, and so prevent the filling up with gravel, &c. of the space left for the water.

The sewers are deodorised and disinfected in many ways. A view of the apparatus which is inserted in the crown of some sewers, in the middle of the street, is sketched in plan and sections at fig. 43. The charcoal-trays can be observed in plan at D, and in section in the sketches above and below. Fig. 44 represents the common method of ventilating and disinfecting the larger pipe-drains of the streets; and here the charcoal screen D is placed in an upright position. The sewers are similarly treated, but the movable filtering screens are laid across the shaft, as drawn at

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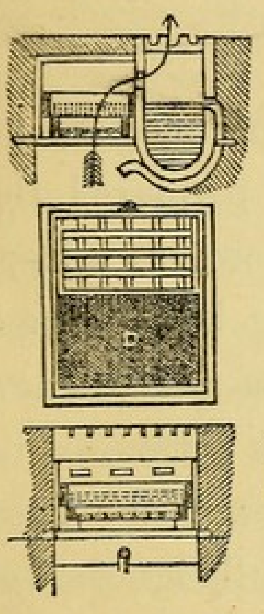

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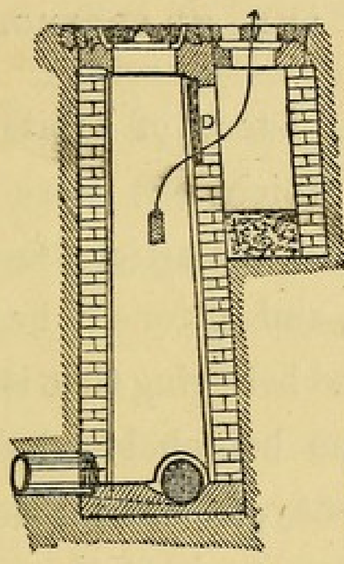

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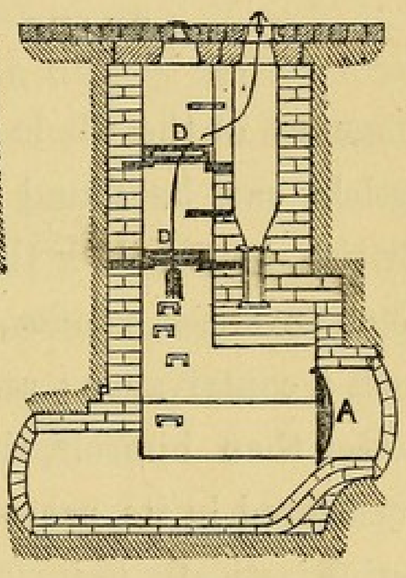

fig. 45. When there is a break in the sewer, a flap is fixed at A; and this prevents, or is intended to prevent the foul air from reaching the higher districts of a town. The sketches figs. 40 and 41 were first prepared by Mr. Rawlinson, and are copied from an official pamphlet of his.

CHAPTER III.

TRAPS AND TRAPPING.

Perhaps in the whole history of sanitary matters no article can be found which has more perplexed the British householder than the article known as a trap. Each inventor, vendor, and fitter-up has lauded some such a contrivance; and believing that the artisan knew better than himself, the householder has patronised it, persevered in its use—nay, in some cases, even argued enthusiastically in its favour, although really ignorant of its exact working. Now it may be taken for granted that more disease is traceable to injudicious draining than to aught else in the way of sanitary neglects. And first of all 'in pride of place' amongst the many defaults of drainage, sits what we will term *imprudent trapping.* How can it be otherwise, when, as is mostly the case, the cesspool is unventilated, the sewer insufficiently so, the house portion of the drain boxed up, and there is no escape for the compressed gases unless they bubble up through the water contained in the trap? The consequence of this is, that, independently of the suction which the house fires will exert under ordinary circumstances upon the drains, the germs of disease will find their way, with the offensive and other gases, into the very bed-rooms. Honestly speaking, traps are dangerous articles to deal with: they should be treated merely as auxiliaries to a good drainage system. If the house be disconnected from the sewer in any of the ways pointed out in my last article, a trap to all else than the closet might safely be dispensed with. Nevertheless, it will be found very convenient to use traps in the sink, the lavatory basin, the bath overflow, and the kitchen waste, if only to prevent the rush of cold air. Some little effluvium may also escape from the portion of the drain on the house side of the disconnection, and other contingencies might arise, where a barrier of water, however slight, would be advisable. I will now indicate the various species of traps which are used in and around buildings, and point out their merits.

What is called a syphon for insertion in a line of drain-pipes is drawn at fig. 46; and this is relied upon to prevent the return of foul gases from a sewer or a cesspool. If properly laid and frequently flushed out, it will be found serviceable; but, if badly laid, or if it become clogged, it proves very troublesome, and even mischievous. It would be preferable to adopt in all cases the inlet syphon, shown at the lower portion of fig. 47. If the syphon were used just as drawn, with a brick wall surrounding it, the well-hole ventilated, and with an upright pipe rising from its inlet to the ground line, it would form the very best house-drain disconnector. No gas from the pipe C, which leads to the sewer could enter the house by way of the house-drain B, because it would be withdrawn by the ventilating pipe A, which stands over the water-trap inside the syphon.

A sink-trap of pottery ware, on the close syphon principle, is represented at fig. 48, and is found ex-

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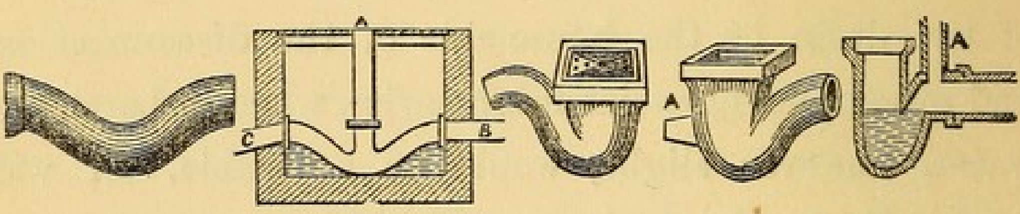

tremely useful, provided the drains are disconnected from the sewer. In certain cases—as, for example, in a laundry—it should have an aperture at the back, in order to connect with a ventilating pipe leading to the exterior of the house (see fig. 49). The drain would, however, be more effectually ventilated if the effluvium-pipe were fixed perpendicularly over the drain, as at fig. 50. In the former case the gas is waited for until it has risen through the trapping water, and in the latter it is withdrawn beforehand.

Besides the common, the outlet, and the closed syphons just described, there are S-shaped ones, a few of which it will be necessary to illustrate. The common earthenware closet-syphons are drawn at fig. 51 and 53; the former being less compact in shape than the latter. An iron trap of the same construction is given at fig. 54; but, unless properly enamelled, this is not such a cleanly article as the glazed earthenware syphon. The above class of traps will work very satisfactorily, provided that the soil-pipe is efficiently ventilated. A refine-

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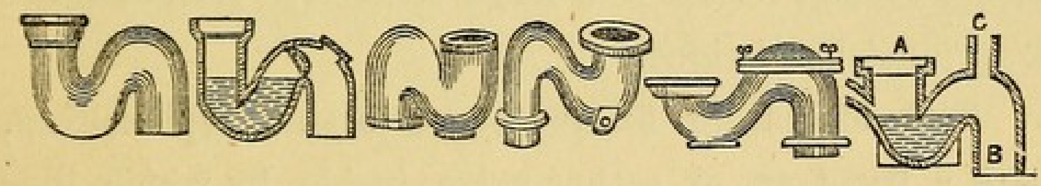

ment in the shape of an access, with cover situated at the highest point of the sigmoid, is exhibited at fig. 55. This pattern is intended for more effectually removing obstructions and for the better cleansing of the trap. It is a desideratum, but it is one very difficult to obtain upon an earthenware syphon. On an iron one, as may be noticed at fig. 55, a good screw with proper packing would replace a light cover, which could not be screwed firmly down, and which would have to rely upon cement or other luting.

Fig. 56 represents a trap which is used in the closet-pan, and it embodies all the requirements of modern times. The pan of the closet, which is fitted into the socket A, is ventilated by a pipe which joins the ventilating-pipe C, and goes up to the roof. A two-inch supply pipe from the cistern divides behind the closet-pan, ond one moiety enters the pan above the opening A, whilst the other enters the syphon-trap under the opening A, through the inclined channel. These two streams of water act simultaneously when the water-valve is raised, and scour out both the pan and the trap beneath down the pipe B, into the drain. Apart from the value of this improved syphon as a closet-fitting, its use as a large ventilated sink or other trap must be obvious.

The design, fig. 52, represents a sink syphon-trap, with a flap-trap, or rather valve, inside, by which it is intended to prevent the sewer air from entering a building. If a partial vacuum arose in the sewer, the valve would open sewerwards and establish an equilibrium, but the sewer air could not pass into the house unless at the moment when the waste-water of the sink was rushing through the opened valve to the drain below. A proper ventilation of the sewer would render such a complicated arrangement quite useless.

Proceeding now to the kitchen or scullery sink-traps, I illustrate at fig. 57 the common house bell-trap, or rather the common domestic air-poisoner. If the majority of houses were inspected at a given hour in the day, the cover with the inverted cup—which, when down, forms the slight and only trapping—would be found to be taken up by the servants in order that the water should drain more quickly away, and carry with it the multitudinous scraps of meat and other food refuse; or, the cover would be removed because the trap-chamber was filled up with the accumulated grease, and would not work when it was down in its proper place. The result of this uncovering would be that

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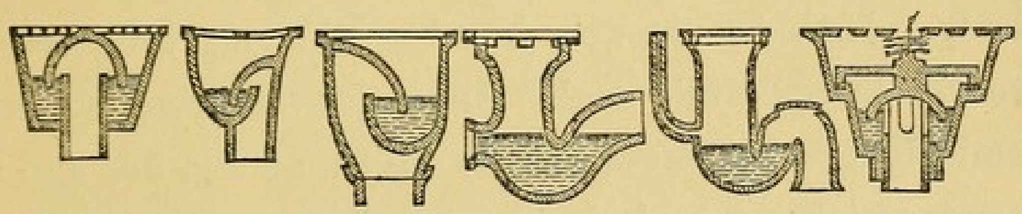

the drain-gases would rise unobstructedly up through the pipe and disperse over the house. If the house-drain were in direct connection with the sewer, and the latter poorly ventilated, a lighted candle held over the uncovered pipe would be speedily blown out.

A metal bell-trap of a new pattern has just been brought out, which is intended to prevent the removal of the top or trap-forming portion. The bell is fixed to the trap-body by a spindle, which is made long enough to enable it to be raised for flushing the waste-pipe or cleaning out the trap, but is so fastened that it does not hold out a temptation to the servant to remove it.

Should the waste-pipe ever require forcing, however, the spindle can be withdrawn by a workman provided with proper tools. This form of trap is drawn at fig. 63.

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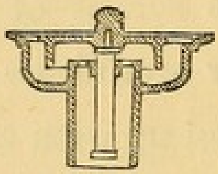

One remedy for this state of things would be the substitution of a trap like fig. 58, in which the diaphragm composing the trap is attached to the side of the trap-body. If this cover were lifted up the trap would still retain its hydraulic seal. An improved form of trap embodying this precaution is given at fig. 59, and a cover which can be *locked* is placed above it. Another locking grate syphon-trap is exhibited at fig. 60.

This is more suitable for the sinks of some large establishment, and renders admirable service there. A ventilated syphon sink-trap, with a removable cover, to afford inspection and admit of removing obstructions, is drawn at fig. 61.

What I consider a uselessly complicated sink-trap is exhibited at fig. 62. Here there is a bell-trap at the bottom, and above that again a flange fits flatly on an indiarubber packing, the whole being pressed down from the top, when not in use, by a chain with a pin made to pass through its last link. But, if servants cannot be entrusted with a common bell-trap, of what service would be such a trap as this? The only traps suitable for kitchens and similar places are automatic ones, similar to those drawn at figs. 58 to 61.

Another class of bell-trap is drawn at fig. 64, and this is a sort which is screwed into the bottom of a bath in order to remove the waste-water. It will not be needful to describe this pattern, as the section sufficiently explains its action. Provided the cover were firmly screwed on, and the drains disconnected and ventilated, there would be little objection to its use; still, a proper syphon in the waste-pipe itself would be preferable. The object drawn at fig. 65 is an article-intercepting trap, and is indispensable in a butler's sink. The overflow-pipe of the sink or basin is

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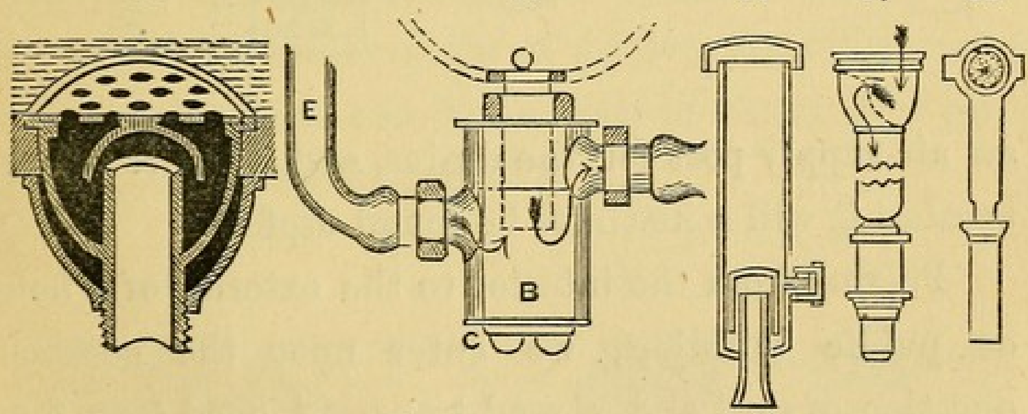

depicted at E, and the waste-pipe to drain is shown opposite to it. Should a silver-spoon, for instance, pass down the plug-hole in the basin bottom, it would fall into the water-trap chamber (B), and be recoverable by turning the thumb-screw underneath.

Two traps for the overflow-pipes of a drinking-cistern are drawn at figs. 66 and 67. The former acts partly as a filter, and the latter is merely an adaptation of the trap drawn at fig. 59. They might prevent the influx of cold air into the cistern. No cistern overflow, even with traps affixed, should be soldered into a soil-pipe or waste-pipe of any description, but should be led downwards by a separate pipe, and be made to deliver on the ground, or over the disconnecting trap-chamber of the drain, as previously drawn and explained. Fig. 63 exhibits

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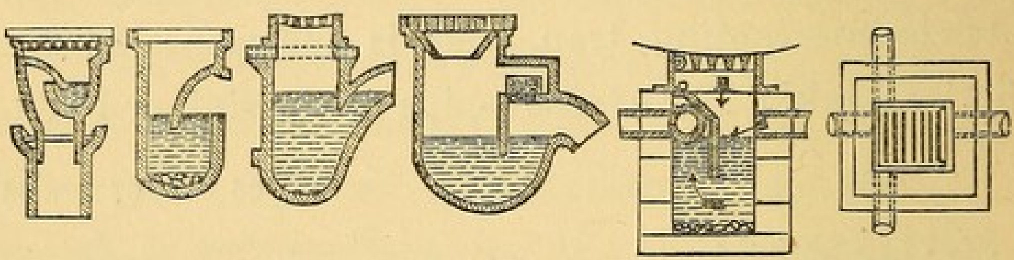

an air-supply post for the drains, and I figure it here, because it will sometimes be found useful.

Passing from the interior to the exterior of a house or public building, we enter upon the necessary question of yard and of road-traps. A good trap for a back-yard is the large-sized trap drawn at fig. 69. A still larger one, suitable for a court-yard, and one which affords a resting-place for silt or gravel until these are removed, is shown at fig. 70. These two traps would merely have thin cast-iron or earthenware gratings, and would not be useful where there was much traffic. The road gulley-trap (fig. 71), however, is made suitable for building in a paved or flagged roadway, and is sold with a strong dished-out iron grating, of the depth of the road foundation. These three traps would ventilate the drain or sewer into the yard or road, if the water in them evaporated, as is sometimes the case in the summer-time, or when the drain or sewer is otherwise unventilated. It might be, also, that the surface-water drains into one common tank, for flushing or gardening purposes, and if so, a bad smell would struggle up to the ground surface and disperse over the gratings. A cure in such a contingency would be afforded by placing a box of charcoal over the grated aperture in the shelf inside the dip-trap, as illustrated in fig. 72. An excellent kind of trap for the paths of gardens or other recreation grounds, and one that admits of cleaning, is given in plan and section at fig. 73.

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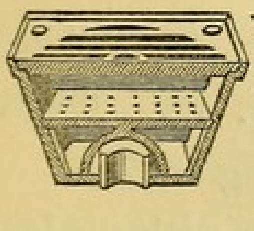

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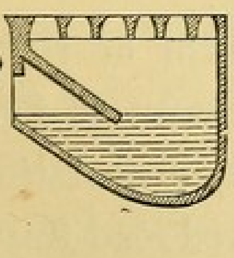

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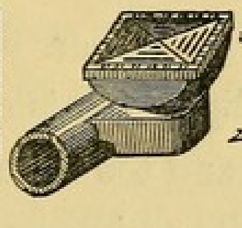

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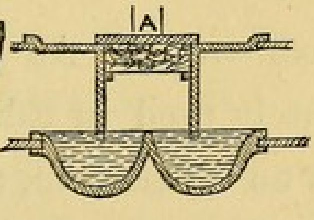

A third form of the everlasting bell-trap, made with an overhead movable grating, and one which is used in stables, is exhibited at fig. 74. A ten-inch cast-iron trap, like that drawn at fig. 59, with a wrought-iron perforated cover, would, however, be much better than either this or the special trap, No. 75. Where the drainage of a stable runs in closed surface channels inside the stalls and loose boxes, specially constructed horse-pots are rendered necessary, or some such a contrivance as is shown at fig. 76. A stable-trap, with a disinfecting tray over a double syphon chamber, is drawn at fig. 77, and is highly efficient. If kept well flushed with water, the ammoniacal and other gases from the drains can never escape to taint the atmosphere of the stable or cowhouse, but will be led off by the ventilating pipe A.

There remains just a word to be said concerning

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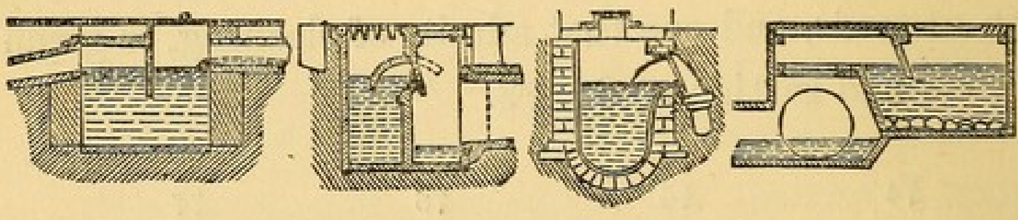

road-traps. An improper form of such an article, lately used in Edinburgh, is drawn at fig. 78. There is no ventilation, and too much evaporating surface.

Fig. 79 exhibits an improved road-trap, with a valve or flap inside, and with half its area (on plan) fitted up with a hinged access-plate. A road gully-trap, on the reciprocal ventilating system mentioned in the letter-press to fig. 52, is given at fig. 80. The last trap I require to figure is the ball valve-trap, seen at fig. 81. The ball rises up and fits into the overhead circular opening every time the tide rises and fills the lower drain. In common practice, an use for such a contrivance would rarely if ever arise.

The above may be said to represent, eclectically, all the more useful traps. I have examined and engraved elsewhere[1] some scores of others, but have chosen the foregoing as representative ones, and as likely to fulfil all ordinary requirements.

Memoranda on Trapping.

The old bell-traps which permit the covers to be removed should never be used, for reasons previously stated. A trap which is difficult to untrap should always be adopted.

The readiest manner in which to cleanse out a closed trap is to pour boiling water through it twice a week; this will melt all grease, and otherwise clear it.

A house which is thoroughly disconnected from the sewer, and the soil-pipes of which are well ventilated,

[1] 'Healthy Houses.' 2nd Edition, 1*s.* London: Simpkin, Marshall & Co.

might perhaps, as far as smell is concerned, safely dispense with traps altogether; still it will be found wise to affix one to the sinks, troughs, wash-basins, bath-overflows, and cistern-wastes, if only to assist in keeping out the winter cold.

In ordinary cases the pressure of air in the drains is even insignificant, but sometimes the extra pressure proceeding from fermentation is sufficient to force the hydraulic seals of some traps. Traps may, therefore, be used which are too small, for other reasons than the liability to evaporation. A trap should interpose a good body of water between the air of the drains and that of the house. Of course, when foul gases are seen to bubble up through the trapping liquid, the necessity for a ventilation of the drains is very patent.

Where traps are in any way depended upon, care should be taken to keep them in cleanly condition. The least foul water left in the bottom of the trap will soon infect the whole.

Where houses, otherwise closed and confined, are not, and cannot be, properly disconnected from the sewers, the latter derive air from various inlets, and this is drawn upon through the traps by the house-fires for the air necessary for combustion. In such a case, a supply of fresh air for the fireplaces should be brought from the outside at any cost. In some houses where even the house-drains are well-ventilated, and where disconnection from the sewer has been attained, the fires have been known to suck up air from the empty spaces round about the foundations when the doors and windows were closed.

Where syphon-traps are attached to sinks or other wastes, they cannot be relied upon if the pipe runs quite full; for sometimes, and always when the incline is great, the syphon-action will empty the depression of the pipe, and leave the room open to the air from the drains. The cure is to make the trapping portion of the pipe larger than the pipe itself. A waste-pipe, however, should never run full.[1]

[1] There are several other precautions to be observed with regard to trapping; for instance, each section of the house drains should be ventilated, if only to provide against the emptying of the traps by the action of a great body of running water in the drains—the water compresses the air before it, and leaves a partial vacuum behind, which sucks away the trapping-water. When syphon-traps, too, are connected with a soil or waste-pipe, and when such traps are unprovided with separate ventilating pipes, a large body of water passing down the waste-pipes will empty the traps. It is also unwise to construct a syphon-trap at the foot of the soil-pipe leading from a water-closet apparatus with a sigmoidal bend, unless the last-mentioned trap be ventilated. To lay a series of syphon-traps in an unventilated march of drain-pipes is also an error. A philosophical explanation of some of the ordinary errors in trapping will be found in Mr. Latham's 'Sanitary Engineering.'

CHAPTER IV.

WATER, EARTH, ASH CLOSETS, AND URINALS.

It is not to be denied that, in the case of London, where the water-closet system reigns supreme, the rate of mortality is wonderfully low. It is very doubtful whether an equally satisfactory result would follow were any of the dry-closet systems to replace it, although many have brought themselves to believe so. Earth-closets, ash-closets, and carbon-closets, have each been recommended as preferable to water-closets; but it is the growing opinion of all who carefully study the subject, that water-closets are the most to be desired, especially in large towns and cities. In all likelihood the earth-closet will ultimately find its proper place in isolated cottages, lodges, and the like; the ash-closet will be finally selected to meet the requirements of villages and districts where a sewer-rate must remain unknown; and the carbon-closet, under like circumstances, will be adopted in country workshops, and other exceptional places.

Sewage is beneficial to the earth, but the sewage should be brought to the earth, not the earth, after a costly fashion, to the sewage. Ashes, also, when mixed with drainage, command a certain price; but they would be equally valuable if the admixture took place leisurely at the sewer outfall. Charcoal also constitutes an excellent deodorant, but its value is greater as a filtering medium for the combined sewage of a town provided with sewers, as has been instanced at Newcastle-under-Lyne, where the manure so treated has been known to sell at a good price.

Water-Closets.

Nothing can be more satisfactory than a good water-closet apparatus, properly connected with a well-ventilated sewer. It is cleanly to a degree, and at once allows the removal of all objectionable matter to a place where it can be utilised in a wholesale manner. The dry systems cannot be held up as *disinfecting* the soil, but as merely deodorising it. They may be otherwise theoretically perfect, but in practice they are cumbersome, and mean almost hand-to-hand collection. On an outlying estate where water is plentiful, a well-constructed cesspool is preferable; and it is only when there is a paucity of water, and when a cesspool cannot be carried to a proper distance from the dwelling, or efficiently ventilated without creating a nuisance, that the dry systems become fairly valuable. As for the worth of the removed earth or ashes as a manure, they cannot possibly be more precious than the pumped-up liquids and solids of a cesspool, where all unnecessary water is kept from entering. All four systems have their own peculiar advantages in certain stated conditions of things: no one will gainsay that. In the following report I endeavour to point out where each is to be safely recommended. I have also figured the most improved contrivances for carrying out each method.

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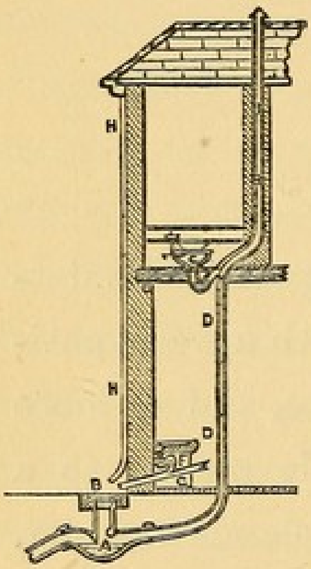

A perfect arrangement of a water-closet is drawn at fig. 82. The closet, C, is trapped below the seat, and the soil-pipe, D D, is disconnected from the sewer by the ventilated trap at A, situated exterior to the house. It often happens, however, that this form of an opened-up delivery into the drain is objectionable, as the trap, A, may be situated in a small courtyard, where an exposure of the fæces, even for a moment, might be dangerous; and in this case the soil can be led direct into the drain in the usual manner, and only the rain-water pipe, H, the sink-waste, F, the bath-waste, G, and the cistern-overflows made to deliver over a disconnecting trap. But, in order to compensate for this departure from strict rule, it is necessary for the soil-pipe to run up to the roof outside the closet-trap, as drawn at B B. By this means the drain is thoroughly ventilated. A soil-pipe, indeed, should always be ventilated, even when a disconnecting open trap is used outside; for a certain amount of lodgment will always be found in the soil-pipe, and in hospitals in which infectious disorders are treated this might prove dangerous. The trap arrangement, A, here drawn, can be easily copied if this specially-contrived article cannot be obtained, as there is nothing 'patent' about the disconnection of a drain, or the ventilation of a soil-pipe.

It should be borne in mind that the ventilation of the soil-pipe is necessary for other reasons than ridding the house of smell. If unventilated, the confined sewer gas will attack the lead itself, and after the lapse of some few years, corrode it into holes. The parts first to leak will be those joints where solder is used, and hence *cast-lead* soil-pipes are better than *milled-lead* ones, provided that the former have been carefully proved.

Where there is a water-carriage to the sewer, and a number of closets are required to be nested together, a water-closet range is frequently erected, as drawn at fig. 83. The sketch given shows a range of five closets, before the partitions are put up, and doors fitted for privacy. The action of discharge is made by lifting up the lever at the lower and deeper end of the trough, A, whereupon the valve is opened, and the contents flow into the drain, or sewer. The water-

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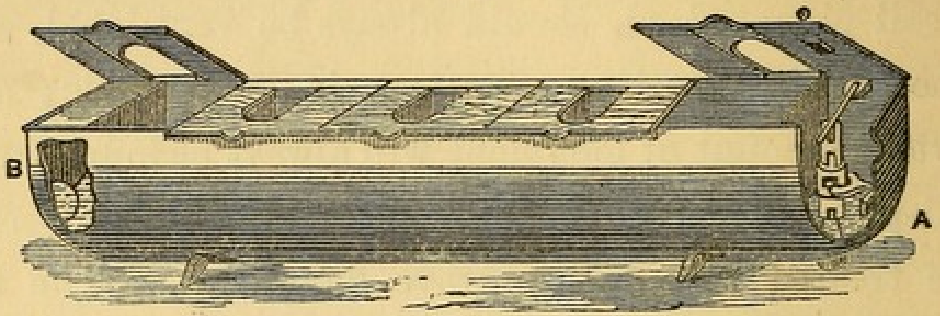

supply is at the end B; and when the lever at A is allowed to fall, and the valve drops into its socket again, the sluice-box into which the ball-cock is fitted, and the trough itself, re-fill automatically to the proper height. This is an excellent arrangement for work-people, or hospital servants, provided it be made the duty of some person to see the valves regularly lifted every day, and provided the range be fitted up in an open yard; but it would prove objectionable inside a sick ward. In the latter instance, the very best automatically flushing single closets should be adopted, each one independent of the other, and duly ventilated by the soil-pipe.

Memoranda on Water-closets, &c.

The water-closets are best confined to one part of the house, and ought to be built one over the other. The building which accommodates them should, where-ever possible, project out from the house; a separate tower is, however, most desirable. They should never open into a passage of the house, but command a vestibule or ante-room.

The windows in the closet and vestibule should reach ceiling high; and if they be made so that they cannot shut entirely to the top, or if they be unprovided with ventilating-glass in the upper panes, air-bricks should be inserted in the line of cornice. Closets too often ventilate into a badly-ventilated staircase.

The soil-pipe should be made of the strongest lead, as the sewer-gases often injuriously affect it. Iron soil-pipes are objectionable, and so are iron continuations of the lead-pipes—at least indoors—because lead and iron will not join properly together. Iron also expands and contracts very much, and the joints open and allow the effluvia to escape. Earthenware pipes should always be held inadmissible. The soil-pipes should also be cased over, so as to invite rather than repel inspection.

A zinc safe should be fixed tray-fashion under the indoor-closets, in order to guard against any leakage of the working parts.

Common hopper-closets should never be erected inside the house, as they accumulate filth largely. Pans with a large evaporating surface are likewise objectionable, unless the supply of water be ample. An automatic flushing action should be arranged to all juvenile and all servants' apparatus.

The wooden casing or framing should be made so as to come readily asunder, and the clamped flap or lid should have a hole in it just over the pull-up handle, so that the contents of the pan can be discharged when the lid is down. The wisdom of this will be admitted after noticing the blackness caused on the lead-painted under-side of the flap by the action of sulphuretted hydrogen gas.

Where the expense is not objectionable, and in all cases where the ventilation of the soil-pipe is insufficient —a state of things always to be found in crowded towns and in badly-arranged houses—a self-acting apparatus may be fixed above the seat, by which the flushing water can be mingled with some powerful disinfecting fluid at every discharge of the closet. See p. 74.

A housemaid's sink should be provided on every floor of a house; otherwise the closet will certainly be used for her purposes, the safe below filled with the overflows, and an influx of bad air drawn into the house every time the handle is lifted up to quickly empty the slops.

Earth-closets, &c.

In places where there is no water-carriage of the soil it may be found advisable to make use of earth:

and to show that this is feasible, I copy, at fig. 84, a plan devised for carrying out an upstairs system of earth-closets. A special apparatus is here employed, and the soil-pipe is carried down to a vault, beneath the lowest closet. At the bottom of the receptacle of each closet is placed a sliding valve, which is opened by the withdrawal of a handle when the holder is full, and the contents then fall down the pipe into a vault, as shown at A; or if there be no vault, into portable pipe-tanks, sold for the purpose.

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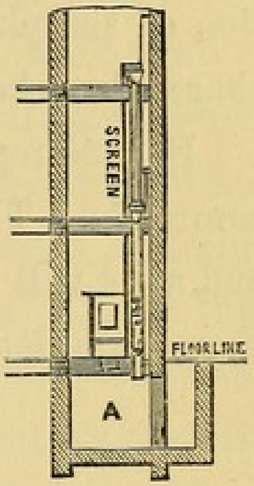

Besides the earth and ash-closet systems, what has been called a carbon-closet system has been introduced into the market from Leeds. It is a self-acting arrangement, the depression and elevation of the seat performing all the necessary work of distributing a minimum quantity of charcoal exactly where it is required, and removing the excrement. There can be no doubt that, if the charcoal be finely granulated, the deposit will be kept remarkably free from odour. Another advantage is that it can be worked with less than a fourth of the weight of the deodorising material as compared with earth or ashes. These carbon-closets can also be fitted to the several stories of a residence, and in this case a reservoir of charcoal is placed at the top of the house, and all the closets draw upon it. A cesspit is situated outside the wall to receive the soil, &c., and is emptied by the scavenger once a year. The contents of the cesspit are then treated for the utilisation of the phosphates and ammonia, and the realised charcoal can be returned to the closet reservoir for re-use.

Fig. 85 represents at A a view of the common earth-commode. The dry earth is contained in the space D, and at B will be observed the kind of apparatus put there in order to measure out the proper quantity to

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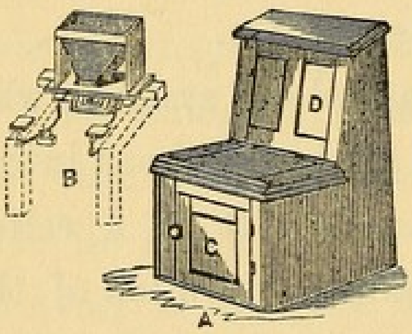

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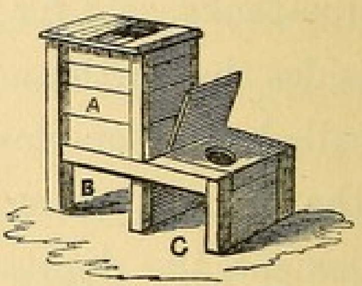


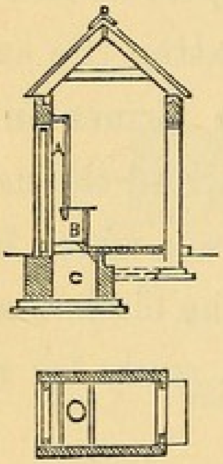
distribute at each operation. I have here drawn a self-acting system, by which the earth is discharged when the upward movement of the seat takes place on rising therefrom. In all cases where these closets are used by the household, an automatic delivery of the earth is indispensable; for, without it, an omission to pull the ring or lift up the lever, is of common occurrence. In sick rooms, this method of distribution of earth may be found objectionable, as more or less vibration follows the rising, and this is apt to disturb the nerves of a patient. The movable pan is enclosed in the space C.

Fig. 86 represents an ash screening and deodorising closet. It is very suitable for use in the back yards of lodges, or of isolated cottages; in fact, in all places where there is no regular communication with the sewer. When in use, the seat depresses, and communicates a motion to the screener, situated within the box A, and thus the ashes which were introduced by the aperture at the top are agitated, with the effect of separating the ash-dust from the cinders, and placing the former in a measurer. On rising, the seat is elevated, and the ash-dust in the measurer jerked out over the soil which has fallen into a portable vessel at C, whilst the cinders are thrown simultaneously into the space B, ready for re-burning.

Where water-closets can be used, an ash-pit presents no difficulty, as the contents can be periodically removed; but where there is no sewer, and the site is too limited in extent to afford a properly constructed cesspool at a proper distance from the habitation, where the drainage could be water-led, there is no doubt that an earth or ash-closet will be found very desirable. An earth-closet, to be used where a separate ash-bin is kept, is drawn at fig. 87, in plan and section. The earth-box is represented at A, and between that and the closet-seat framing B, is fixed a distributing apparatus. A door is constructed at the back of the closet, so as to enable the earth-box to be filled, and the vault C emptied; but if there be no means of making a gangway outside, the filling and emptying can almost as easily take place from the inside.

An ash-closet with an ash-pit below for the general reception of all kinds of refuse, is drawn at fig. 88.

87



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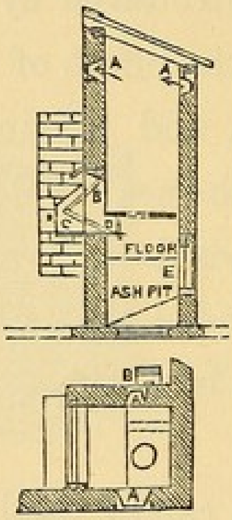

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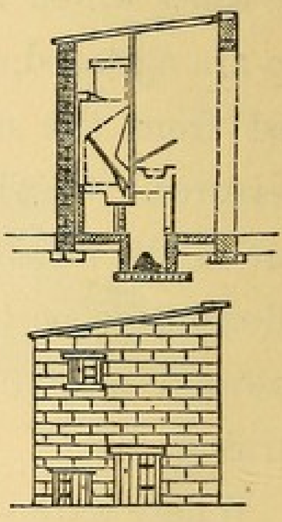
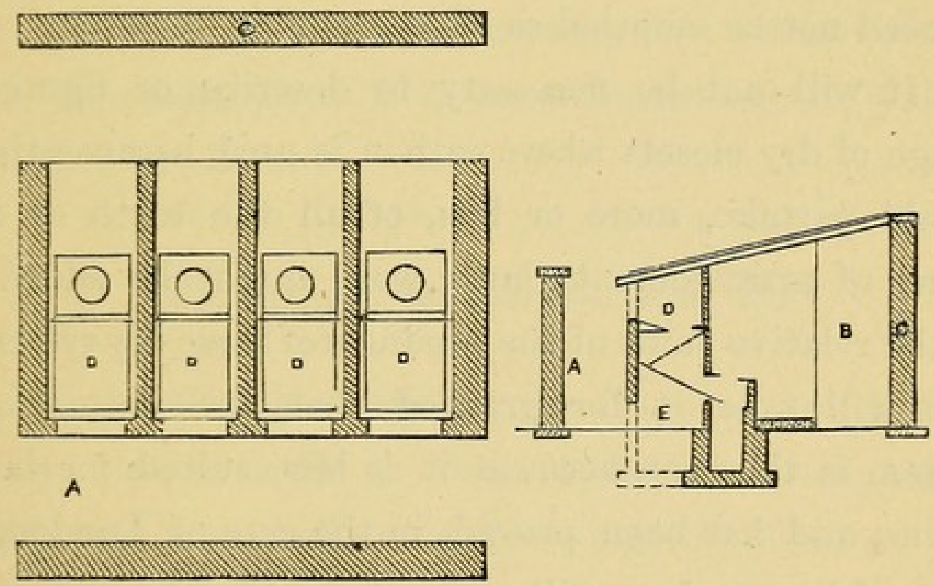


Two air-bricks are built in near the roof, at A, to remove any smell from the closet, and the floor of the ash-pit is also concreted, so as to prevent any saturation of the soil. The ashes are put into the receptacle B, and as the cinders fall towards the withdrawing box C, the ash-dust finds its way into the distributer D, so as to be ready for use. The pit is easily cleaned out by means of the door shown at E.

It frequently happens that it is found undesirable to construct a general ash-pit, where ashes, broken pottery, vegetable refuse, and garbage of all sorts can be thrown, and found preferable to convey elsewhere everything except the ashes, using these as a deodorant for the excreta. In such a case, I can recommend the ash-closet drawn at fig. 89, having erected one, and frequently noticed its working. The upper part of the sketch gives an elevation of this closet; the ashes as collected from the hearths being thrown in at the door.

90



The cinders fall into a box, and the ash-dust and fæces into either a portable tank behind the door, or into a water-tight vault. The upper sketch illustrates the closet just after having been used and the cinders screened.

Closet arrangements on the nested, or range principle, can also be built on the earth or ash systems;

and in large manufactories, where ashes are plentiful and water is scarce, or a sewer is absent, a plan like that shown at fig. 90 will work sufficiently well. In order to obtain proper ventilation, however, the passage B, between the closet-doors and the curtain wall C, is indispensable. A passage at A is also necessary, in order that the ashes may be thrown into the cinder compartment D, below which is situated the screener. If the ashes be first of all screened from large cinders and clinkers, so much the better, as the cinder receptacle E, need not be emptied so often.

It will not be necessary to describe, or figure, a range of dry closets where carbon is used, because these would partake, more or less, of all the earth or ash forms of arrangement; but a word might be added as to the relative value of the products of these dry systems. We will take it for granted that the water-closet system is the best, because it is best suited for large towns, and has been proved, in the case of London, to be healthy; and we will also assume, that by precipitation, or irrigation, the greatest value can be derived from the products. With the dry-earth system, and supposing that 2½ lbs. of earth is used each time, the profit derived from the sale or use of the manure, is about five shillings per ton. It cannot fairly be taken at more, even when the same earth has been used over and over again. I should be inclined to estimate the profits upon the ash-closet manure at the same sum, *plus* a saving of 20 per cent. of fuel, brought about by the cinder-sifting apparatus. As for the carbon-closet, its value to the householder as a manure is *nil;* for ordinarily, when the tank is emptied, the contents are taken to the chemical works and burned in retorts, whilst the ammonia is distilled off. He would probably be allowed a certain price for the material; but it is safer to suppose that the chief benefit to him would result from the fact that he would be saved the purchase of fresh charcoal by the return of the carbon to him, freed from its phosphates and its ammonia.

Memoranda on Earth-closets, &c.

The earth most suitable for these closets is of a loamy nature, such as that known as brick earth. Sandy and peaty soils should be avoided.

Where earth-closets are largely used, heaps of earth should be dried in the summer sun, and stored away; but if only used upon a small scale, a small quantity of earth can be dried upon trays under the kitchen fire-bars, or in the green-house. Specially constructed stoves are, however, sold for the purpose, and can be obtained at the various earth-closet depôts.

After being well-dried, the earth should be sifted in a sieve having about three meshes to the inch, or it will cake and clog the walls of the delivering apparatus.

The hopper which contains the earth should be inspected at regular intervals of time, in order to see that it is properly supplied with earth. About 1½ pints is the average quantity required at every operation of the closet.

No kind of slops should be thrown into the earth-closets, and if needful, a separate pit can be set aside for the reception of kitchen, scullery, bath, and other wastes, and occasionally cleaned out.

When the charged earth is taken from the closet, it should be spread out in a shed roofed over, but with open sides, and remain there for some few weeks, or until it is fit to use over again.

Where ash-closets are in use the ashes should be well screened from cinders and clinkers, broken pottery, vegetable refuse and the like.

Should it be desirable to use a disinfectant with an earth or ash-closet, it should be a powder, Cooper's Salts for example, not a fluid disinfectant or deodoriser.

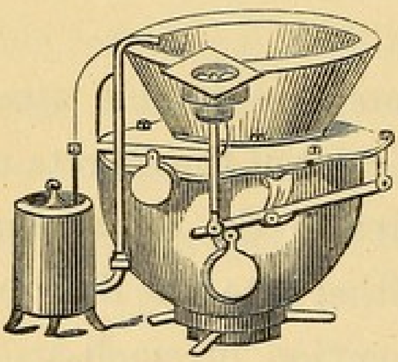
Dust-bins, &c.

It may not prove superfluous to notice here a few precautions as to the use of dust-bins in sewer towns. These should be emptied as frequently as possible, and for this purpose they should be made portable. Very often the dust-bin is a closet under the stairs, or a fixed enclosure with a lid over, necessitating the emptying of it with a shovel. This kind of arrangement is not desirable, however, at any time. There should also be a separate box for the reception of the vegetable refuse, and this latter should be removed daily, if at all possible. The bin which is to contain the ashes should also be fitted up with a screener, which will preserve the ashes for re-burning. It is preferable to sift the ashes here and outside the house, rather than inside. To conclude, care should be taken that no air-inlet for heating or ventilating purposes should be led into the house from the vicinity of these refuse deposits.

Disinfection of Water-closets, &c.

Within the last few years considerable attention has been directed to the treatment of the excreta at the moment that they are delivered to the drain, and the question has resolved itself either into the distributing over the soil of a certain portion of smell-arresting powder, or the injecting into the closet basin a quantity of deodorising fluid. Undoubtedly, by such means, the air of the closet-room is rendered less offensive, but whether the fæces are disinfected and rendered innocuous or not depends upon the material used. Of the relative value of these disinfectants I have nothing to say, but have merely to point out a contrivance or two which may be relied upon as affording a perfect mechanical delivery of a fluid. I purposely pass by those systems which have been devised for the liberation of a suitable powder, as I cannot think that these will be again preferred to fluid disinfectants. It would also be a waste of time to describe a disinfector which is not automatic in its action ; and I will, consequently, make no mention of those schemes in which a special manual attention is essential to a proper distribution.

91



92

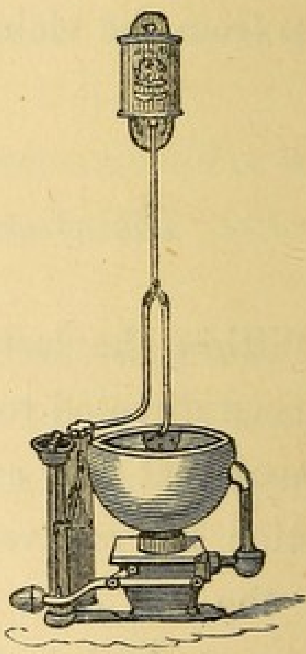


Fig. 91 represents what is called a Baker's disinfector ; and in this case there is injected into the closet basin at the moment of closing the valve, or fall of handle, a measured quantity of the chosen fluid; and as this mingles with the water whilst it is still in the state of agitation consequent upon its descent from the cistern or the waste preventor, the water, which is meant to lie in the basin and act as an hydraulic seal, becomes well charged with the disinfectant. The trapping water is thus in a better condition to arrest and fix any foul odour which may have arisen from the receiver or soil-pipe; and not only this, but it will, in some sort, preserve the closet room from smell during the moments of voidance.

I shall complete this section by giving at fig. 92, a view of another self-acting disinfector, viz., Brown's patent; and in this case the disinfecting fluid is delivered to the basin at the same time as the descending flushing water. The vessel containing the deodorant is here fixed *over* the closet apparatus, and in it, a syphon is formed by a small tube, one end of which is led into the closet supply pipe. When the lever is lifted and the water rushes down, a vacuum is formed in the syphon which holds the measured-out disinfecting fluid; in other words, the quantity of chemical solution there is withdrawn with the cleansing water into the basin of the closet. A small orifice in the bottom of the coil or syphon pipe, which is in the disinfecting jar, permits this measurer to refill ready for the next operation. Both of the above contrivances serve the purpose for which they are intended; and although the former is vended only for the distribution of chloralum, and the latter for Condy's fluid, each can be trusted to administer either preparation equally well. Both the above descriptions of disinfectors are perfectly easy of erection, and, with the printed instructions sent out with them, an ordinary plumber can readily affix them to any kind of closet. As regards the cost, neither need exceed the sum of thirty shillings. The Baker pattern, holding a gallon, will serve to disinfect about a thousand discharges; and the Brown pattern, containing a pint, will supply about one hundred and forty different actions of the closet. For the rest all will depend upon the relative values of the disinfectants used.

There can be no doubt whatever that such inventions possess a certain value in places where the soil-pipes of the closets are unventilated, or insufficiently so, and that if they were affixed to the 900,000 and odd water-closets in the Metropolis, a great benefit would accrue; but I am inclined to think that in cases where the soil-pipe is properly ventilated by a continuation of the whole or half sectional area of the soil-pipe up to the roof, their adoption may be considered quite supererogatory. They will, however, always prove useful to attach to the pipes which supply the water for cleansing out stables, kennels, shambles, and the like places; and they may also with advantage be fixed to the delivery-pipes of liquid sewage, when this manure is used close to the mansion.

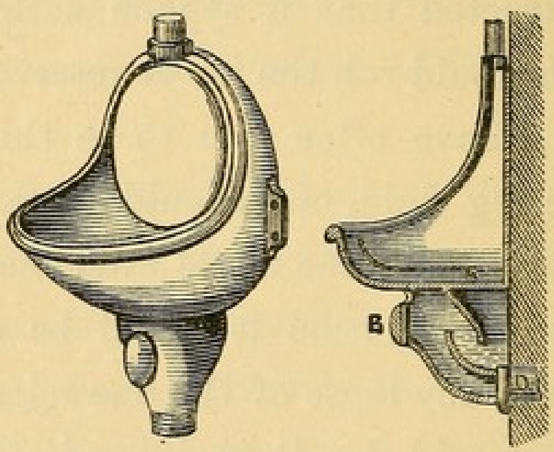
If a disinfecting apparatus be adopted to a water-closet, it ought to be free from the following defects. The disinfecting fluid should not escape prematurely down the drain, and so leave none of the desired liquid in the pan; the apparatus should also be so contrived that a longer or shorter upheaval of the handle should not result in allowing the measure of the medicated fluid to flow through the trap of the closet, and thus leave water only in the basin or pan. It should also be so constructed that a syphon action should not ensue, which would rob the jar or reservoir of its whole contents, as I have often seen to be the case. As for the disinfecting fluid, one should certainly be chosen which cannot corrode the metal attachments; and if it were a coloured solution it would be all the better, inasmuch as if any lapse of the due release of the fluid occurred, it would be then immediately discovered. But any disinfectant can happily be made to fulfil this last condition.

Urinals.

There is no reason why the urinal should necessarily be banished outside the house, and considerable discomfort caused thereby. When they are so expelled, very often the water-closet apparatus is used with the risk of filling up the *safe* underneath with an objectionable and foul smelling liquid, to say nothing of evaporating chambers and saturated seats. Fortunately the construction of the urinal apparatus has advanced equally with that of the closet, and very superior patterns can now be had at any good sanitary warehouse.

I need not occupy my space with a description of those contrivances intended for out-door use, save to

93



reprobate in a word the old stone latrine, but shall content myself by pointing out what I consider to be the arrangement most desirable for the closet, the lavatory, or the bath-room.

Fig. 93 represents a urinal which is fitted up with a trap underneath, and this trap can be ventilated by a pipe leading outside when considered desirable. It is intended to be fixed above a treadle plate, which, when stood upon, provides a rush of water into the basin from the pipe at the top, the flushing supply ceasing, when the weight of the foot is removed.

The contents of the trap will, therefore, for the most part consist of pure water, and if needs be a disinfecting apparatus can be applied here similar to that described under the head of Water-closets. By the insertion of a ventilating pipe, however, between the top of the trapping water, and the grating at the bottom of the basin, any deodorizing arrangement may be rendered unnecessary.

These urinals are best constructed of glazed ware, as enamelled iron does not always continue satisfactory. The margin of the basin should also be lipped, so as to prevent any overflow. Where a trap is inserted under the basin, an inspection plate is also advisable, and a preference should, in my opinion, be given to those urinals where the basin and trap form one piece of earthenware as drawn above.

CHAPTER V.

CESSPOOLS AND OLD BRICK-DRAINS.

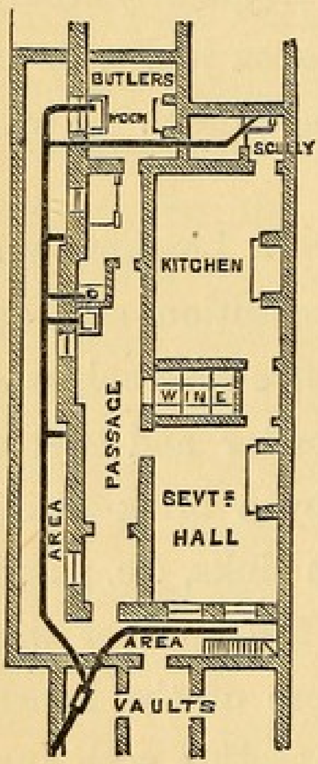
There is not much difference between the uses to which cesspools are put, but there are a few variations, nevertheless, in their mode of construction. Some are built up with dry brickwork inside, but carefully domed over, and the liquid contents allowed to drain into the surrounding soil. Others are steined with bricks in cement for the purpose of preventing such infiltration; and cesspools of this class may be found further defended from any chance of leakage by clay puddling outside the walls, and cement rendering inside. Some cesspools are made of a certain depth, and the liquid overflow drains into a still deeper well, whence it is withdrawn by a pump. Cesspools of this class are now generally made very compact—in shape a parallelogram —with an upright screen or fender halfway, so as to divide the liquids from the solids. If a cesspool must perforce be built for the use of a house, &c., this last kind will prove the best pattern to copy; but besides being made watertight by the use of clay and cement, and carefully domed over by a brick arch, it should be ventilated by a 6 in. upright pipe, the solid portion made accessible by a manhole, and the *liquid half* fitted with a pump. Where there can be no overflow provided, an index can be fitted in the ventilating shaft, to give notice when pumping is necessary.

The cesspools to which I wish to refer more particularly, however, are not those situated outside the house, but those which long ago have been foolishly built inside. For the most part, these latter will be found of the watertight order; but it frequently occurs that they were purposely built with open joints, so as to economise the labour of emptying them. I will give a few examples.

In 1870, a house in Wimpole Street, London, was discovered to be in a very offensive condition, and, on opening up the basement, a chain of five cesspools was exposed, each about six feet in diameter and twelve feet in depth, connected together by a brick-drain. The oldest pit lay nearest to the main sinks, &c.; and it would appear that when that was full another was dug, and so on until the atmosphere of the house proved unbearable. There was no connection with any sewer, and the liquid wastes simply disappeared in the gravel. Next door, four similar cesspools were laid bare; and, in addition to these, a hole fourteen feet square and eight feet deep, full of putrid water, and its silt, was discovered exactly in the middle of the kitchen. Likely enough this hole had been made for the use of the workmen who built the house originally, or it might possibly have been the ancient idea of a rain-water tank. Unlike the cesspools, it was deep enough to reach the clay, which between High Street and the bottom of Portland Place is close to the surface.

It will perhaps be advisable to give a few illustrated examples of some bad cases in town and country, and I shall therefore do so. It will at all events save a great deal of word-picturing and mere description.

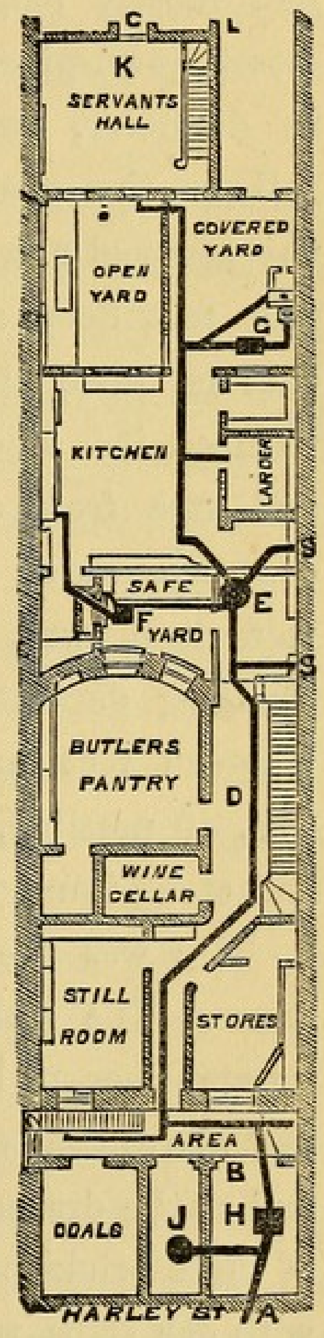
94



Sometimes drains are laid without the slightest fall, and I have even known some which have inclined towards the house.

At Fig. 94 I give a sketch of the basement of a house in Wimpole Street, London, built some thirty years ago, the solid portions of the sewage and other wastes of which *never reached the sewer during the whole of that time*, but remained in the brick-barrel drain. During the present year these drains got choked up. Between the scullery and the main drain in the area the nuisance proved the worst, inasmuch as the brick drain passed through part of the house. Between the dip-trap in the vault, which was wonderfully clean, and the sink at the butler's room, was a considerable depression in the drain, and there, also, two large dip-traps, full of black silt, were discovered on opening up the ground. I never saw a worse case of neglect in arranging the fall of a drain. A good fall could easily have been got, for, when replacing the barrel drain with earthenware pipes, I found sufficient and to spare.

95



At fig. 95 is an example of the basement-floor of a house in Harley Street, London, which I opened up in the latter end of 1873. The dark lines represent the old brick drains, and the sewer lies in the middle of the street—the entrance to same beginning at A in the cellar B, which cellar is situated, with its fellows, under the foot-pavement. The fall of the drain was from C to A, or rather ought to have been; but owing to the fact that the drain was for the most part *lower* than the sewer, and especially so about D, the effete matters for the last thirty years or more had mostly lodged in the cesspool E, close to the closet down-pipes S S, which cesspool was five feet in diameter, twelve feet in depth, and was found full to the overflow. The scullery wastes ran into the cesspool F, which was about four feet square and four feet deep, and the outlet was into the pit E— that is, when the ground was sufficiently soaked as to need it. The cesspool at G was tolerably empty, and free from deposit. The cesspool at H, on the contrary, which measured five feet square and eight feet deep, was, like that at E, full of black foul smelling deposit. That at J—a circular-shaped one, fourteen feet in depth and six feet in diameter— was, if possible, still worse, as an old servants' closet had stood immediately over it.

Nor was the nuisance altogether confined to the house. The stable buildings began at C; and as the ground-floor, or lowest floor, of these was some seven feet above the basement-floor of the servants' hall at K, and as the drains towards the mews were simply made of three bricks on edge at the sides, covered on the top with oak slabs, with nothing but the bare gravel for a bottom, it was not to be wondered at that the servants' hall was perfectly uninhabitable, owing to dampness, natural and artificial. To make matters worse, a closet-soil downpipe at L delivered—unattached to the drain—against the unprotected wall between C and K. In the house alone, about forty barrow loads of black sewage deposit and foul refuse had to be carted away, and a suitable shoot was not found nearer than the neighbourhood of Highgate.

At fig. 96 is represented a badly drained residence, in the Midland Counties, and the state of which I was called upon last year to remedy, I may say with perfect success, inasmuch as I abolished all the cesspools here shown, and provided a properly disconnected and ventilated one at a proper distance from the mansion.

I shall first of all describe the cesspool A, which was twenty-two feet deep, and received the waste of butler's sink, ground-floor and first floor closet excreta, service room sink waste, water tank overflow, and amongst some other effete matters, the soil from the dressing-room closet at F. It also drained part of the garden walks ; at G the pipes then suddenly sank to the basement level, and ran on, where shown by dotted lines, into the same cesspool. This arrangement proved the bane of the whole house, for as the cesspool A filled up it simply overflowed into this cellar drain, and on taking the latter up the whole was found choked up, and a basement cesspool in it was also full to the brim.

It was from this point of vantage that the gases were found to have invaded the house.

The cesspool at B was comparatively shallow, but it

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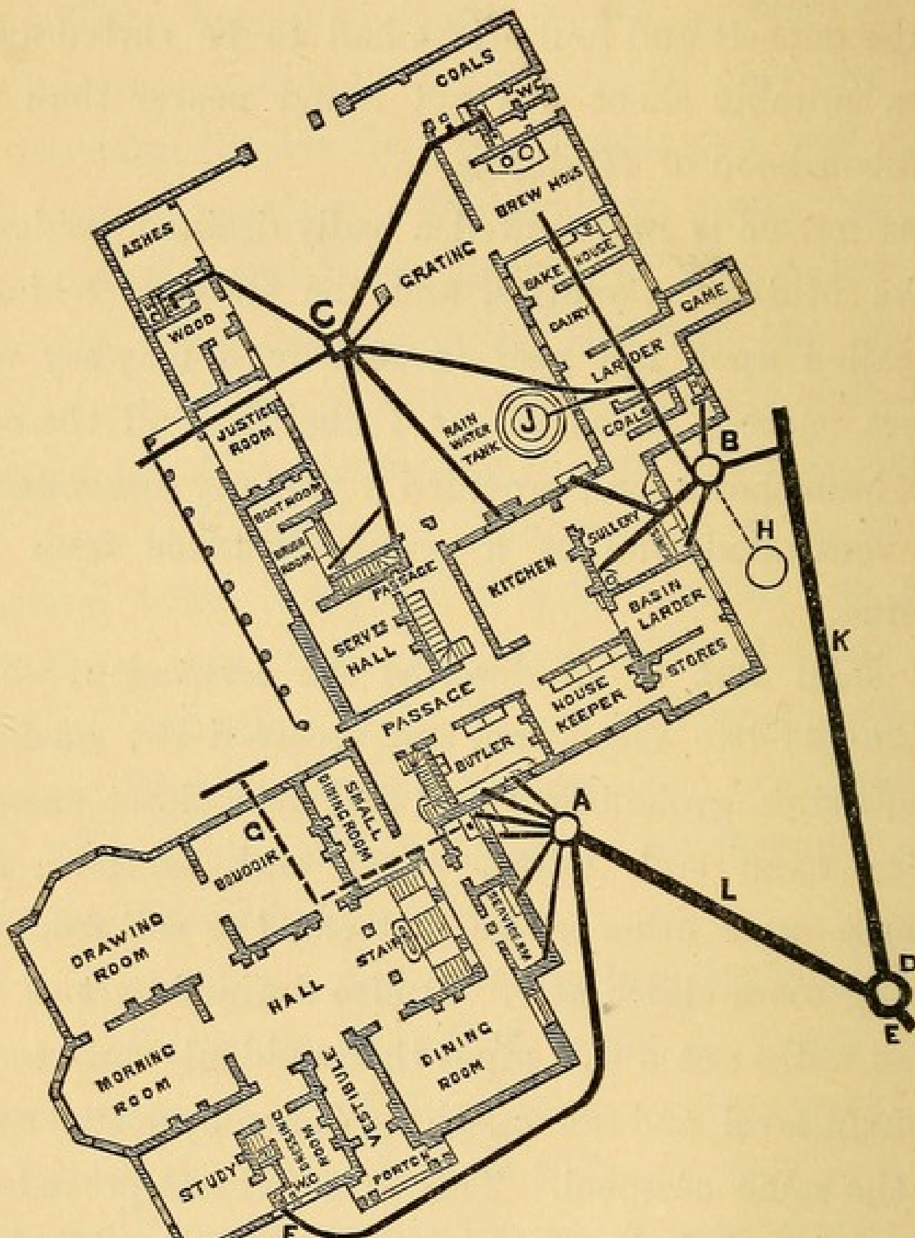
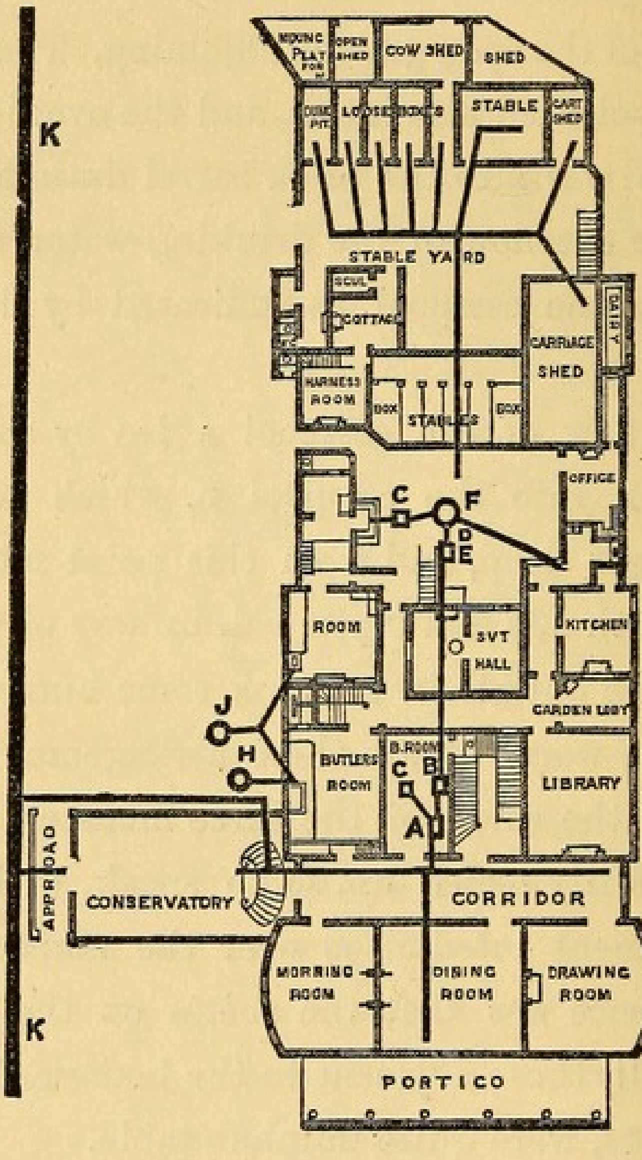


had sufficient duty to perform. It received the wastes from the sculleries and housemaids' sinks, larder, dairy, bakehouse and brewhouse floors, servants' waterclosets, adjoining the cesspool, and the rain-water tank overflow. At the end of each wing of the offices besides the *coals* and *ashes* respectively were two other water-closets, and these drained with other wastes into a cesspool in the middle of the yard at C, which also received the yard rain water by way of the open grating adjoining. The overflow of this cesspool C led also into B, and the overflow of the latter cesspool was into the brick barrel drain at K. At one time, the overflow of the drinking-water well at H led into the same cesspool, as indicated by the dotted line.

The overflow of the cesspool A led by way of the brick-drain L into the cesspool D, which was some twenty-one feet deep, and from this point D the overflows from both A, B and C pits led, by way of the brick sewer E, to the outfall in a brook some hundred yards distant. The worst of all these arrangements lay in the fact that the whole of the three monster cesspools were hermetically sealed up, so to speak, with domed roofs and cement luted flags over the manholes, and one consequence was that the rooms on the bedroom floor, especially those adjacent to the housemaids' sinks and the closets, were quite uninhabitable.

A residence which I was lately called upon to remedy, and which presented even worse points than the foregoing, inasmuch as the cesspools were partly in the basement of the house, is sketched at fig. 97. This drawing exhibits the ground-floor plan, but the drainage must be supposed to be in the cellar below. By this arrangement a better idea can be got of the insalubrity of the rooms

97



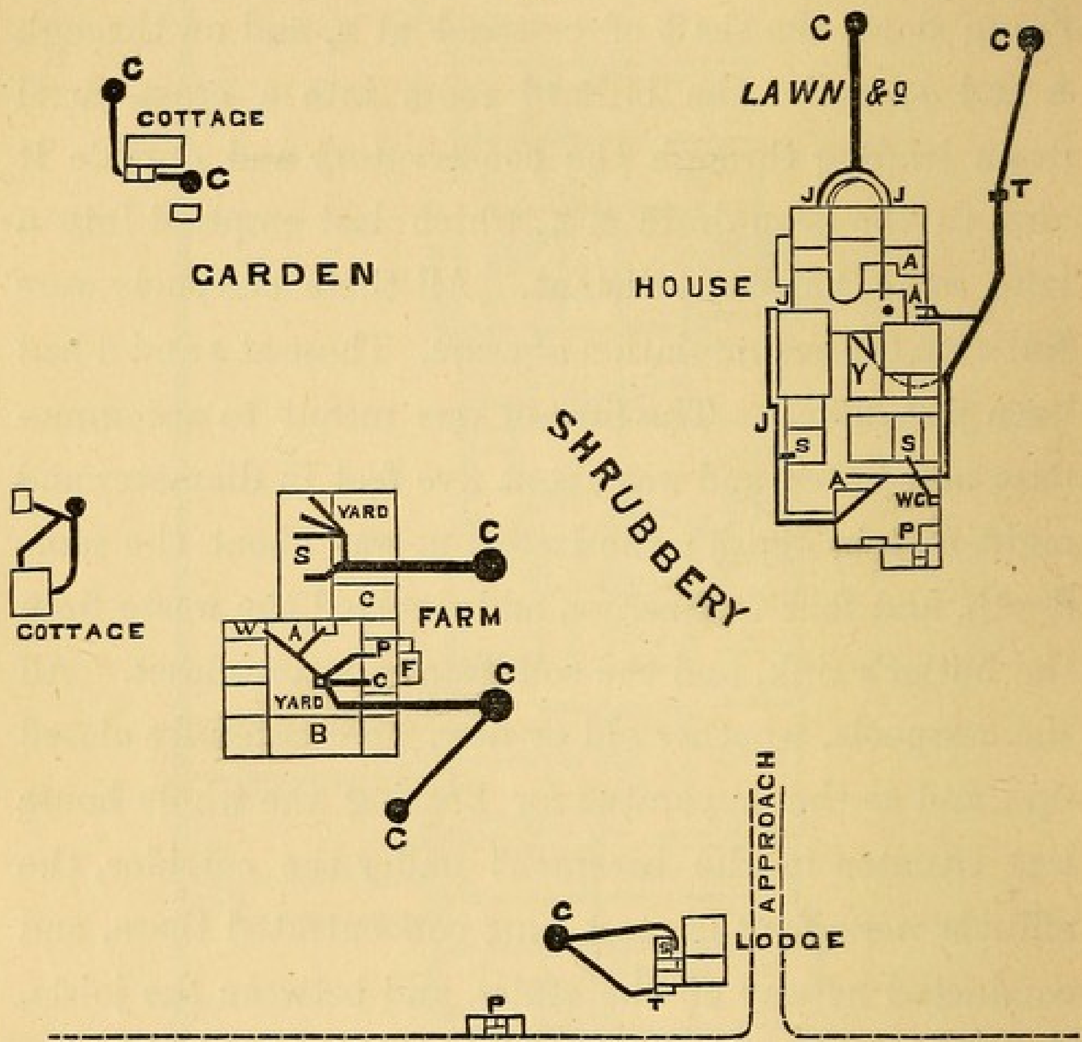
above the basement or cellar cesspools and old brick drains.

At A I laid bare a cesspool about five feet square, and five feet in depth; at B, one four feet by two feet and five feet in depth; and at C a smaller one, communicating with A. All were full of soil, silt, and filth. In the yard at F was another cesspool five feet in diameter, and some sixteen feet in depth; the overflow of which, together with the overflow of the scullery cesspool C, ran down the shaft of cesspool at E, and on through B and A, under the billiard room into a cross-barrel drain leading through the conservatory and outside it also, to the deep drain K K, which last emptied into a lake some half-mile distant. All these cesspools were full with the accumulation of years. Those at J and H had been just added. The former was meant to accommodate rain-water, and was about five feet in diameter and eight feet in depth; the latter, H, was about the same depth, and four feet across, and received the waste from the butler's sink, and the soil from a water-closet. All the cesspools, whether old or new, were carefully closed up; and as the apparatus for heating the whole house was situated in the basement under the corridor, the effluvia were for the most part concentrated there, and conducted by way of the stairs, and between the joists, throughout the whole of the reception and sleeping rooms.

A rather more complicated case occurring on a somewhat porous soil, in the North, is set forth at fig. 98.

Here the house wastes of every kind were drained into the two cesspools C C, in the low-lying fields beyond the lawn, each cesspool being about six feet in diameter, averaging nine feet in depth, domed over, and the manholes covered with stones. The outlying cesspool

98



was furnished with an overflow grating at T, situated over a secondary cesspool. The one cesspool, as will be seen, received only the rain-water from the stacks J J, but the other received all the drainage from three upstairs and downstairs closets at A A A, the urinal, the lavatories on ground-floor, and sink overhead, the butler's sink at B on ground-floor, the housemaid's sink upstairs, the scullery sink at S, the pump trough overflow at W, and the rain-water down-pipes at J J. It also received a portion of the rain-water from the court-yard Y. At this point Y the drain-pipes dipped direct into the cellar, collecting on its way the washings of the basement floors: and perhaps the worst arrangement in the whole house was here, for had it not been that the rain-water from the court-yard Y, and the cistern overflow ran through the basement, the traps in the cellar would have been invariably dry, and the house everlastingly invaded by gases.

The cesspool, which was interrupted at T, proved, of course, to be the main cause of mischief; and, although the other one was foul, this one proved to be simply horrible. When the stone cover was removed, and the contents stirred, it literally boiled up for an hour, yielding a strong and most offensive smell, and thickening into a crust again at the top. A small grating at the side permitted its overflow to debouch into the fields; but such ventilation was ridiculously insufficient, and there might as well have been none at all. In fact, this cesspool was ventilated direct into the house by way of the sinks and the closets, especially when the handles of the closet valves were uplifted. A supplementary ventilation of the cesspool was carried on by means of the rain-water pipes at J J, and the heads of these terminated, of course, close under the eaves, about on a level with the top panes of the bedroom windows. To conclude, the ash-pit was in the walled up court-yard at P.

The *farm offices* were situated at no great distance from the house, as seen in woodcut, and these were also drained into cesspools. The cesspool at C which drained the stables S, I had some difficulty in finding, as its whereabouts had been forgotten. It was ten feet in depth, four feet in diameter, and had some eight feet of contents, four feet of which was accumulated black filth. The middle cesspool C, into which the closet A, the pump W, the piggery P, the cowshed C, and the poultry-yard F were drained, was closed over like the other one, and the overflow was into another unventilated cesspool, viz., the lowermost one at C. The soakage from the decaying manure, &c., in the central yard kept these cesspools generally full—when they overflowed the liquid manure cart was put into requisition.

The *lodge* was also connected with a cesspool which received the scullery waste and the rain-water. There was an ash-pit and privy beside the boundary wall at P. The *bailiff's cottage* and the *gardener's cottage* were also drained into cesspools as shown on the plan, and most of the rooms were suffering from dampness.

Owing to the above surroundings, some or other of the inmates of the house were constantly ailing. In consequence of my report, however, and the steps I pointed out as necessary to be taken, the mansion was rendered quite healthy, and, as I was informed by the medical attendant of the family, the former ever-recurring sicknesses were banished. The means I employed in all these cases were such as naturally followed the principles explained in this volume.

When cesspools, either inside or outside a house, are hermetically sealed, there is some danger of an explosion if a lighted candle be brought too near the opened up place of escape. On one occasion which came under my notice, it was found necessary in a house which was drained into an unventilated cesspool, to raise the pavement flags under the sink, in order to trace some rat-holes. The sink was especially well trapped with a patent syphon. The workman required a candle, and, as he lifted up the flag and laid bare the drain, the pent-up gases exploded and severely injured him. It is therefore necessary to give these places a wide berth, for more reasons than a zymotic one.

I have just alluded to rats, and might here add that these animals are the most reliable harbingers of sewer-gas eruptions. As a rule, wherever there is a bad drain smell, there exists an old brick barrel-drain or rat-run: very often these are also in conjunction with the modern sewer. I have before me a piece of cast-lead pipe, nearly a quarter of an inch in thickness, which had been gnawed by these vermin in order to admit them, by way of the sink-waste, into a house at Tulse Hill, London. They managed to make a hole through it, and on it are plainly discernible hundreds of their teeth-marks. Once in the house, it was found almost impossible to extirpate them; and at the beginning of the crusade, when the boards and flags were pulled up, I am not exaggerating in the least when I say that over fifty nests were laid bare, besides a goodly collection of all kinds of bones, flanked by once shining articles, such as scissors, corkscrews, and one or two silver spoons. A favourite cat, and a good mouser, which I had sent there before I opened up the floors, died after a few days' experience of the place; it was said by some from the effects of nocturnal warfare, although it is just as likely that it was from grief, and because he had, unlike Alexander, too many worlds to conquer.

Speaking of rats, it does not invariably follow, that because a rat is seen about a house it is a sewer-rat. For instance, on taking up the flags near D on fig. 95, some five nests were discovered and one rat despatched; it proved to be, however, a house rat, or, more strictly speaking, one of the barn-yard species. The latter have more or less pointed heads, whereas the head of the sewer-rat is fuller and rounder, and the neck thick and clumsy.

When a rat-hole has been exposed, the best preventive of their return by the same run, is to fill up the hole with broken glass or tar. The rat is perhaps the cleanliest of the whole vermin tribe, and will never defile itself with anything which water will not readily remove.

Old Brick-Drains.

Occasionally a considerable amount of danger may arise from the presence of ancient brick-drains under the basement floors. These have been appropriately termed 'elongated cesspools,' and require removal quite as much as the cesspools proper, which they generally serve to connect.

On opening up an old brick-drain, the crown of the arch—if the drain be of the barrel pattern—will be found in tolerable preservation; but the bottom or invert will be generally discovered in a perished condition, the mortar gone, and the bricks rotten. In very bad cases, the floor of the drain will be here and there broken up, with a consequent soakage into the soil at such places. Pieces of the crown may also have fallen in, and the passage of the excreta partly obstructed. If the drain has been made with brick sides and flag-stones at top and bottom, the stones forming the bed will be found very uneven and with open joints, and the subsoil around will be black and foul smelling.

Nearly all the old houses in town and country possess such brick-drains, and not the least part of the evil lies in the fact, that one-third of the diameter would have sufficed to lead away all effete matters.[1] Where brick drains are found—and a search should be made for them—they should be taken up and glazed earthenware pipes laid in their place. No hesitation should be observed in this matter; for, where a brick-drain exists, there are many other things equally objectionable, which only the opening out of the drain will expose. When the old drain is laid bare, the whole of the brickwork should be taken up and carted away, and the earth around it also, if it shows any signs of filthiness. Some people are satisfied with removing the crown of the arch, laying the pipes over the old invert, and filling up around with the broken rubbish got out of the trench. Others have actually laid the new pipes alongside the brick barrel, and contented themselves with disconnecting the latter, thus converting the old drain into a gas retort, and really making matters worse. The only safe system, however, is to cart away all the old formation and provide new. No amount of lime or disinfecting powder will purify the whole bricks and the sodden earth around. A concrete bed should also be prepared for the new pipes, and when the latter are laid in, they should be covered with

[1] The brick-barrel drains of the house sketched at fig. 94 were *twelve* inches in diameter.

a few inches of concrete. If this be done, leaks will be impossible.

There is one precaution to take in bedding the joints of drain-pipes in mortar or cement, and that is, to see that, in pushing the pipe ends into the sockets, a ridge of the cement or mortar be not formed inside the drain. On taking up a long drain on an estate in Shropshire during the present year, I found that the stoppage had been entirely owing to the men's stupidity in this way.

It is necessary to take proper care to envelope the drain-pipes inside the house with concrete, and it is as necessary to concrete over the whole floor of the basement, in order that no foul air should be sucked into the house by means of the fireplaces and heated flues. If the ground upon which a building stands is porous, it is also filled with air, and, if a leaky gas-pipe or faulty drain-pipe has been laid in it, this poisoned *ground-air*, as it is now called, will assuredly be passed into the rooms for respiration. Dr. Pettenkofer instances a case where lighting gas traversed twenty feet of street, and penetrated the whole foundations and basement of a house, with fatal results. He has also discovered that the ground under all houses is charged with carbonic acid, and that in some cases there exists as much of this pulse-lowering gas a few feet below the surface as in the worst of unventilated houses. It is imperative, therefore, that the basement floors should be concreted over their whole area, and all drain-pipes laid in a water-tight trench of the same material. Strictly speaking, a pipe with concrete surrounding will not be air-tight, but it comes sufficiently near to that desirability. If there be no cellar, a well-ventilated air-space should be kept between the double flooring and the ground for the same general reason.

CHAPTER VI.

DAMPNESS.

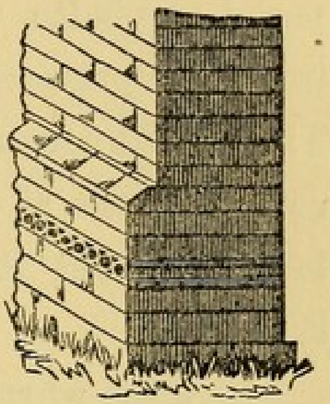
Damp-Proof Courses.

Every one is aware of the dangers which might arise from residing in a house that is constantly damp, and how important it is to provide against this enemy to health and comfort. Perhaps the best way to form a just estimate of this subject will be to follow mentally the erection of a dwelling from its foundation upwards, and notice what evils might arise, and how they may be averted.

A residence designed by me, and which is now being completed, in the neighbourhood of London, contains 180 rods of brickwork, or rather over four-fifths of a million bricks. Allowing for the lime, sand, and water, the space taken up by the walls is about 54,000 cubic feet. The foundations under the ground-line occupy about 8,000 cubic feet, and represent 115,000 bricks, presenting an upright surface of about 5,000 superficial feet to the damp or possibly wet earth. Under favourable circumstances, the foundations of a house of this size up to the ground-surface will at first contain about 5,000 gallons of water; and if the subsoil is very humid and the bricks poor and porous, the latter will absorb and retain 7,000 gallons, *plus* the water contained in the mortar. If no damp course has been laid just above the ground-line, this wet will be continually striking up into the walls of the house above ground—by capillary attraction, exerted over a horizontal surface of 2,400 superficial feet. Dampness from this source has several times been traced up to thirty feet in height above ground. The cure will therefore consist in laying down 2,400 feet (superficial) of damp course on the top of the walls the moment that the foundations rise above the ground level, and thus build the real walls of the house upon an impervious stratum, cutting them off from the possible 5,000 gallons of water.

There are various kinds of suitable damp courses used by architects. Sometimes a double course of slates, or one course of sawn Welsh slate bedded in cement, is laid along the top of the walls when they have emerged above the ground-line. Some, again, interpose there a layer of sheet-lead, weighing four pounds to the foot superficial. Another system is the paying over the tops of the walls with a coat of hot bastard asphalte or bitumen mixed with sand. There is also a kind of so-called asphalte damp-proof course sold in sheets ready for laying on the walls; but the hot layer is generally considered preferable. A course or two of enamelled bricks, or ramped glazed bricks, are also occasionally laid, in order to arrest the rising damp. But the best article devised up to the present time is a vitrified stone-ware tile, made in thicknesses from one to one-and-a-half inches, and perforated in order to ventilate the space between the ground and the joists of the floor, and also to prevent dry rot in the timbers. A view of this last contrivance is given at fig. 99.

99



The proper place at which to insert the damp-proof course is a foot or so above the ground, or high enough to obviate the effects of splashing and dripping after heavy rains. Some architects also surround the base of the house with a piece of stone flagging about a foot in width, and slightly tilted up towards the walls, in order to prevent soakage ; and the plan is a good one. Where a damp course is used, the reason why it should not be laid too near the surface of the ground is, because in time it is apt to be covered by the earth, which always accumulates there, as the paths are re-gravelled, or fresh *humus* is laid to the roots of the plants. Creeping or trailing plants should, moreover, derive their sustenance from the ground, and should be attached to the walls by means of lattice-work or wires. A *thin* wall, in which the suckers of ivy penetrate, is necessarily always damp.

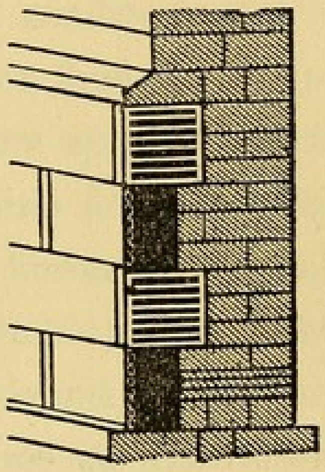
In adopting a damp-proof course, care should be taken that the article chosen should be able to resist the superincumbent weight of walls. Sheets of prepared asphalte will not, for instance, resist the immense pressure of a tall tower, whilst lead will. The weight necessary to crush the perforated stone-ware course (drawn at fig. 99) can hardly be reached by any building; but it is the most expensive of all the systems.

In cases where old buildings are unprotected from rising dampness, it is quite easy to cut out for and insert a damp course such as is drawn at fig. 99. Many houses which once proved uninhabitable have been rendered perfectly healthy in this way.

Dry Areas, &c.

A great many old and a great many new houses both in town and in country have their basement or cellar-floor built without dry areas of any kind, the walls simply abutting against the water-saturated earth; and the consequence of this folly is, that the interiors are always damp and uncomfortable. A way to cure this state of things is to construct a dry area wall on the outside, leaving a space between that and the basement-walls—and even a few inches will afford sensible relief. A brick or a half-brick wall connected with the main wall of building up to the ground-line, by means of an occasional brick stretching between the two, is the common system adopted; but this is not altogether to be recommended, as ordinary brick stretchers still act as partial conductors of the wet. Fig. 100 represents an arrangement to be recommended; and here again are used the vitrified stoneware tiles drawn as flat damp courses, as at fig. 99, only that they are now placed perpendicularly. A still better method is to construct a second or area wall, which shall be unattached to the main wall save just above the ground-line. The best device is of course to build an independent wall to the requisite height, and then cover the intermediate space by an iron grating; but this is an expensive remedy, and might also prove unsightly.

100



In erecting a dry area, care should be taken to ventilate the open space between the walls, or the air there will become foul. A small air-shaft, rising up to six inches above the ground-line and covered by a grating, will generally suffice. The bottom of the area should also be concreted over and drained, and proper steps should be taken to prevent the inroad of rats.

Constructing these areas outside or inside the house is always preferable to battening the inside basement-walls of an old and damp dwelling-house with wood and then boarding over it. It sometimes occurs, however, that little else can be done—as, for instance, in a house where there is a basement on one side of a party-wall and none on the other, or where another inside wall is an objection. Even then the narrow space between wall and boarding should be ventilated. Some are content with ventilating it into the room itself by means of occasional perforations, but this is not a commendable plan. A special shaft might in most cases be constructed so as to lead the close air outside. Instances, I think, will also occur where the space may with benefit be ventilated by way of the chimney-flue.

Hollow Walls.

A building which stands in an exposed situation is generally built with extra thick walls, in order to resist the effects of drifting rains ; but it has been more customary to run them up first with the usual minimum amount of materials, and, if then found pervious, to slate over the walls having exposed aspects. That this outer casing was positively necessary, will have been noticed by those who have inhabited some sea-side villas. The slating of exterior walls in this way prevents the rain from being beaten into the walls by boisterous winds, and also prevents the more constant saturation which takes place in an ordinarily wet season ; and if some ventilating spaces be left where the slates lap, the remedy is not a bad one. A visit to some of the littoral towns in the north will enable one to remark also many other cures for this evil—with its damp wall patches and its mildewed paper hangings. There more especially also will be observed outer walls which have been treated with hot, boiled, and sulphurous oils ; gas and pine tars ; pitch ; asphaltes ; chemical and other paints ; lime, concrete, and mastic cements ; silica, encaustic, and other 'impenetrable' solutions ; water-glass, soap and alum, and scores of other damp-resisting preparations. Sometimes also may be noticed walls built with glazed bricks, and cased with washable enamelled tiles. These will all keep out the external wet, but they will also keep in the wet generated in the interior, which will prove a greater source of mischief in the end.

All these remedies for damp walls are wrong in principle. They shut up the pores of the wall-substance outside, just as much as if they were filled with water. There remains, therefore, only the walling inside these paints for the absorption of the water which is collected there from the air of the house, and such accommodation cannot last for ever. If a new house were originally built of ordinary brick or stone, and coated over with an 'impenetrable' solution however well dried before being inhabited, by means of forced fires and commensurate ventilation, it would not be very long occupied before the walls, by condensing the watery vapour given off by the inmates in breathing, cooking, &c., would be rendered perfectly damp again; the reason being that the walls are then without porosity, and cannot pass the moisture developed inside the house to the exterior of the wall, where it can readily evaporate. The Professor of Hygiene at Munich was perhaps the first to take this view of the functions of a wall, and to compare the building of impervious walls to the wearing of India-rubber textures. Both protect from exterior wet, but as they impede the exchange of air between the inside and outside, they generate a wetness in the interior—upon the skin or upon the walls of the room.

Such are the reasons why all damp-proof paints for the exterior of house-walls are even dangerous. Buildings erected with vitreous slag, like some cottages which I have seen in the iron districts of South Wales, or those constructed with glazed bricks, are of course still more reprehensible. Better build with very porous bricks, provided that the superstructure will not crush them, than with bricks which cannot absorb water at all, nor transmit the air. Sandstones in which the siliceous grains have been cemented together with durable deposits, free working limestones, magnesian limestones, and most granites (if their absorption of water be never followed by disintegration), and even some artificial stones—these are all porous to a certain extent, and consequently to be recommended. Concrete walls, when the concrete contains just a sufficiency of binding medium, may also be made eligible. I speak now of solid, not cavity, walls.

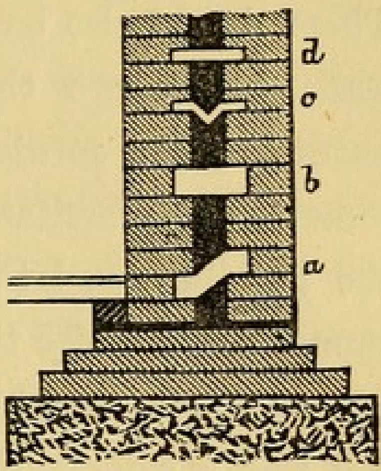
The same general rule as to the desirability of permeable walls applies to all the interior walls of a house, for these bear some such relationship to the exterior walls that under-clothings do to outer garments. If it be unhealthy to wear for any length of time India-rubber outer coats during a wet and cold day, and even for any length of time on a wet and warm day, it is still more unsound to wear a macintosh material next the skin. It is, therefore, a mistake to paint or varnish walls, or to line them with wall-tiles, mirror-attachments, or cement-bedded veneers. Stencilling or water-colour painting upon merely distempered walls can be made to yield as much flat ornamentation as need be desired. The most sensible walls I have seen are those in the passages of the ducal residence at Chatsworth, which were merely built up of rubbed masonry, and neither plastered nor painted. Ordinary plastering will not destroy the porosity of a wall, but houses which already have their walls painted and varnished should be especially well ventilated. We might take many more lessons from our forefathers. When they wished to hide their walls they hung tapestry before them; and if they did paint them, it was not in oils but in frescoes.

I must not be understood as saying that the more porous the materials of a wall are the healthier the house will always be; for, as any one may imagine, a wall may be built of too porous a material—as, for instance, of mud or road-drift; but rather as recommending a certain perviousness of walling materials; and as, with some others, condemning all walls whose *exterior* stopped-up pores prevent the evaporation of water outside, or whose *interior* unporous surface serves merely to precipitate on the inner walls the water derived from the air inside the house. The thing to avoid is a wall-material which will admit water too easily; the thing to adopt is a substance which will just fairly admit the air. With Pettenkofer's apparatus air can be driven through mortar, sandstone, and even some limestones; water will also pass through them, but far less readily.

In a country like ours, where the majority of houses are built with whatever comes first to hand, it is satisfactory to think that everything positively necessary is reached by the adoption of hollow exterior walls. Walls, like garments, interpose between the outer air and the inmates. Hollow walls are doubly agreeable. They render a house cool in summer, and warm in winter. It does not follow that because there is a hollow space the ventilation is impeded, for there is a constant interchange of air between the two walls, just as between coat and vest. Hollow walls are also very readily cleared of drifting wet.

There are several methods of erecting these hollow walls. Sometimes ramped bricks are used, as at *a*, fig. 101; or straight bricks may be inserted, resembling that seen at *b*, and both may have glazed or enamelled surfaces. They are generally laid twenty-seven inches apart, and alternately spaced. There are, moreover, many patterns of iron ties—some made with a depending piece in the middle, and thus forming a water-drip, as at *c*; others are perfectly straight, like that at *d*. These are also variously fashioned at the ends—some bent up at one extremity and turned down at the other; but the kind most commonly used now are those made with clawed ends. As for the space usually left between walls, some architects prefer three, some two, inches. In the house mentioned by me at

101



the beginning of this chapter, the walls have a two-inch space between, and the contents of this hollow space exceed 3,000 cubic feet.

There are some precautions to be taken when building hollow walls—for instance, providing for some means of draining the base of the intermediary space. The best plan is to leave a few small openings there, to the exterior of the house; and, as the hollow walling begins, or should begin, from the damp-course, any water, whether generated inside or outside, will thus readily find exit without soaking into the foundations. There should also be a few air-bricks inserted along the walls, just where the hollow space is left off. The nature of the cornice or the weight of the roof will sometimes necessitate a few solid courses at the top of the building, and the ventilating bricks are best put immediately under these. The hollow space need not be continued round the corners of a structure unless the wall is sufficiently thick to withstand this abstraction of strength where often most wanted. If the walls, too, be kept hollow up to the extreme top, the tie-beams of the roof should sit upon stone templates which cross the space and rest on both walls. As for the window and other sills spanning the hollow, it is a mere matter of strength of outer walling.

Hollow walls are easiest built in brickwork, but they can of course be erected in stone, concrete, or other material. As regards thickness, walls of this description may be built which measure only nine inches across both walls and hollow space as well: for instance, the house and farm-offices of the residence I have previously alluded to are built of two half-brick ($4\frac{1}{2}$ in.) walls, with an air space of two inches. This thinness of wall is, however, only suitable for one-storey erections, or for top storeys of higher buildings. Where the height or weight of superstructure calls for thick walls, the hollow should be begun at such a distance from the face of the outer wall as will preserve the whole space truly perpendicular. The only other caution I can bring to mind is to see that iron ties are so shaped as really to *tie* the walls together, and that they have been either galvanised or dipped in boiled oil, &c. The mortar-droppings should also be well cleaned from the top of the stretching media, and from the foot of the hollow spacing as well.

Damp Pavements, &c.

Many houses are rendered unhealthy by the damp condition of their pavements, particularly in the basement floors—the reason being that the flags have been bedded in mortar laid directly upon the cold earth, instead of having been laid upon a bed of concrete. A wise system is to cover the whole floor superficies with proper concrete, six inches in depth, and then to bed the stones upon a layer of cement upon this concrete. The best plan is to put in the concrete at such a level as will allow of piers or walls being built upon its surface, such piers, &c., being about a foot or so in height, and prepared to carry the stone flagging. Whichever plan be adopted, it is imperative that the subsoil be drained as much as possible, and care should be taken that the walls are guarded by external areas, or the water may find its way through the walls and cover the concrete.

I have seen cellars which have been duly protected by areas from the wetness of the environing soil, and yet, from the absence of ground drains, the piers which supported the flags were found surrounded with water. The only cure for damp flags is to take them up, excavate underneath, put in a bed of concrete, and lay them in cement upon that or upon piers or sleeper walls. If the house has been built, or is being erected, upon *made* ground—*i.e.*, shot rubbish of all kinds—it will be necessary—urges Mr. Rawlinson—to interpose a layer of charcoal.

The Drying of Buildings.

The dampness which results from basement-walls surrounded by damp earth, or from underground paving which had been simply laid upon the cold clay or moist earth, can never be removed by any amount of firing, because the evil is a persistent one. It often occurs, however, that it is necessary to occupy as quickly as possible a new house; and here fires may be made of service, provided that the dwelling has been properly erected. If we institute fires in a room newly built, we render the air in it capable of taking up more than its natural quantity of water; and if we continually replace this fully saturated air by fresh air, the room will speedily become dry. Heat and ventilation combined are the only means by which one can force on a suitable dryness. And yet this is not universally known, for it is not long since I found a builder attempting to dry the walls and ceiling of a newly erected billiard-room by burning coke in two grates placed in the centre of the room, and insisting upon keeping the windows closed for fear of letting in the cold outside air. One thing I might add here, and that is, that the fires should, as much as possible, be kept up in the proper fireplaces, because the ventilation is thus rendered more perfect. A ventilating grate possessing a chamber behind it, which is duly fed with air from the outside, and that sends this air heated into the room, is also of more service than the common form of grate.

CHAPTER VII.

WARMING AND VENTILATION.

Unlike the people of bygone centuries we are even embarrassed in choosing as to how we shall heat our habitations in cold weather. Previous to the seventeenth century only peat and wood were used, but since then the use of coal has grown almost universal amongst us. New fuels have also been elaborated, for instance, gas and the hydro-carbons. In modern times we have also revived the Eastern arts of heating by means of hot-air flues, have invented heating by the use of steam pipes, and, moreover, introduced the high and low pressure hot-water warming. Heating dwellings by steam-pipes has, however, been almost abandoned, and it will not be possible in the present work to describe the warming of rooms by the circulation of hot water. The theory, moreover, of the latter systems is everywhere understood.

I may also, in my remarks upon heating, safely dispense with any description of the *close* foreign stoves, whether Dutch, German, Russian, or American. These, for the most part, save our fuel at the expense of our health. Moreover, closed stoves which hide the fire from our eyes have never been favourably received in this country, and whenever we do find it advisable to adopt one we have many favourite and useful patterns of our own which we infinitely prefer. In February last year a Norwegian stove with which not much fault can be found, was highly lauded, and an English agency established. Several French ideas in ventilating stoves have also been since introduced amongst us. But really, if we would only go to the trouble of choosing a proper kind of grate we might safely gratify our preference for *open* fires.

Ordinary Fireplaces.

The ordinary fireplace of the present day is a disgrace to our community, for it permits a great portion of the fuel consumed in the grate to be completely wasted. The objections to be urged against it are many. Besides those of waste and incomplete and unequal heating, are the draughts of cold air which flow firewards, to the great inconvenience of the occupants of the room; the insufficient ventilation of the apartment, the aptitude to smoke, and the prevalence of dust; the cost of frequent chimney-sweeping which it necessitates, the labour of having continually to supply fuel for combustion, and the risk of fire to person and to property which it always renders possible.

The use of objectionable grates is still persisted in, it would seem, because they are cheap, and because the commonest workman can fix them. It is in the cottages of our artisans that the worst specimens are to be found; but many patterns nearly as bad are foisted into the drawing and other rooms of the upper classes. There are thousands of dwellings in every town and city constructed as if man had been created expressly for the house, not the house for a man. It is the same with the fireplaces; the air would appear to have been intended for the use of the grate, not for the benefit of the occupants of the house.

A good fireplace admits of a steady consumption of fuel, and does not waste it. All the heat produced by combustion is realised in the room; the fire needs little attention, and no poking to keep it from forming black cinders; and, whilst the room is sufficiently warmed at the expense of a minimum amount of firing, a thorough ventilation is secured.

Everyone is sufficiently conversant with the ordinary fireplace and with the common grate, whether with or without hobs and trivets. Indeed there are few who are not also well acquainted with the improved registers of the present day both univalve and bivalve. Many of the latter are now fitted up at an expense which is at first sight incomprehensible. Lately, grates have been introduced that are attached to swinging panels, which, when thrown back like the boxing shutters of a window, permit a wider radiation of the heat, and when closed together—as would be the case in summer when no fire is required—these panels, from their ornamental appearance, form excellent fire-grate blinds. When the fire shines too fiercely in any direction these swinging doors can, moreover, be adjusted so as to act as fire-screens, and if the panels are divided into two heights the top portions when closed will act as very good *blowers.* The kind of grate also, known as a dog-grate, is now coming rapidly into use again, and when the recess in which it is placed is lined with enamelled tiles, which, although they absorb and radiate slowly, still reflect well, and when the fuel which is burnt therein is suitable, a considerable amount of heat is obtained from it. This old-fashioned grate, which is lineally descended from the andiron of the seventeenth century, would be a still greater favourite if it were possible to procure an abundance of hard wood lumps or prepared peat for its especial use. Whether the three Companies formed during the past year for the manufacture of *dense* peat will prove commercial successes is still very doubtful. I have, during the last two years, for my own information, abstracted the whole of the peat patents, and between 1836 and 1873 the English patents alone which have proved useless number over three hundred. Unprepared peat is next to worthless in a modern dwelling, at all events in towns, even if its smell proved unobjectionable.

The majority of the best residences are now supplied with register stoves, and fitted up with fire-clay lumps. Compared with the older patterns in use before Count Rumford's time, these have done excellent work. In case a reader should desire to remove any incompetent grate, and, as I have frequently done, substitute one on the Rumford system, I give at fig. 102 a sketch

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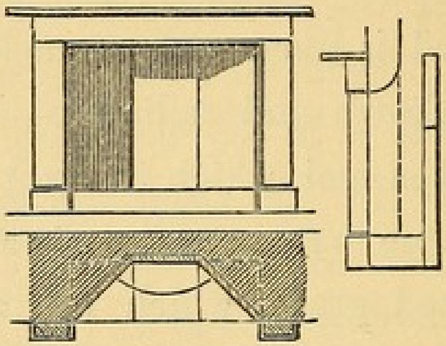

of one, omitting the fire-bars, about which there is nothing peculiar. Indeed, any fire-bar front will serve the purpose, and ornamentation can be eschewed or the contrary.

In setting out a fire-place on this principle, divide the hearth recess into three equal squares, as shown on plan *a*, and take the diagonal of the two outside squares for the angle of covings. This will be 45°, but some little divergence may be made to accommodate a favourite grate. The depth of the fireplace and the back of the fireplace will thus be one third of the front opening. The flue in the narrowest part above the fire should not exceed five inches, and the way to obtain the exact position of the flue is to let fall a plumb line from the inside of chimney-breast (see dotted line on section) the five-inch set-back to be made from where the plumb hits the hearth. The coving behind these grates—which, by the way, may have hobs if preferred—is best formed of fire-bricks, and if kept cleaned down or well black-leaded, they are really not objectionable even in a drawing-room. Fire-bricks or fire-clay lumps prevent the fire from going quickly out, and they also partly compensate for the sudden changes of temperature in cold weather consequent upon opening doors or windows of rooms.

One fault of the foregoing kinds of grates is that they heat by radiation only, and by an acknowledged rule, this heat at ten feet distant from the fire, is 100 times less than that given off at a distance of one foot. It may be the most healthy way of heating, inasmuch as it warms the person and cannot overheat the air, but in a long room two or three fires would be found necessary in order to comfortably warm the inmates. Perhaps the greatest objection however is, that excessive draughts often set towards the fire from the door, in order to replace the air which has been warmed and withdrawn up the chimney. When sitting before some fireplaces of the kind, one side of the person may be tolerably warm and the other side disagreeably cold. The feet and legs which are in a direct line between grate and door will especially suffer. The head suffers too, and is injuriously affected by the foul and heat-expanded air which bathes it.[1] If this influx of cold air be interrupted, the chimney will simply *smoke*, as there will be no cold air to press the warmed air, &c., up the chimney. Mr. Rawlinson has quoted a case where he cured a smoky chimney by cutting a slit in the lintel of the doorway: this was simply to establish the proper current, and many other apparently singular cures have been recorded.

Fire-grates fed with Air from outside.

In order to reduce the risk of such draughts to a minimum, it is customary to lead the air from the ex-

[1] The modern Chinese, near Pekin especially, heat the floor surface *from underneath* with balls of small-coal and dung, which evolve but little smoke. They warm their feet, and by this means enable the upper part of their persons to endure the more condensed and invigorating atmosphere. The ancient Romans did the same with the hypocaustum. Mr. Edwin Chadwick, C.B., considers it perhaps the best method of warming buildings. Dr. Parkes is of the same opinion. The Dennett Arch (fireproof) system would, I think, render the system easy of achievement, and at the lowest possible outlay. Captain Galton, in his experiments, showed that to maintain 18° over the outdoor temperature for two days, the cost was 3*s.* 4*d.* with warmed floors, and only 1*s.* 4*d.* with the ventilating fireplace.

terior of the house to the underside of even the commoner grates. The air-duct may terminate in a grating in the hearth under the fire, fitted up with a sliding or other regulator, or the air channel may be constructed so as to traverse the body of the fender and deliver the air from inside its radius. It does not signify very much which system is adopted, as the result will be the same, viz., the heating of the air as it enters, part of it being drawn up the flue, and the balance of the warmed air circulating in the room.

A fire thus fed with fresh air never supplies itself with oxygen by means of a downcast current in the chimneys of adjoining fireplaces.

The 600 cubic feet or so of air per minute ordinarily required by a fire must be had from somewhere, and this air should not rush violently from the lobbies or passages, but be properly directed in a sensible manner to where it is wanted.

Open Ventilating Grates.

This is the name now generally given to those grates and stoves which are immediately connected with chambers into which fresh air from the outside is led and heated, and out of which such warmed air is passed into the room. They are destined soon to replace all the more old-fashioned articles, not only because by their adoption the heat is utilised, draughts rendered impossible, and due ventilation secured, but because they offer facilities for heating adjoining rooms, or rooms in the upper stories, from one and the same fire, simply by leading tubes to these places from the warm-air chambers. It may, therefore, be as well to describe a few of the more important kinds.

Fig. 103 gives a view of the Galton ventilating fireplace. The grate is fitted with iron gills at the

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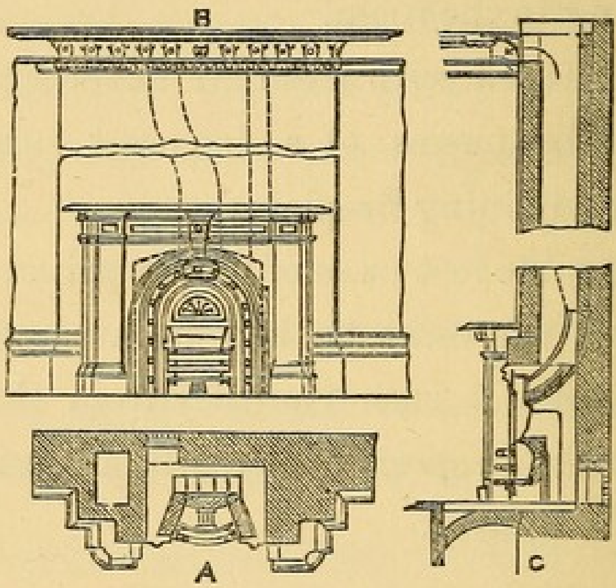

back (see plan A), which gills are heated by the burning material in the grate; and as fresh air passes through the grating at the back into the chamber formed by this gill-surface and the brickwork recess, it is warmed, rises up the hot-air flue leading out of the top of the chamber, and finds a passage into the room near the ceiling. In some cases the warmed air passes into the room near the top of the chimney-breast through a louvre ventilator, and it is also frequently led into the room from behind a perforated metal plate in the coving of the cornice. The inside of the grate is lined with fire-clay lumps, and a half-inch space between the *back* lump and the iron back of the grate admits a supply of air to the fuel and secures a more perfect combustion of the gases. The smoke passes up the chimney in the usual manner, in a separate flue, having no connection with the hot-air flue, as will be noticed in the elevation B and section C.[1] This system of fireplace works admirably, provided the smoke-flue is properly attached to the grate. Despite all precautions there is frequently a slight escape of smoke, which is indicated by a blackness round the inlet near the ceiling. This, however, chiefly arises from the smuts with which the cold air entering from the outside is loaded; and in both cases Captain Galton recommends a filter of cotton-wool, to be placed, if possible, at the fresh-air inlet outside, and a second one at the warm-air inlet into the room.

A ventilating fireplace which differs from the foregoing, inasmuch as the air-chamber is attached to and forms part of the fireplace, is that known as the London school-grate. The objection to adopting most

[1] When a single flue is preferred, it is made sufficiently large to accommodate an iron smoke-flue inside. The single flue in this case acts as a warm air-chamber, heated by the smoke-flue which it encloses.

ventilating grates on account of the cost and trouble of building brick air-chambers and flues—whatever that objection is worth—is thus avoided. Another peculiarity of this last mentioned grate is the adoption of a syphon-pipe, which withdraws the vitiated air from the ceiling level down to the ashpit, and assists combustion.

A grate of this ventilating order which *projects* some six inches below the chimney-piece has lately been introduced; and here the smoke and heat rise to the top of the grate, and, being arrested there by the grate-roof, descend until they reach the side flues, whence they find their way up the chimney. Hot-air chambers are variously arranged in the front, back, and sides of the fire-flue. A ventilating grate is also in use at Charing Cross Hospital, which not only acts as a medium for the circulation of warm air into the room, but also as a hot closet. The bottom of the grate is of solid iron, the sides of fire-clay, and the smoke is withdrawn through an aperture at the back. The hot closet is fitted up with sliding doors.

In choosing a ventilating grate for a house, I should give a preference to one which is constructed with shelves of fire-clay at the back, instead of iron, in order to retard the introduced fresh air in its passage to the outlet, until such air is well heated. A grate of this description is exhibited at fig. 104—*a* representing an elevation of the shelves at the back. The fresh-air duct will be noticed below, and also the warm-air outlets in the shoulders above. The space taken up by the hot-air chamber can be seen in plan at *c*, and in section at *d*. The number and size of these shelves or baffles should be determined by experience, and should afford a total of heating surface considerably beyond

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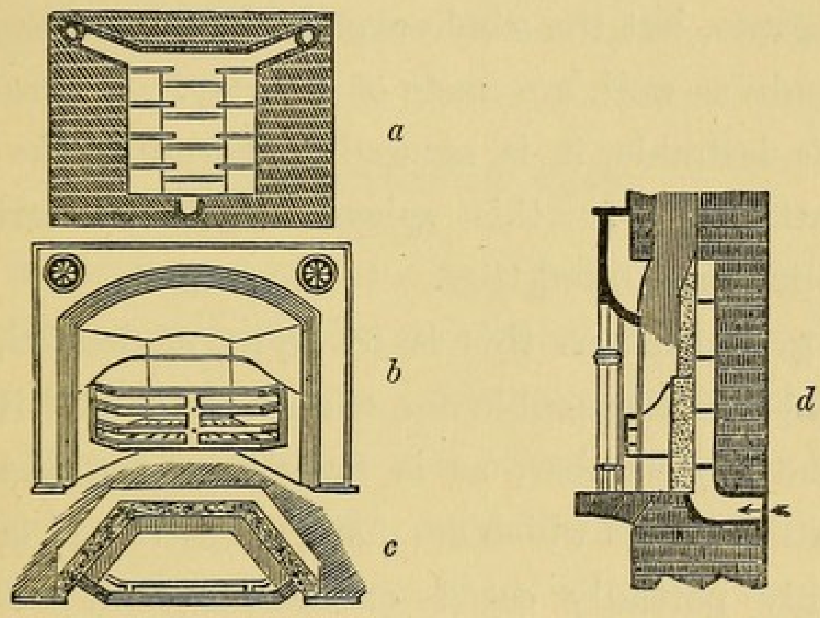

that exposed to the direct action of the fire inside the grate. In the sketch here given the warmed air is led into the room from the two circular orifices seen at *b*, but in some instances they are preferably placed at the sides of the chimney projection.

Fire-clay casings are objected to by some on the score that they are easily broken. If it were customary to put out the fire by drenching it with cold water, I could easily understand a consequent fracturing of the jambs and back; but this is an uncommon practice, as is also a total removal of the heated fuel on retiring at night. Still the fire-clay will suffer damage in time; and, in order to remedy this as readily as possible, supplementary and movable fire-clay back and side fittings, the same height as the fire-bars, are, as may be seen, provided to these grates. In this kind of grate I may mention that not only the fuel-containing portion of the grate, but the whole exposed surface of the sides and jambs as well, are made of fire-clay. Where ornament is desirable, it is secured by bevelling the front, and attaching to this splayed surface a series of enamelled or painted tiles.

A grate such as this is to be recommended, inasmuch as it is impossible for the smoke to find its way into the air-chamber, as is sometimes the case with ventilating grates which are mainly constructed of iron, and only partially cased or backed with fire-clay. There is, then, a necessary junction between the iron and the clay, and here smoke is apt to find its way into the air-chamber when the fire is at first lighted, and before expansion has had due effect. In the grate now under review, the bolting of the bars can be done so as to avoid this danger, or they can be slid into grooves of fire-clay material. The mouths of the hot-air inlets are fitted up with either balancing, sliding, or turning valves, in order to assist in regulating the temperature of the room. Such valves should never be bedded in the walls, but screwed upon a frame or suitable grounds.

I have now given a short description of some of the best ventilating grates, and it will be noticed that they distribute the hot air and withdraw the respired air at various heights up the wall of the room. Provided that the fireplaces and flues are properly constructed, each system will satisfactorily heat and ventilate a room.

Open Ventilating Stoves.

A ventilating stove acts in the same manner as a ventilating grate—viz., by warming air introduced from without for distribution in a room, and for maintaining an equable temperature in such room, at the same time effecting a commensurate ventilation in a natural manner. As cases continually occur where the use of stoves proves preferable to grates, I will describe two kinds which are very valuable in differing circumstances, and both of which preserve the open fireplace. It must be borne in mind that these ventilating stoves are not suitable for places where a fire is wanted to burn all night without attention, as this benefit can only be secured by the adoption of the gas-calorigen, or by slow combustion stoves. Fig. 105 represents the pyro-pneumatic stove, the inner part of which is constructed of fire-clay lumps, and the outer casing generally of decorated iron. The lumps are constructed with vertical air-passages, the bases of which are connected with a channel communicating with the external air, and the warm air issues from the top of the stove into the apartment. A sketch of both an ascending and descending smoke-flue is here given; but a descending flue should only be resorted to in those exceptional cases where an upright flue is found a matter of impossibility. If a descending flue be found indispensable—

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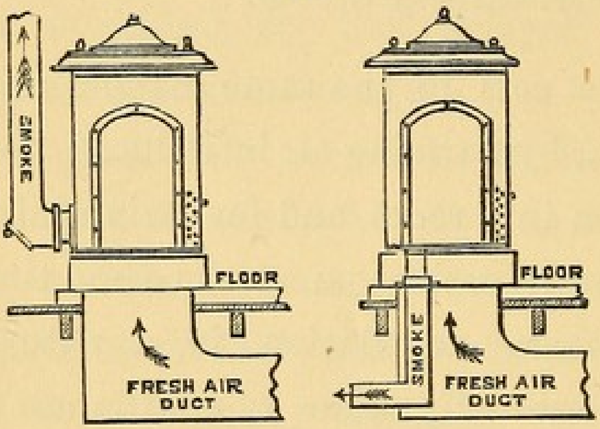

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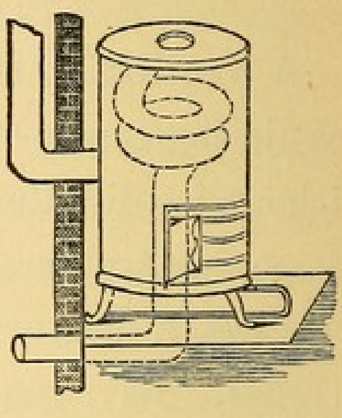

as would be the case when the stove is to be fixed in the centre of the room—a large gas-burner or rarefying apparatus should be placed where the base of the upright chimney receives the end of the horizontal flue; and if this pilot-stove, gas-jet, or whatever it may be, be lighted a short time before the stove itself is kindled, all smoke will be satisfactorily withdrawn.

The most scientifically constructed coal-stove is the coal-calorigen, given at fig. 106. The stove body is constructed of thin rolled iron, and the front is generally fitted up with sliding-doors. Inside is a thin coil of wrought-iron, communicating at one end with the outer air, and as the fresh air enters, it is heated in its passage through this coil, and flows into the room through the aperture at the top of the stove. It is found in practice that the warmed air rises, diffuses itself over the ceiling, then slowly descends to the floor, and is drawn into the fire by way of the fire-box. A constant circulation is thus obtained. The coal-calorigen will be found extremely useful in the case of a damp house, as by its use a constant current of heated air is perpetually ascending to the highest part of the building. As for the cost of the coals consumed, it averages threepence daily.[1]

Memoranda on Fresh-air Inlets for Ventilating Grates or Stoves.

The fresh-air ducts can be led to the backs of the fireplaces in many ways; but the directest route is the best, as, for instance, from the outside of the opposite

[1] This coal-calorigen is so constructed as to retain a deposit of carbon in its interior, and this, it is said, prevents the absorption of oxygen and the emission of hydrogen and oxide of carbon.

Dr. Bond, Medical Officer of Health, Gloucester, writes me to the effect that a good coating of silicate solution upon the outside of an open iron stove, prevents the diffusion of these deleterious products. He has experimented upon one with this result.

wall, parallel between two joists, and through the trimmer to the air-chamber. It may occur, however, that the joists run in a contrary direction; and, if so, and if the notching of the whole series would weaken the floor, the air-tube can be led along the ceiling of the room underneath; or, should the joists of the adjoining room run in the favourable direction, the air-duct can be led to its proper fireplace from behind. It may also be brought into the room along one of the recesses formed by the projecting chimney-jambs; and where two fireplaces exist back to back, only one room need be disfigured in this way. Where the tubing *must* cut away the trimmer, the latter can be strengthened by two pieces of iron bolted together through it. It may happen, too, that there is a lean-to building behind and a party-wall all round the room, and in such cases the air-duct can be led from the exterior wall between the joists of the room above and down the wall to the place where it is wanted. The same rule will hold good where the tube is wanted to supply a basement fireplace. The only thing to avoid is the leading of air from too near the ground-line; and it would be wise to allow of no inlet closer than two feet from the ground. Inlets should also as much as possible be situated on the south or south-west aspects; and in no case should they be above or near the gulley-holes, dust-heaps, or other sources of contamination. To conclude, the mouths of the inlets should be protected by air-bricks, not only to break up the air, but to protect the tubes from the inroads of slugs and vermin. Cotton-wool filters may be attached to the inlet-gratings in cases where sooty smuts prevail.

These air-ducts can be constructed of various kinds of material—in fact, anything that can be made air-tight. Some architects bed pipes in the walls, and if this can be done it is the most economical system. If earthenware pipes are anywhere laid upon the ground, they should be of the socketed and glazed kinds, and the joints should be well luted with cement. Where they run between the joists, they can be made of zinc, with soldered longitudinal seams and close-fitting telescopic joints, and these may be made either round, square, or oblong, to suit the exigency of the case. The air-passages can also be made of wood; but in such instances the wood must be planed over inside, and tongued or dovetailed at the angles. An important matter to bear in mind, also, is to leave some means of cleaning out the dust which will be certain to lodge in these air-ducts; and, where such dust is not intended to be withdrawn by a fan or some similar contrivance, a portion of the wooden or zinc pipe can be made with a cover at some convenient place. Contrivances resembling soot-doors can also be made at the angles, if any exist. If drain-pipes form the media of conveyance, they can be occasionally varied by pipes affording means of access.

Smokeless Open Grates.

There is in this country an almost insurmountable dislike to firegrates which in any way hide the fire from view; but often, in order to obtain this open appearance, most objectionable grates are used, which send volumes of black smoke up the chimney at a ruinous waste of coals. It surely cannot be sufficiently known that grates can be purchased of the kind called *smokeless*, which heat the room for a considerable length of time without attention, and which entirely consume the smoke. Instead of throwing the coal on the top of the grate, it is stored in a chamber below the fire-bars, and a *lifting bottom* raises up the coal as it is consumed, torch-like, from above; or an ornamental *trough* is fixed to the lower portion of the grate-front, which trough is filled with coal, and, when the fire has to be fed, a right- and left-handed screw, in front of the trough, is turned by a ratchet-work, moved by the poker, the burning fuel being raised up and fresh coals deposited underneath. By either of these systems of feeding, the coal below is partially coked and prepared for burning; the whole of the gases evolved by the burning coal are also consumed in the top layer of incandescent fuel. Perhaps the greatest boon secured by this kind of grate is the increased vitality of the fire, which follows the closing of the bottom of the grate with iron so as to hold the fresh coals, and the consequent avoidance of too great a flow of oxygen to the under side of the grate. If a servant only takes the trouble to light a fire in such a grate properly—at say ten o'clock in the morning—it will be found to be still alive at ten o'clock at night. It frequently happens that a fire is required in a room where it cannot receive the ordinary attention necessary for replenishing it; or there may be a reception-room which is but occasionally used during the day, and yet which it would be unwise to leave without a fire. Perhaps it is a library or consulting-room, where an enforced absence is unavoidable at times, and the time of return equally unforeseen; or it may be a hall, a passage, or even a picture-gallery, where a steady genial warmth is desirable without much attention. In all such cases, and in numberless others, if the heating is to be performed by means of a fireplace and coal, the smokeless grates are very valuable.

A reversible grate on the slow combustion principle has lately been introduced to take the place of the ordinary dog-grates, and at the present moment the idea is being extended so as to suit the register grate arrangement. The fuel for lighting is laid at the top, and allowed to burn until the fire needs replenishing, whereupon fresh coal is thrown on the fire, the grating shut down, and by pushing forward a pronged poker the fire-basket is turned upside down. The red-hot coal is thus brought to the top and the perfect combustion of the lately added fuel attained. When the fire has burnt low fresh fuel is added at the top, and the grate reversed as before. This reversible grate is adapted to all kinds of fuel, there is no complicated gearing, and as the fire-basket reverses the uppermost grating adjusts itself.[1]

Slow combustion Open Grates and Close Stoves.

The slow combustion grates for the most part afford the advantages derived from the use of the smokeless grates; but their construction varies, inasmuch as the fire is not necessarily lighted from above. The space between the bottom bar of the grate and the hearth is filled up with a sheet of iron or other material, and perforations are made in it at intervals, so as to admit just sufficient air for combustion; and in this case the ash-pit is generally below the hearth. For the use of reception-rooms, these grates are now fitted up

[1] This is one of the many original ideas of Franklin. His fire-cage was, however, a circular one.

with ash-pans, which fill up the space before alluded to, and the fronts of which are ornamentally pierced.

The chief inducement to adopt grates of this description, and the main reason of their present popularity, is the saving of coal which they effect; but stoves on the slow combustion principle have long been favourably known. In places where fires are required to be kept going both day and night, the Arnott's stove and its congeners are well-nigh indispensable. Some of them are constructed with gills or projecting ribs around the exterior, and these serve to modify and dispense the heat equably. The Belfast stove of this description is made so as to accommodate any possible amount of ornament. The fuel burnt in such stoves is either coke or anthracite coal, which is placed at the top of the grate, and the ashes are removed at the bottom. Some require feeding only once, and others only twice, during the day. They can also be made to burn twenty-four and even thirty-six hours without attention, at a cost of about sixpence *per diem.* One objection made to their use—viz. that the fire is invisible—cannot be averted; another, that the air is apt to be burnt by their adoption, can be remedied by placing upon them a suitable dish containing water for evaporation.

The most recent of all the slow combustion stoves is the patent one drawn at fig. 107; and since the rise in the price of coal, it has met with considerable patronage, from the fact that a fire once lighted in it can be maintained for twenty-four hours at a cost of twopence. It is cylindrical in shape; the body (C) having an exterior casing, which is perforated with holes to allow the escape of the heat, the jacketing or space between being filled up with powdered terra-cotta. The top (D) is similarly constructed, and fits in an annular groove, which is kept filled with fine dry sand, to prevent the escape of smoke into the room.

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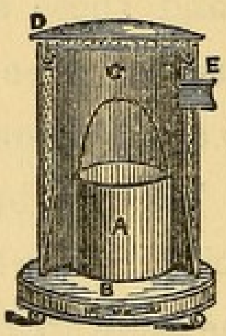

The products of combustion pass into the flue by means of the pipe leading out of the top of the receptacle, the nozzle (E) of which must be kept free from soot, in order to be efficient. It can be fixed before any fire-place, or iron pipes can be adopted, as in the case of an ordinary stove. The firebox (A), which should be kept in duplicate ready to replace the one in use, is first of all nearly filled with coal and coke mixed in lumps about the size of a pigeon's egg. A piece of paper is next placed upon this, some small wood above that, and then a little coal upon the wood. It is then lighted and covered by the movable top (D). The damper (B) is partly closed after lighting, and the closing of this damper readily extinguishes the fire. It is best placed upon a sheet of non-conducting material, such as lead. The material introduced should be perfectly dry, and should also be free from dust. This stove is certainly a curiosity in its way, and gives off a genial heat, as I have frequently seen—its only fault being that it derives its supporting air from the room, and heats by radiation only.

Heating by means of Gas.

Gas is either employed *temporarily*, because of the promptitude with which its flame can be applied, as, for instance, in heating baths; or *permanently*, because of its cheapness, as in stoves and fires. Well applied, four cubic feet will boil a gallon of water in twenty minutes at a cost of ·22 of a penny, which is about a third of the cost and time required by the use of coal. Numerous gas cooking and heating stoves have been introduced of late years, and that they have been greatly appreciated is beyond all doubt. It is not necessary here to enter upon a description of any of the numberless common patterns extant, but it might be well to record the opinion of the best engineers, that the simplest gas-stove is the best. They should not be surrounded by a non-conducting material, as that affords no advantage, but the contrary. An Argand or fish-tail burner should also be used instead of rings pierced for so many separate jets, and, where practicable, the Bunsen burner should be employed, as the admixture of common air with the gas not only prevents the formation of soot but also intensifies the heat.

Open Gas-fires.

It frequently occurs that firegrate-openings have been constructed in places where it proves inconvenient to burn coal, partly on account of the want of proper attendance, and partly because the fire is not constantly required. In such a case, it is customary to fit up a service-pipe under the grate, and to fill it with lumps of roughly pulled fire-clay, in order that, when the gas is lighted, the flame shall impinge upon the lumps and cause them to become incandescent. Pumice stone, asbestos, peroxide of manganese, and metallic platinum are also burnt in this way, and in each case the result is a cheerful open fire, which gives off an excellent heat. All that is necessary is to take care that the grate is not choked with the material chosen, and that there is a commensurate ventilation.

Gas Ventilating Stove.

Perhaps the best contrivance for heating and ventilating a room by means of gas is the gas-calorigen, drawn at fig. 108, which consists of a cylinder of wrought iron, closed at top and bottom, in order that the burner in the interior should have no communication with the air of the room. Outside the wall is a small cylinder, open only at the top, and two tubes lead from this into the stove—the bottom one supplying the flame

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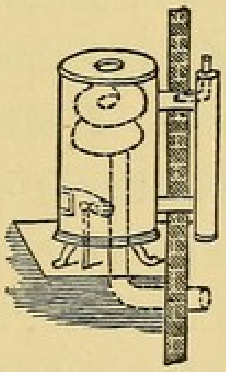

with the necessary air, and the top one carrying away the products of combustion. The fresh air which enters the stove interior comes into contact with the heated air which leaves it, thus regulating the flow, and also economising the heat. The combustion of the gas being thus provided for without permitting the fumes to enter the room, the next thing to ensure is a heating medium for the room itself, and this is secured by leading a tube from the exterior air to the under side of the stove, and carrying it through the same, with a retarding coil as shown. The fresh air from without is thus warmed in its passage to the orifice at the top, and the result is warmth and ventilation with an absence of all draughts. When the calorigen is required to be fitted to an open fireplace, the old grate is removed, and the front opening closed with a plate. The cross-tubes are then pushed through the plate, and in such cases the outside cylinder is not required. I have lately fitted up two of these joined together in the fireplace of a hall; and not only the hall, but the passages adjoining and the whole staircase, is now admirably warmed. They are also well adapted for maintaining an equable temperature in the bed-room. I have, moreover, known a gas-calorigen to be persistently capable of registering fifteen deg. above the external temperature during a very severe winter, and that, too, in a room of over 1700 cubic feet, with the roof and three sides constructed of glass.

Lighting Coal-fires by Gas.

It may not be generally known that a jet of gas can be adopted for lighting ordinary coal fires, thus saving the cost of paper and wood, besides proving more cleanly. This kind of fire-lighter consists of a piece of copper pipe attached to an elastic tube which screws on the nearest gas-bracket; and, when the coal has been broken up and put in the grate, the end of the metal tube is inserted in the coal and the gas ignited. Two Bunsen burners are sometimes applied in a similar manner. This ease of application is a great boon, even apart from the fact that, at the cost of one-tenth of a penny, a bright fire can be produced in ten minutes.

Smoky Chimneys.

An enumeration of the causes of smoky chimneys would tire the most patient reader, but it is now generally known that, if a flue be properly contracted at the top, all the heated smoke will be speedily and satisfactorily withdrawn. Neither is there any necessity for disfiguring our chimneys with horrid-looking cowls and abortive pots, as is frequently done. In most cases of smoky chimneys a cure can be effected by the adoption of the contrivance represented at fig. 109. Here the wind, blowing against the external slope of the cones (*a*), tends to increase the exodus of the smoke, and the partitions (*b*) serve to isolate each flue from the back-smoke of its neighbour. Both the cones and partitions are made of terra-cotta, and are designed so as to suit every style of architecture. I have very seldom known this arrangement to fail in preventing a smoky chimney; and, did such a case occur in my practice, I should use the iron injector apparatus, drawn at fig. 110. The arrangement is composed of a

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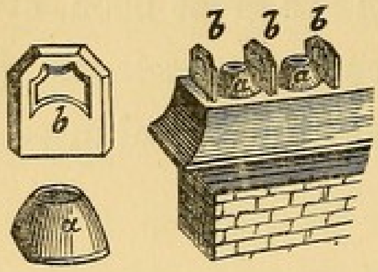

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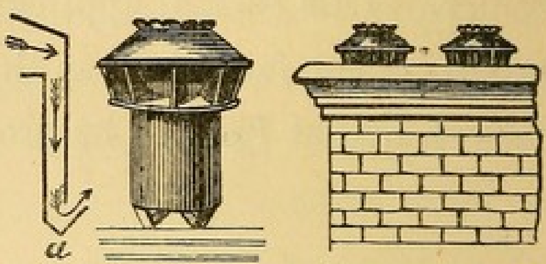


series of outside mouths, which receive the wind and pass it down narrow tubes, at the foot of which, when well compressed, it is caught by an angular valve (*a*) which compels it to escape with great force into the smoke-flue proper, and thence out of the top. A continual suction is in this way created at the mouth of the chimney, and it works well, even in a comparatively still atmosphere.

It is still an open question as to whether a city would be benefited if a complete combustion of coals were universally adopted in our domestic fireplaces, or whether the remedy would not be worse than the complaint. If we fully realise the large amount of fuel which passes up the chimney in the shape of smoke and soot, we should be simply liberating more carbonic acid gas, a heavy body which would certainly descend from our low chimneys and poison the atmosphere of our streets. It is very proper to compel manufacturers to consume their smoke, but then they have lofty shafts, and the deleterious gases are well diffused before they reach the zone of breathing.[1] When the smoke nuisance was first decried,[2] the tall shaft was even then recognised to be a necessity. In the meantime economical people use balanced fire doors to their kitcheners, &c., and save their coals.

Ventilation.[3]

By ventilation is meant the removal of vitiated air and its replacement by fresh air. We ventilate our rooms in order to get rid of the offensive organic impurities given off by the inmates, and in order to dispel the moisture which they have imparted to the air. Or we may ventilate a room in order to remove air which has become burnt or extra dry. We also ventilate in order to withdraw the fumes of smoke or the smell of gas. We ventilate to disperse from but recently

[1] The proper adjustment of the air to the fuel is the sole secret of perfect combustion. A visit to the paper mills at Ilford, near London, in order to see the working of the Prideaux apparatus, would well repay any manufacturer unacquainted with it.

[2] By Mr. T. Spencer Wells, twenty-one years ago.

[3] I take it for granted that everyone knows the ordinary maxims upon this subject: that a staircase should always be ventilated at the top; the advisability of opening a portion of the window under certain circumstances, and so on.

opened rooms the mouldy smell betokening the presence of fungi which have had time to develope and decay. Or we ventilate our sick rooms in order to cause such a dilution of the air as to render infection impossible.

The chief reason for ventilating is, however, to get rid of any excess of carbonic acid—a gas which we cannot sometimes detect until we observe the lights to be burning dimly—and also to increase the diminished oxygen. The increase of carbonic acid and the decrease of oxygen is a certain proof of the unhealthy condition of the atmosphere. The relative proportions from purest to impurest air are set forth in the following sliding scale, which I have compiled from the works of Dr. Angus Smith and other authorities.

	Oxygen	Carbonic acid
	per cent.	per cent.
Sea shores and mountain tops . .	20·992	0·0336
Pure town and country air . . .	20·960	0·04
Sitting-room, not close . . .	20·890	...
Dwelling, during the day, *mean* . .	...	0·068
After 6 hours in a room with lamp, good draught	20·840	...
Bed-room at night, with part-open windows	...	0·082
Study: 4 inmates, 3 gas-lights, and fire; *taken at table* . . .	...	0·1177
Bed-room at night, with windows closed	...	0·230
After 3 hours, in a room with fire; 3 gas-lights, 2 inmates, closed doors, &c.; *taken* 5 *feet from floor line* . .	20·75	0·38
Same room, and same time as foregoing; *taken only* 18 *inches from ceiling* .	20·46	0·69
When a candle will not burn . .	18·50	...
Worst specimens in unventilated mines	18·27	...

Fresh-air Inlets.

We may therefore at once assume that both fresh air *inlets* and foul air outlets are requisite in every room.[1] Where inlets are unprovided in a room heated by a common fireplace, the air to support combustion is drawn down to the fire through the flue which was intended for the withdrawal of the smoke, and when this incoming air is *blown in* by the wind, the ascending smoke is puffed back into the room. The only cure for this is to create an inlet at some proper place. There would be no objection to the inlets of fresh air being placed at the floor line provided that the air were warmed before its introduction into the room. But inlets of cold air from without at carpet level prove intolerable, and unwarmed air is best brought in about eighteen inches below the ceiling. The inlets may be distributed round the room, but none of them should be so close to the foul air outlet as to cause the fresh air to be at once led off. There is less risk of draughts if the main inlet be placed in the wall opposite the fireplace, but a great deal depends upon whether the air is led into the room direct from the outer air or

[1] I cannot in the present small and merely suggestive work quote the formulæ for calculating the effective sizes of these inlets and outlets. All the useful ones are to be found in Dr. Parkes's 'Practical Hygiene.'

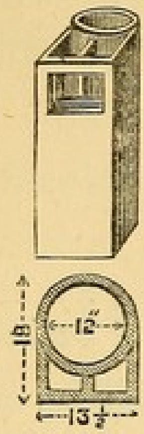
borrowed from a passage. The best inlet is the upturned louvre pattern, fitted with a suitable regulator. If these pure-air inlets are made equal to twice the sectional area of the flue there will be no chance of draughts.

A room heated from an ordinary or unventilating fireplace by radiation only, greatly varies in temperature at different parts of the room, and, according to Dr. Parkes, as much as from 4° to 6° Fahr. The variation of temperature in the different portions of a room heated by warm air from the Galton stove does not exceed 1° Fahr. This is a strong recommendation of the ventilating grates. With the latter grates there is also a perfect intermingling of the air in the room with the warm air passed in from the air-chamber. As a general rule the thermometer will read the same at floor, at window, and at ceiling heights. It is very different with an ordinary fire-place. An experiment was made in February last year by Dr. Russell of St. Bartholomew's Hospital in a room 15 ft. × $13\frac{1}{2}$ ft. × $10\frac{1}{2}$ ft. high (2,126 cubic feet of space) with the roughly fitting doors and windows closed, and with a fire and three gas-burners alight. Two persons only were in the chamber, making observations, and thus the conditions were exactly the same as in thousands of houses during the winter season. After three hours had elapsed the temperature at 9 inches below the ceiling had risen 17·5°, at 5 feet above floor line it had risen 15°, and at the floor level 4° above the temperature taken before the doors and windows were shut, and when the room was filled with fresh air.

Foul-air Outlets.

A room requires, as well as an inlet, a foul-air *outlet* to be provided, which should be as near the ceiling as possible. Otherwise the air will be respired over and over again. Such an outlet would be an Arnott's or other valve fixed in the chimney-flue at the top of the room. This is not an automatically-working cure, and there is, moreover, a danger of cold air and even smoky down-draughts when the *smoke flue* is pierced. A brick air-flue, say 9 in. × 4 in., should therefore be built alongside the smoke-flue, curving with it, and terminating with a suitably large air-brick under the chimney-cap. If such a separate flue be fitted up with a grating near the ceiling, the rarefied air in the flue will maintain a constant ventilating action. The products of combustion from the gaseliers can also be led into the same flue, as will be noticed further on. At fig. 111 is represented on plan, a terra-cotta smoke-flue and foul-air shafts combined, which is much used, especially in the North of England, where stone is abundant and where they can be inserted in thick walling. They would quite divide an ordinary brick wall and destroy the bond.

111



When these are piled up sufficiently high in the work a length is introduced having a piece cut out in order to receive a valve or grating, as shown in the elevation.

Such outlets in the smoke or foul air flues are not, according to some, absolutely necessary, when ventilating grates are adopted, because most of the foul air is burnt in the grate. They will, however, be found indispensable in the summer time, when the fires are not lighted, and should indeed be always provided when building a house. Sometimes a tenant will not use ventilating grates, but will replace them with more showy registers, in which case he would have to insert a valve in the *smoke* flue but with a certainty of blackening his cornice. A separate foul air shaft which properly takes advantage of the heat passing up the chimney cannot be built afterwards, except at a very considerable expense.

Another wise thing is to provide in the walls at various parts of the room, a shaft 4 in. or 5 in. square, leading up to the top of the house, and terminating outside with an air brick, or down-draught preventing valves. These flues are easily built by the bricklayer drawing up a piece of wood scantling as the work proceeds. If a room be very large and there be only one ordinary fireplace, the outlet at the chimney breast will be insufficient to remove the respired air, &c., on a close summer day, and these auxiliary flues fitted up with a valved opening at ceiling can be made to assist in this work by simply lighting a jet of gas in one or two of them, just above floor line. In a bitterly cold winter too, such a large room cannot be heated by one unventilating fireplace, and such a shaft will suit admirably for the accommodation of the gas-calorigen drawn at fig. 108. I have frequently seen large rooms thoroughly heated in this way; a common radiating grate being supplemented by a scientifically constructed ventilating stove.

The ventilating fireplaces do not seem to interfere with the natural currents of air in a room. In a place heated by a good ordinary fireplace, and when doors and windows are closed, the air rushes from the foot of the door along the floor towards the fire, part passing to the fire itself, and part being carried up the chimney-breast, then across the ceiling down the walls opposite, and across the floor to the fire again. When the fire is fed with exterior air by way of the underside of the grate, &c., the current of fresh air from the door is not required, and part of the air which enters under the grate passes up the chimney, the remainder being circulated in the room in the manner before mentioned.

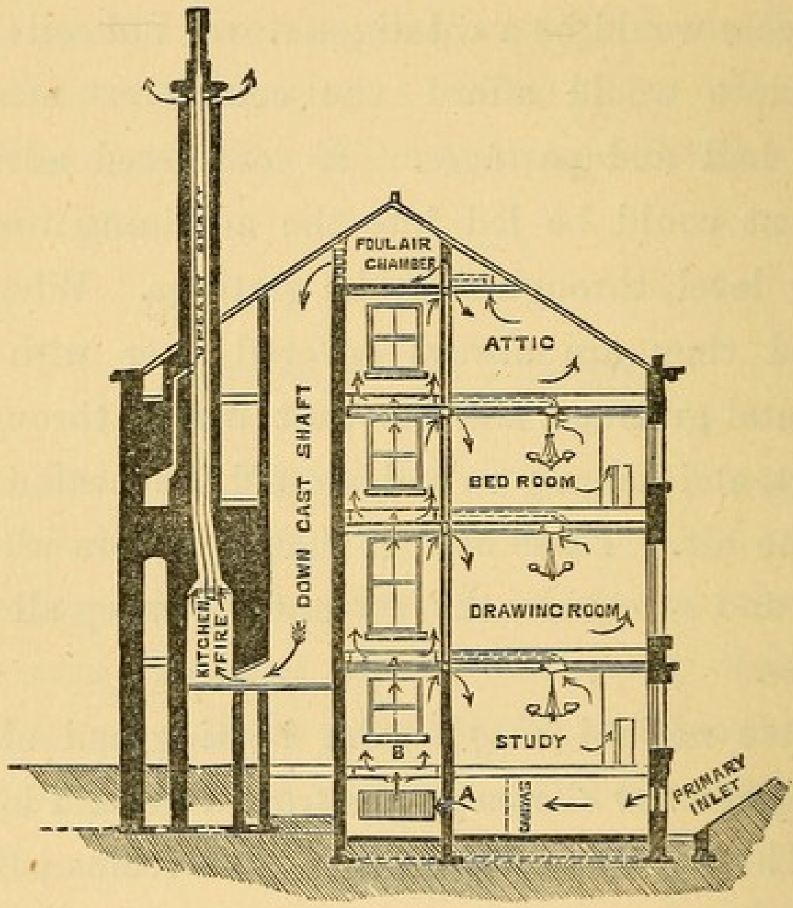
When ventilating grates are in use, the air follows the same course. For instance, the entering air warmed in the chamber behind the Galton grate, fig. 103, is passed into the room through the ventilator near the ceiling, and this freshly warmed air is then blown along the ceiling to the walls opposite, down which it descends and flows along the floor to the fire. The warmed air takes a similar course, whether it proceeds from the front of the chimney-piece as drawn at fig. 104, or from the orifice on the top of the calorigens sketched at figs. 106 and 108.

Warmed Air in Passages.

The foregoing remarks will apply to house or cottage alike, whether ordinary grate, air-supplied grate, or ventilating grate be adopted, but it may be called *single room treatment* only. The majority of the better class of houses are now provided with entrance halls, &c., and if the cold air be allowed to fill them each time the front door is opened, this cold air will penetrate into the sitting rooms, and much of the benefit to be derived from the use of improved contrivances within them will be lost. There can be no question then, that in winter rooms should receive their air supply from a general lobby constantly replenished with pure warmed air. When the door of a room is open there can then be no sudden rush of cold air upon the inmates. It might not be necessary to build a fireplace or erect a stove in the vestibule as well as in the hall, in order to prevent a rush of cold air into the lobby when the front door is opened, but it is certain that to render a house comfortable in winter the air in the passages should be heated by a contingent of warm air. The best *stove* for the purpose would be a calorigen stove, but coils of hot water pipes would afford the completest means of heating hall and passages. If considered advisable, such heat could be led into the adjoining rooms at skirting level, through suitable gratings. When coils are used they are always covered over with fixed ornamental gratings, and the dust drives through the openings, and lodging on and around the heated pipes, taints the air. These casings should run on wheels or castors, and so enable the servants to sweep all round the pipes.

I have noticed *single-room* heating, and also the warming of a few chosen rooms from a general lobby or hall. The ventilation of each of such rooms will however require separate attention, and cannot be made general. It remains now to notice a system of warming and ventilating which shall include the whole house, and which shall not depend upon the individual action of any particular portion of such house, besides being to a great extent automatic. There has been no lack of inventions both at home and abroad which claim to have accomplished all this, but many of them are based upon untried calculations, and appear moreover to be too costly for general use. The most sensible system of *whole-house* treatment which I have noticed is that explained by Drs. Drysdale and Hayward,[1] and

112



who have erected residences in Liverpool in which the system is carried out.

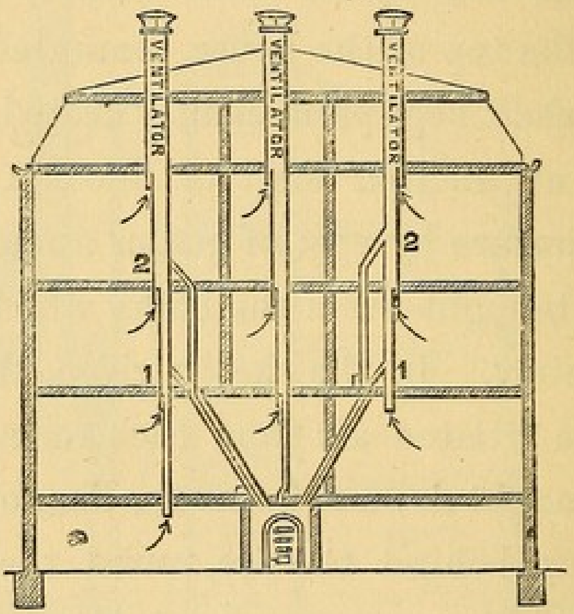
Fig. 112, which is a reduced section of Dr. Hayward's house, will tolerably well explain the plan of which I

[1] 'Health and Comfort in House-building.' London, Spon, 1872.

speak. We will suppose that pure fresh air has been admitted by the primary inlet, filtered through a canvas screen, and heated by a coil of hot-water pipes in the basement or lobby. The next thing is the question of the inlets of this air into the rooms, and these are provided directly from the lobby, and controllable by valves, in order to temper the supply to the varying number of occupants. The foul air exits are situated at the top of the rooms, and take the form of flues which run up an inner wall to one foul air chamber at the top of the house, connected with which is a common shaft kept permanently heated. This air in the common abstraction shaft or flue can be kept at a proper temperature by a jet of gas, or a few coils of hot-water pipes, brought from the boiler which heated the coil in the lobby. In the sketch given, this flue, after collecting the vitiated air from each room, closet, and gaselier, is brought down to below the floor of the kitchen and carried up behind the fire, round the smoke flue and out at the chimney-top. An indispensable matter is the emptying of all the flues of the house into the intermediate foul air chamber and thence into the permanently heated abstraction shaft, which sucks equally from every room, and is so proportioned to the size of the house as to change the air in it every twenty minutes. A study of the arrowings in the sketch will explain much which I have left unsaid.

Another method of warming and ventilating the whole of a house by means of a single apparatus has been introduced in New York by Dr. Griscom. It consists in utilising the chimney of the hot-air stove for the withdrawal of the foul air into supplementary flues adjoining those which convey the warmed air. As seen in fig. 113 each hot air opening occurs near the skirtings of the rooms, viz. at 1, 1, 2, 2. Sliding apertures

113



are also fixed close to the ceilings, which act as outlets for the vitiated air which is contained in the gradually enlarging flues, and which is on its passage to the chimney-top. If simple flues were employed to renew the air of a room it is thought that the air which they would contain might be either colder or heavier than that of the rooms themselves, and might consequently produce an effect contrary to that wished for. The chief advantage claimed for the above system is the ease with which a constant action is maintained. It has also the advantage of being independent for each room in the house, of working during the night owing to the heat stored up in the stove, and of acting in summer and winter alike if only the inlets and outlets are attended to. It must be borne in mind that this attention on the part of some one or another is indispensable. As I have said elsewhere, with reference to the whole-house system of warming and ventilating, the condition of pure comfort and perfect healthfulness is dependent upon the supervision of the owner or servants, according as the varying weather, the wind, or the atmospheric pressure makes such attention necessary. Some one must govern the working of the warming apparatus in proportion to the coldness outside, attend to the valves which regulate the current according to the number of inmates, know how to occasionally isolate rooms, and how at times to *divert* the bulk of the fresh warmed air, for instance, into the bed-rooms, during a severe winter night.

Quantity of fresh Air required.

I have not referred to the quantity of fresh air required in order to ensure good health, but it may be taken for granted that the following is a safe scale for this country.

Places	Cubic feet of space required per head	Cubic feet of fresh air required per head per hour
In dwellings . . .	750	3,000
In schools (per scholar) . .	250	1,000
In workshops . . .	various	2,000
In stables (per horse) . .	1,500	2,500
In cowhouses (per cow) . .	1,000	1,500
Recommended by Professor Gamgee, Dr. Ballard, and others.		

This air, as we have seen, is moved and changed either by natural or artificial ventilation. A great deal depends upon the size of the inlets through which the air is allowed to enter.

In deciding upon the size of the inlets care has to be taken that they are not so small as to cause the air to rush in too quickly and so engender draughts. The air should be changed at least four times an hour, that is, a quantity of fresh air equal to the cubic contents of the room should find its way in and out of the house or room every twenty minutes. The proper size for the outlets which lead into the abstraction flues have also to be carefully computed. The superficial height and shape of a room must always be taken into consideration.

Dr. Parkes, in his 'Manual of Practical Hygiene,'[1] a book which every householder should possess, deplores

[1] Fourth Edition. London, J. & A. Churchill, 1873.

that there is no agreed standard amongst medical men as to the amount of fresh air required, under varying circumstances and conditions, either by man or beast. The public may be certain that unless such a standard is arrived at by the faculty and fixed by the legislature, that considerable blunders will continue to be made by the constructive professions. Here are a few figures which will explain of what Dr. Parkes complains.

	Regulated quantities of cubic feet and space per head
Poor Law Board, *dormitories*	300
Metropolitan Lodging Houses	240
Metropolitan Police Section houses	450
Dublin registered Lodging Houses	300
London School Board, *per scholar*	130
English Permanent Barracks	600
" wooden hut Barracks	400
Prussian Barracks	495
Hanoverian Barracks	700
English Barrack Hospitals	1,200
" wooden Barrack Hospitals	600
Old Hospitals, Paris, *about*	2,118
New Hospital, *Hôtel Dieu*, Paris	3,500
English Hospitals, *recommended*	2,000

Surely a uniformity is as much wanted upon this question as upon Weights and Measures and upon Coinage. At present there is not even a fixed standard as to when air may be considered fairly vitiated.[1]

[1] Dr. Parkes gives 0·6 cubic feet per 1,000 volumes of initial and respiratory carbonic acid as the limit of permissible impurity; other authorities allow 0·7.

CHAPTER VIII.

GAS, AND HOT AND COLD WATER SUPPLIES.

The Gas Supply.

In England as a rule, we are culpably careless about our gas supply. A gas company, for instance, receives notice that the service of such and such a house is ready to be connected with their main, and when they have obtained a signed agreement setting forth who is responsible for payment, the meter is connected forthwith, and there is an end of it. The gas-fitter may have done many things badly, and not done some things at all, but the gas company seldom, very rarely ever, exercises any jurisdiction.[1] The gas-fitter next sends in his account, which is paid, and when the smell of escaped gas from some faulty portion of the pipes has

[1] I am informed that in Liverpool the corporation refuse to connect their main with a house unless the tradesman who laid the house pipes carries their certificate of competency. If this were a rule in all towns, much sickness, according to many eminent physicians, would be prevented. I might add, and many cases of surgery too—for it has been my lot to witness some very bad accidents result to gas-men from careless manipulation, and at least one which proved fatal.

become unbearable, he is sent for to remedy it, and charges for the rectification. The workman may be thoroughly incompetent, as gas-fitting is not, as it should be, a separate trade. Indeed, the artisan who performed the work may be a blacksmith, whitesmith, glazier, brazier, plumber, bellhanger, and gas-fitter all rolled into one.

A gas-fitter *who is a gas-fitter*, and who understands his business, will never take leave of a house until he has tested the pipes for leakage. Where this trouble is taken, the ordinary practice amongst us is as follows. When the pipes have been laid throughout the house, and the company's main connected to the meter, a temporary burner is fixed on each floor of the house, and the gas is turned on. The gas is now ignited at these trial jets and allowed to burn for some little time. The main is then turned off, and at the same time the exact reading of the index is taken. When the gas left in the pipes has burnt out, the taps of the experimental lights are turned off, and if after the lapse of an hour or so the dial of the meter continues to indicate a consumption of gas, it is plain that it somewhere escapes, and the leak is searched for by the sense of smell &c., and remedied.

Whether from sanitary reasons or wholesome dread of fire I do not know, but in most of the large cities of the United States, every length of gas-pipe which has been laid in a house has to undergo even a severer ordeal than the above before the gas is laid on. The inspector examines the joints and elbows, scrutinizes the plugs where brackets and chandeliers are intended to be fixed, and if there is the slightest departure from the rules, he insists upon all being set right. Before, however, the gas-fitter—a separate trade there—asks the gas company to make the connection with their main, he sets about proving the pipes. He stops up, with one exception, all the outlets which have been left for brackets and pendants with plugs or with screwed caps. On the one not so stopped he attaches a force pump, into the interior of which has been put a few drops of sulphuric ether. This pump is now connected with a gauge, and it is then set to work, generally until a high pressure has been registered. A high pressure in a gas-pipe at first appears unnecessary, but gas-fitters know very well that iron pipes have many latent weaknesses, so to speak—seams just ready to open, pinholes filled with grease &c., which might not drop out for years, and a good pressure exerted would rip up the one and cause the others to fall out. When the gauge indicates a certain figure therefore, the pumping ceases, and if the mercury falls, it is evident that there is one or more palpable leaks, which are at once sought for. The escaped ether will guide the fitter to these, and the defaulting pipes are replaced by others. The pumping is now continued, and the same routine recommences. If the mercury still descends and it cannot be detected even by the sense of smell, the joints are separately lathered over with soap, whereupon the weak places will be indicated by bubbles. These parts are then marked, heated by means of a portable spirit lamp made for the purpose, and covered over with an approved and durable cement. When the inspector arrives, the pump is once more set in action, and as the pipes are now tight, he has simply to cast an eye upon the gauge, the column of which no longer shows signs of sinking, examine as before mentioned how the pipes have been laid, and sign the requisite order. Some universal system of house pipe testing should prevail here. It is common enough with us for gas companies to test the gas pipes which constitute the main before they are laid down, but the house pipes are seldom properly overhauled by any one.

An escape of gas in a house is really a more serious matter than is generally admitted. People dread the effects of an explosion from gas, but they seldom recognise the evil effects which proceed from inhaling it. I alluded at page 97 to a fatal case which had been published, and M. Ziegier has recently described another. An escape of gas occurred through a carious piece of pipe in the main, and the gas was conducted along an old foundation wall to some distance, the end of which wall was immediately under the bedroom of a gentleman, who was in consequence seized during the night with the oppression and other symptoms of gas poisoning. It was noticed that but little odour of the gas was discernible.

Besides the danger resulting from the escape of unburnt gas, we have to guard against the inhalation of the products of gas combustion—carbonic and sulphurous acids, carbonic oxide, ammonia, and the like. The evil effects occasioned by these gases have been repeatedly set forth by medical sanitary authorities. Wherever, therefore, a gas burner is fixed, a tube to convey these products into the foul air shaft or to the outer air should be provided. When sunburners, as they are termed, are used—burning large volumes of gas near the ceiling—a special means of withdrawal is always adopted; but it is the exception rather than the rule to find gas-burners connected with a hood and pipe, or any kind of contrivance to rid the room of the irrespirable gases, or to lessen the heat and the humidity of the air which gas-burning entails. The most suitable kind of ventilation for gaseliers is shown at fig. 112, and the plan can easily be copied out in any house, a zinc tube being led from behind the centre flower of a room into the foul air shaft chimney, or outer air. Some ventilating grates, Captain Galton's, for instance, do not require an outlet for the air vitiated by breathing to be inserted into the chimney or foul air shaft, but it must be borne in mind that, no matter what system of heating be adopted, the products of the gas should be led away.

If these products are not removed, the foundations of health will be silently sapped. Everything also in the room will, after a time, more or less suffer. The ceilings will be discoloured, the wall papers will lose their finer tints, the upholstery will fade, the ormolu work will tarnish, the gilt upon the books will sully, and even the oil paintings will lose their freshness.

If a room were adequately ventilated, and the products of gas combustion satisfactorily diluted, there might be no necessity for any special removal of such products, but how many houses are so constructed as to afford a renewal of fresh air to the requisite extent of over 5,000 cubic feet per burner per hour? Few houses, indeed, are able to supply the hourly 3,000 cubic feet needed for the use of the inmates. It is therefore not only imperative to provide an escape for the resultants from gas-burning in a poorly ventilated room, but it is wise to bring in from the outer atmosphere a special supply of air for the gas-burners in a well ventilated one. This, however, necessitates the use of a form of gas-light which guards the fresh air for its own separate use, and fortunately such a thing is in the market.

This ventilating globe light, as it has been named, is drawn on fig. 114, and the working of the system is as follows. When the burner is lighted at the aperture on the under side of the globe by the spirit torch made

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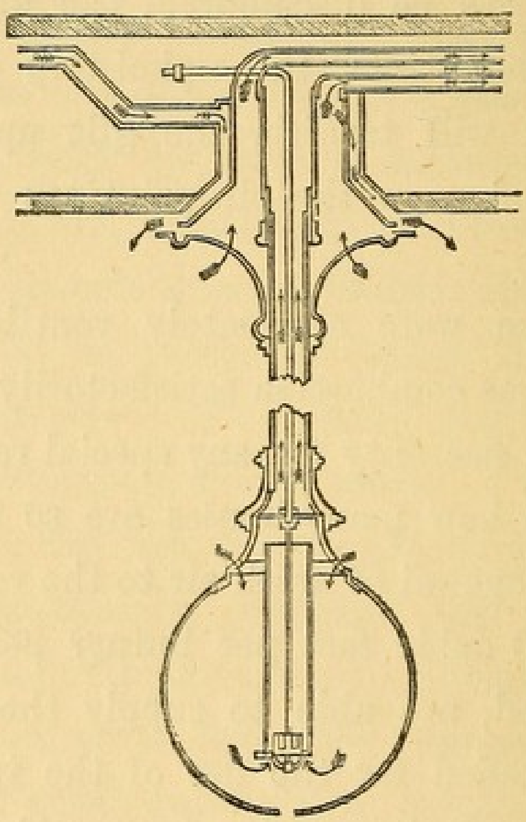

for the purpose, and which avoids all chance of charred fragments of paper or wick falling into the globe, an upward current is created in the inner tube, and, as this tube becomes heated, the air in the outer tube is also rarefied. The effect of this is to cause a movement of the vitiated air of the room to ascend and pass through the openings at the top of the stalk into the chimney or foul air shaft, by way of the specially provided abstraction tubes, which are laid between or across the joists of the room above. As will be noticed in the sketch, a current of cold air from without is led into the room to replace the withdrawn hot air and to support combustion.[1] The burner itself may be so constructed as to heat the gas before it is consumed, and the brilliancy of the flame in this way increased. One globe light will be found sufficient to light an ordinary sized room, but when rooms require more light a cluster of these globes are arranged in the form of a chandelier, the products from each globe being led off through the central tube. Besides the pendent form, these lights can also be used as brackets upon a wall. The degree of illuminating power can be modified by means of a regulation-cock fixed to the supply-pipe in the wall of the room. Too much commendation can hardly be bestowed upon this system of lighting. Until it appeared, it was impossible to consume gas in a nursery without evil effects following. It was also impracticable to illuminate a conservatory without causing danger to the more delicate kinds of plants.

[1] Where ample ventilation for all purposes has been secured for a room, these globe lights with one cone only can be fixed, and the flame fed in the ordinary way, by the air passing through the room.

Memoranda upon the Gas Supply.

There are a few precautions to be taken in laying down gas-pipes which every householder should know, in order that he may detect any negligence of the gas-fitter. For example, the service should have at least one inch in ten feet of a fall towards the main, and the meter should also be fixed above the level of the service where it enters the house. The pipes which supply the house should moreover *rise* from the meter. If the latter has to supply any rooms on a lower level than itself a receiver should be put in the line of pipe so as to intercept the water. A similar receiver should be placed in every flat-lying pipe where it is exposed to condensation from the colder air outside. *Composition* pipes—which are mainly chosen because they are less bulky than iron pipes, and bend more easily—should never be bedded in plaster, as lime eats them into holes.[1] Where very small pipes must be hidden in the walls they should be composed of copper. The iron pipes *inside* the house should be payed over with red lead or oxide of iron paint, and if laid in the ground *outside* the house, between the meter and the main,

[1] Mice will sometimes attack these composition pipes, if laid within their reach. This is well vouched for, but no satisfactory reason has been given why. Most cases of gas escaping will also be found to have resulted from nails or screws penetrating these pipes.

they should be well coated with tar. All rising pipes should as much as possible be fixed so as to be easy of access, and covered over with a movable casing. When pipes must run under the floors, the skirting of those rooms should be fixed upon a hard wood fillet of its own thickness, and the floor-boards laid up to that. By so doing much trouble will be saved afterwards. A plan of the whereabouts of the gas-pipes is also very essential in a large establishment.

When lights are seen to flicker it is a token of the presence of water in the pipes, and this may be either in the home service, the meter, or the main. In the two first cases the gas-fitter will easily remedy matters, and in the last the Company should be requested to empty their syphon. After some years, too, the burners will be noticed to yield a very poor light, and in such a case it may be taken for granted that the pipes are full of what is called corrosion, and require cleansing, or what is commonly termed naphthaline will have formed in the pipes—generally at some rectangular joint unprovided with a receiver—necessitating even a hammer and chisel to dislodge it.

The Hot Water Supply.

Four winters ago one prominent topic of conversation in domestic circles was the danger which frequently accompanies the use of the hot water boilers which are placed behind the kitchen fires, &c., for the purpose of heating water for the baths and sinks. In December 1869 several fearful accidents occurred, notably one near Manchester, where a lady and her daughter were seated before the kitchen fire when the boiler burst, killing the former and scalding the latter.[1] Even when no life is lost the damage done to property is considerable. In the case I allude to the ceiling was brought down, the walls battered, and windows destroyed.

The system of heating which permitted this disaster obtains over nearly the whole of this country. The boiler is placed at the back of the kitchen fire, and the hot-water circulating cistern near the top of the house, the latter being supplied by the general cold-water supply cistern, situated at a still higher point. The boiler is generally as large a one as can possibly be accommodated at the back of the fire, and as the hot water reservoir is at the top of the house, and as some of the draw-off taps are at or near the boiler, all the hot water may be made use of when no cold water can possibly enter the general cistern above by reason of frost. The boiler and pipes, &c., are therefore emptied, and the empty boiler becomes red-hot. In this condition

[1] A cat and dog which were crouching beside the fireplace were also killed.

of things a thaw takes place, the water rushes into the boiler, and the consequence is an explosion.

I have no hesitation in saying that this old system of heating water should be entirely discontinued, nor can all the precautionary measures which have been engrafted upon it since 1869 make it much more acceptable. Another objection to the common system is that when drawing water from any of the taps situated at any distance from the flow or return-pipes, a quantity of cold water, depending upon the length of the branch pipe, has to be drawn off before the hot water arrives.

In the system of Mr. F. Dyer, which I have had fitted up with very satisfactory results, the cold water cistern is at the top of the house, but the hot water cistern, which is of iron and takes the form of a cylinder, is placed anywhere beside the kitchen fire. The cold water is brought down from the general supply cistern in the upper part of the house, and enters at the bottom of the cylinder. The boiler, which is a tubular one, made of malleable iron, is fixed at the back of the fire, and is so small as to contain little more than a quart of water. The fire has free access all round this boiler; therefore the water begins to circulate the moment the fire is fairly lighted. As the water in the small boiler is heated, part of it passes into the cylinder about half way up, and part courses at once through the supply pipes, and where likely to be most useful. There is thus no loss of time, as hot water can be drawn before the water in the cylinder is fully heated. The return pipe, which commences from the highest point of service, is made somewhat smaller in diameter than the flow-pipe, just sufficient in fact to keep the water circulating, and it is connected with the cold water pipe near the cylinder. There is a tap fixed

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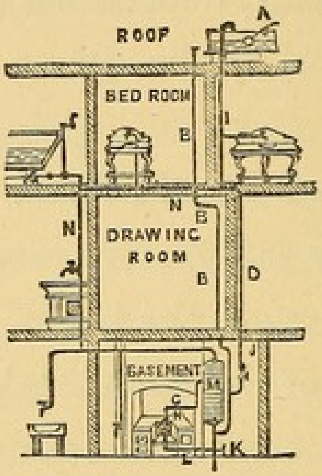

Cold water cistern, A; Boiler, H; Cylinder, M; flows C B N; return, D J; Expansion-pipe, I; Sluice cock, K.

in this return-pipe, the use of which is to enable the servants to obtain, if needs be, warm water in the morning before the fire is lighted, and to do so is to stop the circulation during the night by turning off this tap. The hot water which was in the cylinder will then be at their service. The turning of the tap in question does not prevent the drawing of warm water at any time during the night in any room in the house, only, of course, in this case the cold water which was in the pipes would require to be first withdrawn. The Dyer system is drawn at fig. 115. There are several imitations, but I prefer the original.

It is impossible to suffer from any explosion if this system be adopted. As the cylinder is downstairs, whatever hot water is required must come from the top of this hot-water reservoir. If, through frost or obstruction, no water can flow from the cold-water cistern at the top of the house and force the hot water up, there is a limit to the withdrawal of hot water to the various taps in the house. The cylinder will, however, continue nearly full of water, and remain with this only pledge of safety in it until it has wholly evaporated, which would not be likely to happen under six weeks' time. No frost in our country would last that time without an interval of thaw. There is, moreover, a safety-valve fixed at the top of the cylinder, the weight in the interior of which is apportioned to the head of water it has to resist. An expansion pipe is also led from the highest service to the top of the cold-water cistern. The cylinder itself can be cleansed out by means of a sluice-cock fixed below it, and if a little water be drawn therefrom about once in three months the apparatus will be kept perfectly clean. If there be a linen-closet in the house a coil of pipes can be taken from the cylinder to some place contiguous to such closet, by which means the linen will always be kept perfectly aired and ready for use. If the kitchen were in the basement, and the cylinder large enough, a coil might also be got into the hall or passage above, to heat the entering air.

As will be noticed in fig. 115, there is a draw-off tap at one side of the kitchen fireplace, so as to supply hot water from the cylinder, and this will be found very useful for many requirements of the cook. But she should not be dependent upon this supply for hot water for the purer culinary purposes, because water which has to traverse such a distance and serve so many purposes over the house cannot be considered absolutely pure. There should therefore be, in connection with an enamelled slate cistern downstairs, *carefully removed from the chance effects of frost*, a boiler attached to the kitchen range, and the hot water from this boiler, besides serving the cook, might in most cases be made to supply the nursery and the dairy, where pure water is so important. The same cistern should also supply the drinking water of the house, and if it were filtered it would be all the better. The Water Companies for the most part specify that at least one of the cisterns should be at a low level, and there need be, therefore, no additional expense beyond the enamelling of the cistern.

It was suggested some little time ago by Professor

John Gamgee, that a supply of newly-distilled water for the toilette, in teeth cleaning, &c., might readily be made obtainable from the kitchen boiler, and the means for carrying out the idea is worth prosecuting by those manufacturers who compete in our now yearly established sanitary olympics. Dr. Burdon Sanderson has proved the possibility of disease being communicated by contact with impure water. Moreover, distilled water could be otherwise made generally useful.

The Cold-water Supply.

After giving considerable attention to the matter Dr. Parkes came to the conclusion that twenty-five gallons per head per diem is the minimum quantity of water which ought to be allowed for the use of a dwelling. About this quantity should also daily pass through the house drains into the sewer, in order to insure a complete removal of all the solid wastes. The apportionment of the water per head is as under :—

	gallons
For Cooking purposes	$0\frac{3}{4}$
„ Drinking purposes	$0\frac{1}{4}$
„ Ordinary ablutions	5
„ Cleaning up	3
„ Laundry use	3
„ Bath use	4
„ Water closets	6
„ Margin and waste	3
Total	25

Dividing the number of gallons daily supplied by the seven largest water companies in London by the total population in each of the districts, it appears that about twenty-eight gallons are allowed to each inhabitant. When we consider the wants of the brute creation this supply is evidently insufficient. Glasgow, which is the best water supplied city in Great Britain, allows fifty gallons per head of population, and probably this is the correct figure to count upon.

Cisterns.

Given even the proper quantity of water, many houses are provided with only one cistern, and from this is of course supplied the drinking water as well as the water for the closets. I could point out hundreds of houses in London in this predicament within the radius of a mile. This is very reprehensible, and sickness in a house has been repeatedly traced to such a state of things. An independent cistern should be provided for drinking and purely culinary purposes, as already pointed out. A separate one may also be fixed for the supply of the water used for the scullery, and in connection with the hot water services to the baths, lavatories, and sinks. A third one may with advantage be erected for water closet purposes solely.

The drinking water cistern is best constructed of slate slabs enamelled inside. A wrought iron cistern coated inside with a tar composition has been recommended by Mr. R. S. Burn, a gentleman of great experience, and it would perhaps rank next. Lead cisterns should never be erected in a house. The injurious effect of lead upon the human system has been pointed out times without number, but with too little effect. Lead, moreover, slowly disappears under the action of some kinds of water. Zinc is also an objectionable lining for cisterns for similar reasons, and even well galvanised iron cisterns, although suitable for the storeage of water to be used for common purposes, is unfit to hold water which is destined for the table. The service pipe also which conveys the water from the drinking water cistern should never be composed of lead or galvanised iron. The only *safe* kind of pipe is the leaden-cased block-tin pipe. It may appear ridiculous to add that the drinking water cistern should be regularly cleaned out at least once a quarter, but I have seen such culpable neglect on this head that I feel 'self pardoned' for mentioning it. Water should also be laid on, and a sink provided to every floor of the house, otherwise the housemaid who begins to cleanse a house at the top storey will almost invariably use the same water down to the staircase in the hall.

Memoranda on Cisterns.

In some of the large cities, and in London especially, owing to the regulations which define the water arrangements, not very many liberties can be taken with the supplies, or even with the wastes, but in country houses it is very different, and it would be wise there as elsewhere to guard against the following errors. For instance, the overflow[1] from any cistern should not deliver connectedly with the drain, or into a soil pipe, or even into a rain water down pipe which leads direct into the drain. On the contrary, it should deliver upon the leads or over such a trap as those drawn at figs. 23 and 24, page 30. Too much attention cannot be paid to the drinking water cistern in this respect, and mischief will be certain to ensue from any departure from this sound rule.

By way of example I will now allude to a house which I was lately called upon to inspect. The house was situated in the most fashionable part of London, and contained two main cisterns. The cistern which supplied the kitchen boiler, &c., had an overflow pipe leading down into an *unventilated* house drain, and the dead water in the main pipe which supplied the

[1] The overflow pipe is sometimes fitted up with a trap in the cistern. Pipes should be especially well guarded from frost, or the expansion of freezing water.

cistern was used for flushing the servants' closet in an area vault between the street and the cistern. This cistern was therefore open to two sources of contamination. As for the upstairs cistern, which supplied the drinking caraffes of the bed room, it was even in a worse plight, for the waste from a housemaid's sink branched into the overflow of the cistern, and the pipe then passed into the trap of a closet. A singing bird has been known to be poisoned by sipping water upon the surface of which tobacco smoke had condensed, and what kind of health could be predicated for a person, especially an infant or an invalid, condemned to quaff the scum floating upon the water of cisterns so irrationally treated as these? Filtering will do much to remove impurities in water, and the silicated carbon filter will deliver water quite free from any of the constituents of milk which has been poured into it previous to filtering (and this is a crucial chemical test for a filter), but it would be well not to trust even to filtering in a case such as I have described. It is doubtless wise to fix filters in every drinking cistern, even where good water is laid on; at all events it renders assurance doubly sure, and against the practice the only objection is that of additional expense.

Well Water.[1]

Householders have been repeatedly cautioned against making use of well waters which have not been previously analysed by competent persons.[2] It is safe to presume that a well water is unfit for drinking purposes, and that the water supplied by a water company is pure. Wells have before now been sunk in places almost honeycombed with old cesspools, with a result not difficult to imagine. In sending a sample of water to an analyst it should be put into a stoppered quart glass-bottle, which has been cleaned out with sulphuric acid and then washed out with the water. The bottle when filled should be corked and sealed, and within two days forwarded to the operator. In taking the sample the vessel should be immersed in the water, and the mouth filled at some little distance below the surface.

Rain Water.

Where the plan can conveniently be carried out, and where the drains can afford the withholding of this flushing water, it will be found very convenient to

[1] See *Water Analysis*, by Messrs. Wanklyn and Chapman, 2nd ed. Trübner & Co., 1870.

[2] Professor Wanklyn, and Dr. B. H. Paul and others, undertake these analyses in London. The medical officers of health would direct the householder where to apply.

store that which falls upon the roof of the house in an underground tank. This tank can be built in brickwork, in cement, or concrete work, puddled behind with clay outside, and rendered over with Portland cement inside. It should also be provided with a manhole to afford means of occasionally cleansing it out. The overflow from the tank should never run connectedly into the drain, but deliver in some space open to the air, which can be managed in a variety of ways. In calculating the size of a rain water tank so as to apportion it to the collecting surface, the space *covered by* the roof in square feet multiplied first by 144, afterwards by 25, the average in inches of rainfall during the year, and then divided by 277, will give the product in gallons. Or what is about the same thing, twice the space covered by the roof will give the cubical feet of water likely to be collected during the year.

Some persons are inordinately fond of rain water for culinary purposes, infusing tea with it, and so on, but in such circumstances some caution ought to be exercised that this rain water has not been collected from zinc roofs and lead flats. Those downspouts only should be led into the water tank to be used for cooking purposes which drain tile or slate covered roofs. Even on these roofs a certain portion of the rainfall will have passed over lead flashings, ridges, hips, and valleys This in a large slated or tiled roof, however, will probably not charge the water with more than the $\frac{1}{20}$ of a grain of lead per gallon, beyond which a water becomes dangerous to use.

Even before it reaches the roof rain water is more or less impure, so much so that many plants will grow in it independent of soil. It would be wise therefore to filter it before using it, either in the house or the laundry. The impurities of rain water, according to Dr. Angus Smith, can be completely removed by filtration through the soil. It would be possible to construct an *earth* filter on the delivery side of the rain water tank in order to remove the nauseous taste of oil and soot from the intercepted soft water, but I think that it would scarcely be worth while to do so. A box filter fitted to the top of the suction pipe connected with the pump over the tank would serve all ordinary purposes. If the rain water were stored in a slate cistern or water-butt above ground, a low pressure filter could be fitted to the end of the draw-off tap. Where rain water is of a necessity drunk, the eaves, troughs, and downspouts should be enamelled or silicated, and it should reach the tank through glazed earthenware pipes. Generally speaking, rain water should be excluded from the kitchen. It contains amongst other harmful ingredients collected in the 'upper deep,' especially in towns where manufacturing trades are carried on, too much sulphuric acid, 'which may be held to indicate the sewage of the atmosphere.' Where rain water can be got over and above that desirable for laundry purposes, it will be found most useful for the occasional flushing of drains. Some portion can also be led to a tank in the garden for distribution to the plants. The rain which descends upon greenhouses and conservatories may also with advantage be stored in a cistern fixed in the stokehole, where it can be sensibly warmed, and whence it can be withdrawn to fill the watering cans.

The Vane.—Conclusion.

I have now traced the erection of a dwelling from the drains in the foundations gradually up to the cisterns in the attics, and have briefly adverted to the principal rules which ought to be observed both in building the house and in equipping it with the necessary services. To justly observe the architectural *unities* I ought to conclude my last chapter with a few remarks upon the *roof* of the house, and will therefore do so by pointing out the best kind of vane.

A daily knowledge of the direction of the wind may seem of no consequence, but I am persuaded that more depends upon it than appears at first mention. Let me furnish an example. The main staircases of most houses now terminate in what is called a lantern light, the glass sides of which are made to swing open, and beneath this is generally placed an ornamentally treated flat ceiling-light which hides the lantern above. The ventilation of the whole house may depend upon this arrangement, the object of the swinging lights being simply to allow the escape of the foul air. And it can be easily imagined that if the wrong light has been swung open, that the wind may be possibly blowing the vitiated air back into the house. Had some one noticed in what direction the wind was blowing—and there is surely in every large house some one sufficiently interested in its ventilation—a glance at the perforated margins of the ceiling light and a few pulls at the cords would have shut the one window and opened its *vis-à-vis*. But this is only one of the many advantages of a vane. There are many delicate persons who are debarred from a walk or drive during certain winds, and who might have been saved some risk, and certainly some trouble, if the house had been provided with a vane.

It is the exception rather than the rule to see town houses with this article, and the converse holds true of country houses. But it is simply because it is not customary for town residences to mount a vane, not because they will not work properly in a town, or because there is no actual necessity for them. Apart from valetudinarian reasons I can understand that a vane may prove the centre of much interest and pleasure.

At all events, one may as well be cognizant at early morning of the prevailing wind as peruse it next day in the daily readings of the 'Times.' A youthful meteorologist too, with his anemometer as well as his barometer, hygrometer, and thermometer, might not prove the least useful member of the family.

If I had meant to describe a common *weathercock* I would have left the above sentences unwritten, but I

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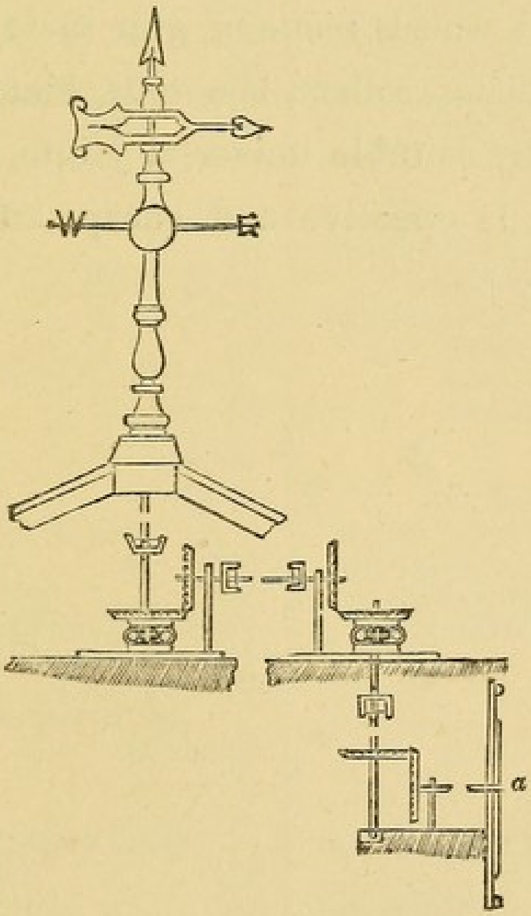

intended to point out one which would register the direction of the wind in the house itself, and show upon the index in the hall or passage every varying sweep of the indicator. A vane upon the house top, the utilising of which necessitates a journey outside, would prove troublesome in the last degree. A contrivance which embodies a perfect registration is drawn at fig. 116. It consists of an iron standard which can be fixed upon any convenient part of the roof, and connected with its copper vane is a rod running down to the passage of the groundfloor. As may be noticed, the rod can be carried in any direction, and down any number of storeys, by means of bevel wheels made of gun metal and poised upon compensating rollers, the rods being kept free from twisting by suitable universal joints, down to the dial at *a*. It is effective and cheap, automatic and ornamental.

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