ELEMENTS OF HEALTH

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AN INTRODUCTION TO THE STUDY OF HYGIENE

BY

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PREFACE

THE intention of this little work—as its title explains—is to form an introduction to the study of Hygiene. The author's main idea has been to give some simple yet practical information and instruction on the preservation of individual or personal health in the ordinary routine of domestic life. An attempt has been made to place within the small compass of the following pages just that amount of practical knowledge in Hygiene which it is desirable that every individual should be in possession of. Matters relating to questions of Public Health—over which the individual citizen has little or no control—have for the most part been avoided.

L. C. P.

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CHAPTER I

WATER

Sources of supply—Rain-water—Streams and rivers—Wells—Springs—Public water-supplies—Constant and intermittent supply: Cisterns—Purification of water: Domestic filters, Sand filtration.

Sources of Supply.—Our water-supplies are derived from the rain which falls upon the ground. Upon reaching the surface of the earth, the rain is disposed of in one of three ways, namely, (1) by evaporation, (2) by flowing off the surface, (3) by percolation, or sinking into the soil.

By evaporation is meant that the water is converted into invisible vapour, which is absorbed into the atmosphere. Evaporation is always greatest when the temperature of the air is highest. Consequently it is at its maximum in summer, and at its minimum in winter.

The amount of rain that flows off the surface depends on the inclination of the ground, and upon the character of the soil. If the surface slope is steep, and if the ground is hard and rocky, most of the rain flows off the surface, and forms, or helps to swell, the brooks, streams, and rivulets, which uniting create rivers.

Where on the contrary the surface is flat, and the ground is loose and porous, the larger portion of the rain, which is not evaporated, sinks into the ground or percolates. It is owing to this passage through the soil that the water is ultimately enabled to become collected into the underground reservoirs, which supply our wells and springs.

Rain-water.—The collection of rain-water from the roofs of houses is a matter of importance in many rural districts, more especially where other sources of supply are deficient in quantity, or bad in quality. Whilst stored rain-water is not very suitable for drinking purposes, owing to its becoming stale and flat when stored for any length of time, yet it is extremely useful for most other domestic purposes, on account of its softness. By *softness* is meant its freedom from chalk or other salts which produce *hardness.* Rain-water is soft because it has not come into contact with the soil. Most soils contain a considerable amount of chalk or other salts of lime—(chalk is a carbonate of calcium or lime). In percolating through the ground the water meets this chalk and dissolves it; the chalk is rendered invisible in the water, but it is none the less there. The water could not, however, dissolve or take up the chalk unless there were present in the interstices of the soil a gas called carbonic acid. This gas renders the chalk soluble in water; if it is driven out of the water, as may be done by boiling the latter, the chalk becomes insoluble again, and forms a cloud or turbidity in the water, which cloud will be gradually deposited on the bottom and sides of the vessel holding the water. It is this deposit which forms the fur found in kettles, boilers, and saucepans in which hard water has been boiled.

As is well known to most housewives, this fur deposit is highly objectionable. It corrodes the metals on which it is deposited; it forms a non-conducting medium between the source of heat and the substance to be heated, which causes a waste of fuel; it forms a coating on food undergoing cooking, which obstructs the proper penetration of heat into the interior of the food, or prevents solution of the soluble materials, when this is the result aimed at, as in the making of tea, broth, beef tea, &c. In hot-water pipes the lime deposit tends to gradually narrow the calibre of the pipes, and such pipes may in time become completely blocked. In boilers the lime deposit forms a non-conducting lining, which when thick enough, seriously retards the passage of heat to the water. It is very difficult to obtain really hot water out of a furred boiler, and there is besides the risk of an explosion. If the iron boiler-plates are separated from the water by much fur, they become overheated, and even red-hot. Should then a crack form in the fur, the water comes suddenly into contact with red-hot metal, and is converted into steam with explosive violence.

There is also much waste of soap where hard water is used for washing purposes. A good lather cannot be formed until the lime in the water has combined with certain of the constituents of the soap, and so been separated from the water. This combination is evidenced by the formation of whitish curds in the water. The production of these curds shows the waste of soap. If perfectly soft water is used, a good lather is very quickly produced with a very small quantity of soap. This is the reason why in towns where the supply of water is hard, most large laundry businesses soften the water prior to use.

In most large towns—especially manufacturing towns—rain-water is too dirty to be used. In falling through the atmosphere the rain washes out of the air much of its soot, dust, and injurious gases, and is consequently impure upon reaching the ground. In country districts the atmosphere is purer, and the rain may be collected from the roofs of dwelling-houses, stables, and greenhouses, and stored in tanks. It should be stored in as cleanly a condition as possible, and for this reason it is advisable to reject the first portions of a shower, which contain the washings of dirty substances off the roof, and to allow such water to run to waste. This may be done by means of a rain-water separator, such as that invented by Roberts of Haslemere. If rain-water is collected in a dirty condition, the storage receptacle becomes lined with a foul sediment, which putrefies, poisons the water, and renders it unfit for use.

Rain and other soft waters have a very considerable effect in dissolving metals with which they come into contact. Consequently rain-water which has been collected from lead roofs, or which has passed through lead pipes, or been stored in lead-lined cisterns, is very apt to contain traces of lead. Even so small a quantity of lead in water as half a grain to the gallon may produce in time symptoms of lead poisoning amongst habitual water-drinkers.

Streams and Rivers.—Unless the stream from its source has passed through uninhabited and uncultivated land, it is very liable to furnish water which must in any case be regarded as suspicious from a health point of view, and in not a few instances as dangerously contaminated. Streams and rivers form the natural drainage channels of the localities they traverse, and tend, therefore, to receive the fluid refuse of habitations, villages, and towns on their banks. Human excreta will probably form some part of this refuse, and in that event the possibility of the spread of typhoid fever through the use of such water cannot be excluded.

No one would willingly drink the water from grossly polluted streams, such as are to be found in many parts of Lancashire and Yorkshire. The appearance alone of such water is sufficiently repellent. But in the case of streams which have been previously contaminated with sewage or other waste matters, but not to an extent to be evident to the senses at places lower down and several miles from the point of pollution, it often becomes an important question as to whether the water furnished by such a stream can be safely used. A perusal of the recent report of the Royal Commission on Metropolitan Water Supply (1893) would lead one rather to think that an exaggerated value had been attributed to the possibly dangerous qualities of such water. The bacteriologists have tried to show that the bacillus of typhoid fever—the microbe supposed to be causative of this disease—does not find an easy resting-place in flowing water; that it is attacked by harmless micro-organisms, normally present in river water, and eventually destroyed; or failing such active enmity, that at least the typhoid bacillus is less well adapted to such modes of existence as are inherent in river water, than the harmless species invariably present there, and that the disease-producing organism in consequence ultimately fails in the struggle for existence, and dies out.

Actual experience, however, seems to point more to the view that there is a danger in consuming contaminated river water, especially at times when the river is in an abnormal state from flood or from prolonged drought; and that it is never quite safe to place at all times implicit reliance on such water, unless it has been previously boiled, sterilised by filtration, or efficiently filtered by sand filtration on a large scale by a public company or corporation.

The mineral ingredients (hardness) of stream and river waters are various. Near its sources, a stream may consist of little but surface water, which is soft, having merely run over the soil, and not percolated through it. In the lower reaches, the water is usually much harder, the volume of surface water having been largely added to by springs in the bed of the river—by water, therefore, which has been in contact with the chalk and other salts contained in considerable thicknesses of soil.

Wells.—There are two kinds of wells—*shallow* and *deep*. As a general rule, to which, however, there may be many exceptions, the water from shallow wells should be regarded with suspicion, whilst that from deep wells may inspire confidence.

In the subsoil containing *surface* or *shallow wells*, the rain which percolates from the surface of the ground through the porous soil, is prevented at a certain distance down—usually from ten to thirty or forty feet—from sinking deeper into the earth by reason of a layer or stratum of impermeable soil, such as clay, which does not permit water to percolate through it. Sands, gravels, chalk, various sandstones, and limestones, are more or less permeable to water, whilst clay, slates, granites, and other hard rocks are impermeable.

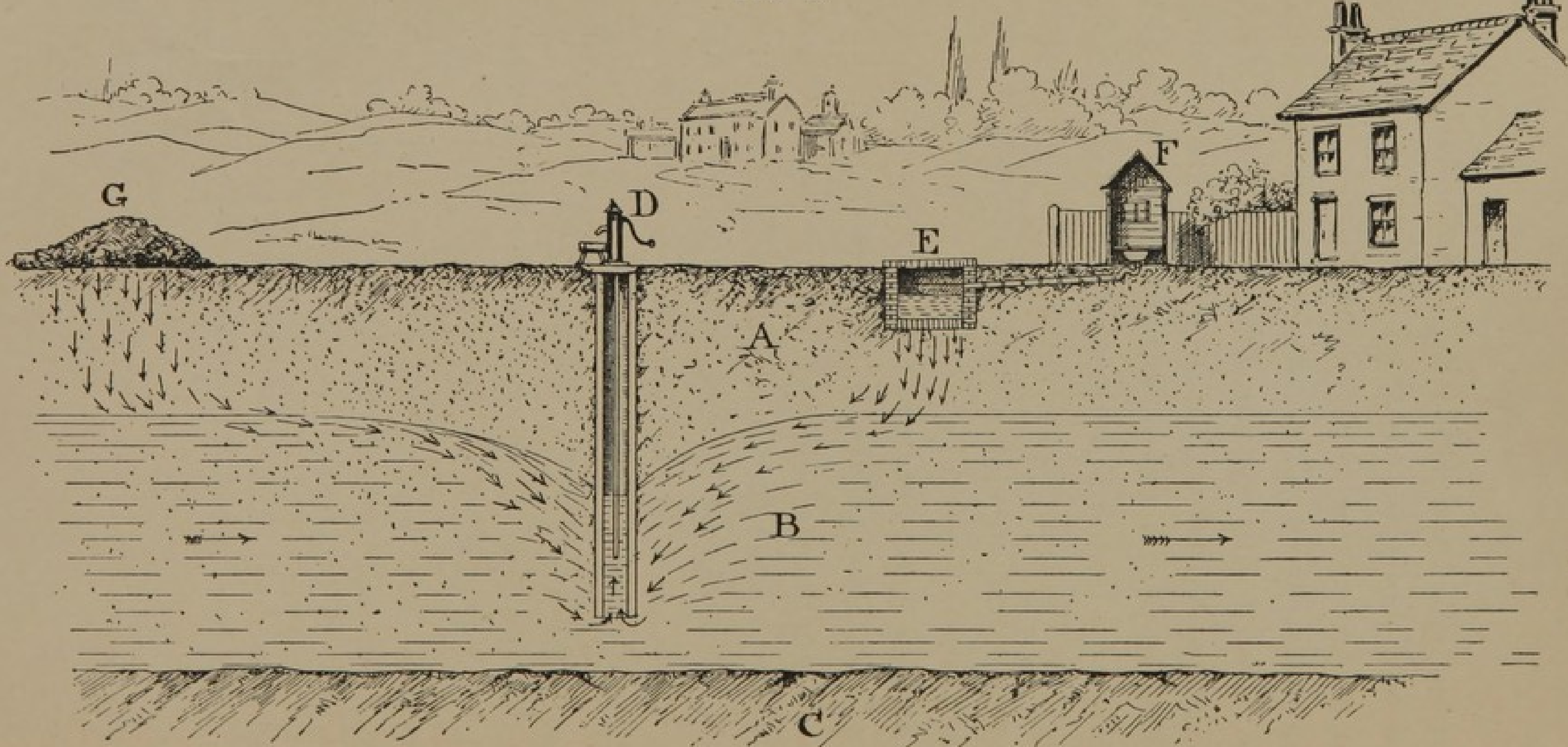
This underground or subsoil water, so collected in the porous soil on the underlying impervious one, is not as a rule stagnant, but is moving slowly yet steadily in one constant direction—namely towards its outlet, which usually consists of a spring or springs at a lower level. As those who rely upon wells are aware, the underground water, which is visible or can be sounded in a well, is not always standing at the same level. As a general rule, to which of course there may be exceptions depending upon exceptional seasons, the level of the water in wells is highest in the early spring (February or March), and lowest in autumn (October or November). The reason of this annual fluctuation is simply that during the cold months of the year there is but little evaporation, and much of the rain percolates into the earth, and so renews the volume of the underground water; whilst during the warmer months, when evaporation is active, there is but little percolation, and the underground water being insufficiently replenished to make up for the loss occasioned by the outflow in springs, its level falls continuously until autumn is reached, and percolation recommences.

The water of shallow wells (Fig. 1) having only percolated through a few feet (ten to thirty or so) of porous soil, since it descended as rain on the surface of the earth, surface impurities lying on the ground, which are taken up by the rain, are subjected to but little purification by soil filtration before they reach the well.

Again, shallow wells in the neighbourhood of habitations are extremely likely to receive filth which has soaked into the porous ground from manure heaps, privy-pits, leaky cesspools, and drains. Liquid filth of this character, in its passage through small thicknesses of porous, sandy, or gravelly soil, is merely strained of its grosser impurities, and not filtered in any such way as to render it innocuous.

Indeed, the latest bacteriological research would

FIG. 1.



SHALLOW WELL POLLUTED BY CESSPOOL ETC.

appear to show that whilst the *bacillus of typhoid fever* does not survive very long in ordinary sewage, after its ejectment from the human body, yet should this sewage be filtered through small thicknesses of soil, certain salts called nitrates are formed by oxidation of ammonia and organic matters in the sewage, the presence of which enables the bacillus to retain its vitality for a considerable period, and to undergo at the same time rapid and continuous multiplication.

This may explain why it is that polluted shallow well waters can retain for such long periods the active infection of typhoid fever—the specific typhoid bacillus being favoured in its growth by the presence of the nitrates derived from the

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FIG. 1.—*Shallow Well, Polluted by Cesspool and Manure-heap.*

A. Porous gravelly or sandy soil.

B. Underground or subsoil water. The direction of the flow of the water is shown by the arrows. The main direction is from the well to the house, but the depression of water in the well causes an in-flow from every direction in a small circle surrounding the well.

C. Impermeable soil holding up the subsoil water.

D. Well with hand-pump. The level of the water in the well has been depressed by pumping.

E. Leaky cesspool. Liquid sewage percolates through the porous soil and is drawn into the well.

F. Closet of house, with drain-pipe leading to the cesspool.

G. Manure-heap, from which filth soaks into the ground. The well is always liable to pollution from this source. The cesspool soakage only pollutes the well when the water level in it is depressed by pumping.

filtered sewage, and being sheltered in the depth of the well from the action of sunlight—sunlight being a very active and potent germ-destroyer.

Another serious source of pollution is that arising from the proximity of graveyards and cemeteries to the well, and the consequent introduction into the subsoil water of matters derived from decomposing animal remains.

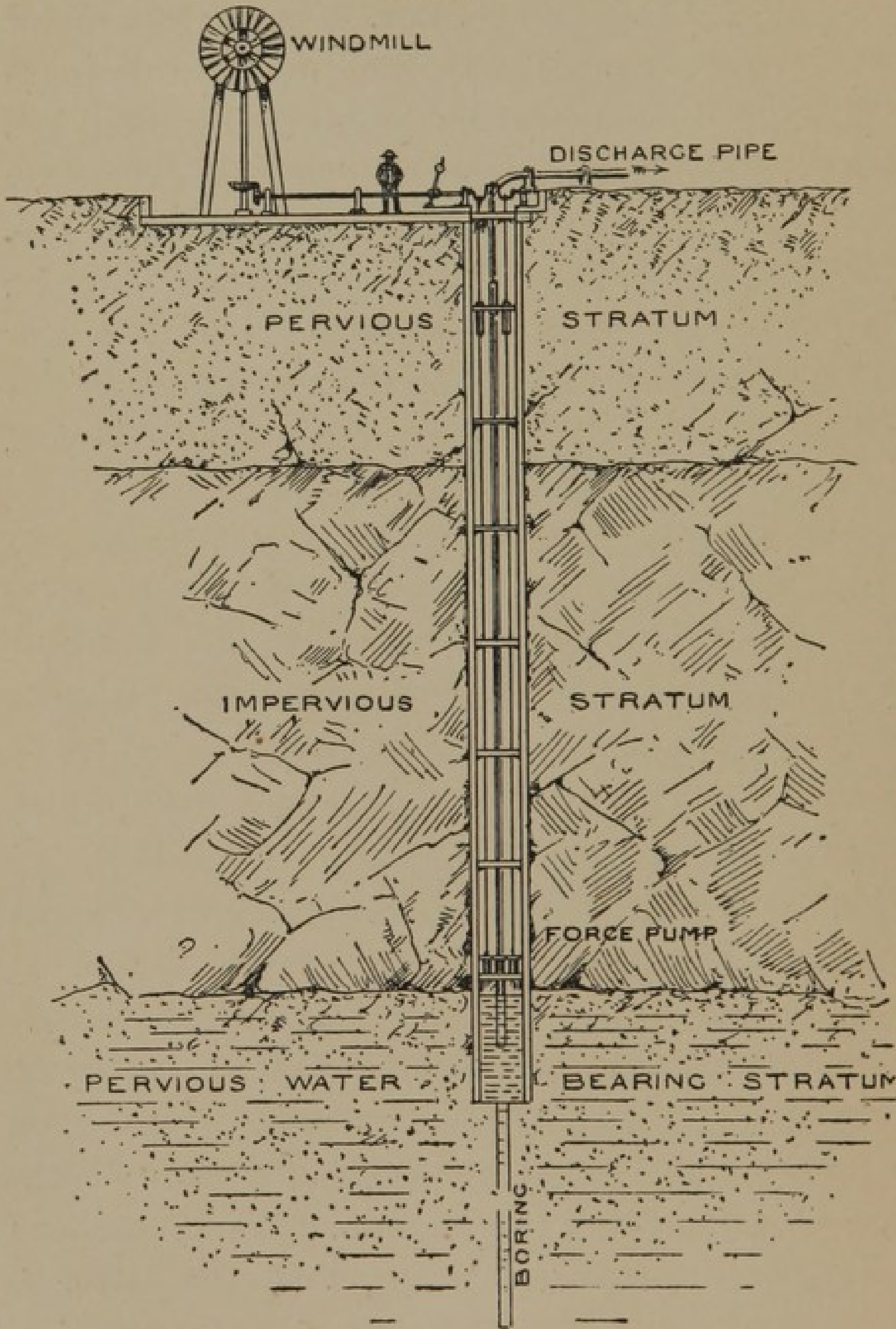
If a shallow well is liable to pollution from leaky sewers, cesspools, or other receptacles of human waste substances, the extent of the pollution is likely to be increased in proportion to the quantity of water withdrawn from the well. When the level of the water in the well is lowered by pumping water out, the well acts as a focus of drainage for all the water in the subsoil contained in a circle of a certain size around the well as a centre (see Fig. 1). The greater the depression of water level, the larger the radius of the circle which the well drains. It follows from the above that a well at a distance from sources of contamination may be supplying fairly good water as long as it is not much drawn upon; but that an increased demand, by lowering the water level, may have the effect of bringing distant impurities within the area of its influence, and so causing dangerous contamination.

The water of a well is occasionally submitted to analysis, when the house and premises supplied from this source are unoccupied, and consequently no water is being pumped out. The analysis under these circumstances may indicate a fairly pure water. Subsequently the house being occupied, and possibly illness having occurred, it is found on analysis that the water is polluted with sewage. The natural tendency is to blame the first analysis; but, as already indicated, the real explanation may be that on the first occasion the water was not subject to pollution, whilst on the second occasion, owing to altered circumstances, it was.

A heavy fall of rain may cause considerable alteration in the appearance of the water of a polluted shallow well. During the dry weather, the sewage which percolates into the well is probably so far filtered during its passage through the porous soil, that the grosser impurities, which render the pollution evident to sight, smell, and taste, are removed. The polluted well-water under these circumstances may be clear, bright, sparkling, and pleasant to taste. After heavy rain-storms, however, the quantity of liquid filth finding its way into the soil may be so excessive as to render ineffectual the purifying filtering powers of the soil, with the result that unaltered sewage becomes mixed with the well-water, and the latter is rendered turbid, foul smelling, and nasty tasting.

A *simple test* for a suspected water is to bottle

Fig. 2.



DEEP WELL AND BORING

some and place it in a warm dark cupboard for a day or two. If the pollution is by sewage, and is excessive in amount, on removing the bottle, the water—originally clear and bright—may be found to have become turbid and evil-smelling. The reason of this alteration is that the microbes or bacteria, which cause putrefaction in organic substances, have been cultivated in the warmth and darkness, and multiplying in prodigious numbers have caused putridity in the organic matters contained in the polluted water.

The water obtained from *deep wells* and borings (Fig. 2) is usually free from organic matters, these having been destroyed by oxidation during the passage of the water through great lengths or great thicknesses of porous soil, such as chalk or sandstone. Oxidation in these porous strata of earth is carried on for the most part by bacteria, which in the presence of air with its contained oxygen break down or decompose complex organic matters, and resolve them into simpler inorganic constituents, incapable of further change or disintegration. The water from deep wells, therefore, is much more likely to be pure than that from shallow wells.

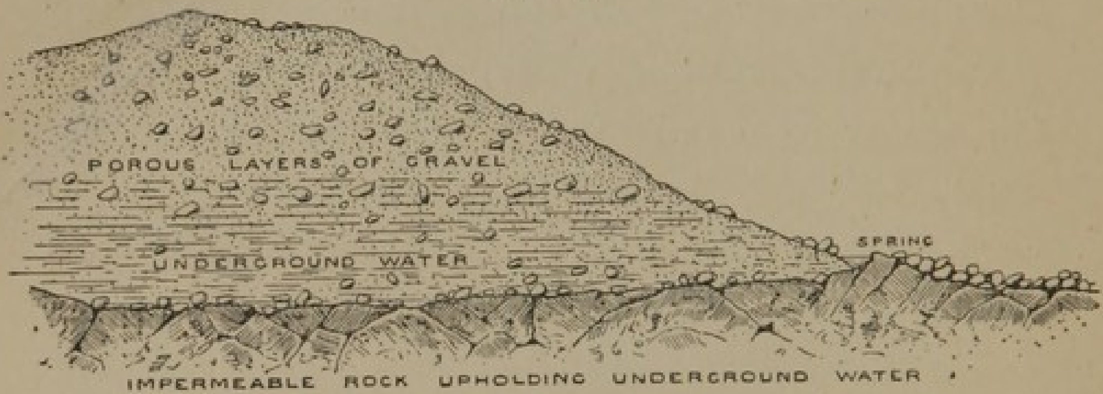
To secure this result, however, deep wells (Fig. 2) should be protected from surface washings, and from soakage into them of liquids from the subsoil adjacent to the surface. The upper portions of deep wells, then, should be lined with bricks set in and rendered over with cement, to keep out the surface and subsoil waters.

Deep wells usually furnish water that is hard, owing to its having taken up some of the earthy constituents of the soil through which it has percolated. This hardness is principally due to chalk dissolved in the water, which is called *temporary* hardness, owing to the fact before stated that boiling the water precipitates the chalk, and therefore softens the water. Deep well water may also, and in addition, be *permanently hard* from salts of lime, other than chalk, or salts of magnesia being present in it, which are unaffected by boiling, and which cannot therefore be got rid of in that manner.

Many deep well waters are found to be remarkably free from microbic or bacterial life. They are, in fact, nearly or quite sterile, *i. e.* free from living organisms. They differ in this respect more especially from river waters, which even after sand filtration are by no means sterile. Sterility in a water supply is doubtless on most occasions a great hygienic advantage, inasmuch as to certain species of bacteria are now ascribed the origin of infectious diseases. Still it should be mentioned that sterility in a water supply is now believed to be on occasion a distinct disadvantage. Should the bacillus of typhoid be introduced into a sterile water in the depths of a well, as for instance happened at Caterham, in 1875, through the discharges of a sick workman polluting the well-water, then the bacillus has the power of undergoing great multiplication, and causing large volumes of the water to acquire infective properties. Introduced into non-sterile river water, and exposed to the action of light in open reservoirs, the bacillus appears to be unable to maintain itself, owing both to the antagonism of the microbes already existing in the water, which is their normal habitat, and also to the destructive effect of sunlight; consequently the disease-producing bacillus tends rapidly to disappear.

Springs.—The water derived from springs resembles that of wells—a spring being merely a natural outlet of a body of the same underground water which the well taps in its subterranean depths. The so-called "main springs" furnish water from large underground reservoirs contained in the fissures, cracks, and crevices of strata of large area and considerable depth. The water from main springs usually flows all the year round, although with seasonal variations; whilst that from "land springs" is derived from limited areas of subsoil not far beneath the surface. The water from such springs is very often polluted in the same manner as are shallow wells, and may besides cease to flow altogether during the summer months.

FIG. 3.



SPRING ISSUING ON SIDE OF HILL

Springs, as a rule, are caused by the "cropping out," that is, the appearance at the surface of the ground, of the impermeable strata that hold the water up in the porous strata above them (see Fig. 3). Springs are very commonly found on hill sides, in valleys bordered by hills, at the feet of cliffs on the sea-shore, and in the beds of rivers.

The perennial springs, which flow all the year round, although usually with diminished volume in the summer, supply for the reasons above stated water of more constant purity than the intermittent springs which are dry in summer-time. The temperature of the water of these deep-seated springs is also remarkably uniform both summer and winter, the underground reservoirs being comparatively unaffected by atmospheric seasonal changes, owing to the great depth of intervening soil.

Public Water-supplies.—There is a considerable advantage to the health of the community in the supply of water by a public water company or municipal corporation, as opposed to the private supply, whose source is too often liable to contamination. Half a century ago, large sections of the community derived their water supply from shallow wells situated on private premises, from stagnant ditches or ponds into which all kinds of refuse found access, or from filthy streams. To-day such sources of supply are becoming much less common; and many of our chief industrial centres have acquired sources of water-supply which are not only adequate for the needs of their present populations, but are likely to prove sufficient for the wants of growing populations for generations to come.

Thus Dublin is supplied with water from gathering-grounds and a large "impounding reservoir" at Vartry amongst the Wicklow Hills, twenty-six miles from the city. Glasgow takes water from Loch Katrine, thirty-four miles from the city. Manchester has lately obtained a new source of supply from Lake Thirlmere. Liverpool by immense engineering works has impounded the waters of Vyrnwy amongst the Welsh hills, creating an artificial reservoir four and three quarter miles in length, and conveying the water a distance of sixty-eight miles. All these waters are pure, soft, and well fitted for all domestic and manufacturing purposes, although some of them are slightly peaty, the peat being derived from the gathering-grounds of the water.

The chief danger of a public water-supply lies in the disastrous consequences liable to ensue upon the introduction of infectious matter into a reservoir or distributing main. Under these circumstances a wide-spread epidemic may arise, involving a considerable section of the water consumers—an epidemic which would have been impossible under a system of separate supplies from private sources. What are known as water epidemics of typhoid fever are now unfortunately sufficiently familiar. Such wide-spread epidemics were unknown, or at any rate unrecognised, before the days of public water supplies. On the whole, however, the balance of advantage is decidedly in favour of the public supply.

Constant and Intermittent Supply.—Public companies either supply their customers with a constant flow of water into their houses, or intermittently—that is to say, the water is only turned on from the mains into the houses at intervals, usually once or twice a day.

The great advantage of the constant service is that no storage is required in the houses. The only cisterns necessary in a house with constant service are those required to supply water-closets and kitchen boilers. The water is therefore derived straight from the mains, and is not deteriorated before being consumed by long storage in cisterns or water butts.

Cisterns.—Water which is stored in cisterns becomes flat and insipid, and is in fact less refreshing than that drawn direct from the mains. Recent observations also show that the microbes in water undergo great multiplication when water is at rest in cisterns or tanks. We are not aware at present of the precise influence such excess of microbes in drinking water may exert upon the human frame. The majority of them may be harmless, but we do not know if the products of their growth are as innocent; nor do we know that harmful microbes may not be included amongst a crowd of harmless species. On the whole it is better, because safer, that water should be consumed in as nearly sterile a state as possible, so that the risk of the introduction of harmful organisms, or of the injurious products of any organisms, may be reduced to the nearest attainable minimum.

Such disadvantages apply to storage under any conditions, even the best; but experience shows that storage in houses is often so carried out as to introduce dangers of pollution which are strictly preventable.

Cisterns are often placed in improper places. The main cistern of a house, used to supply water for all domestic purposes, may be found inside a water-closet, where it is liable to be reached by unwholesome gases; or under stairs or floors, where dust and dirt fall into it; or placed in inaccessible positions, where access for the necessary cleaning is impossible; or without a cover in the open air, so that soot, dirt, and filth of various kinds find an easy entrance into the water.

There is another source of danger to which special attention should be given, namely, the direct connection of the main or drinking-water cistern of a house to the water-closet apparatus or to the drains by means of a pipe or pipes (see Figs. 17 and 18, p. 74). Sometimes it will be found that the overflow pipe (the pipe used to carry away water when the cistern is overfull) is connected to a drain or a soil-pipe—(a soil-pipe being the pipe used to connect a water-closet with an underground drain). In such cases, foul air from the drain may escape immediately over the surface of the water, between the water and the cistern-cover. In this way the water may become dangerously polluted with air from the drain, and with the injurious matters such air may contain.

It frequently happens that the main cistern is used to supply water to a water-closet for flushing purposes. In these cases there is great risk of the water in the cistern becoming polluted by bad air from the closet, if the valve—which must be opened to allow water to reach the closet-pan—is in the cistern itself. The valve is in connection, by means of wires and levers, with the handle of the closet, and, when opened, air from the supply-pipe of the closet is apt to pass back through the water of the cistern, and so cause it to be polluted. There is less risk of such an occurrence when the valve is on the supply-pipe close to the closet-pan, for in this case the supply-pipe contains water and not air, and therefore presents an obstacle to the passage of air from the closet-pan up to the cistern.

If cisterns are required in a house, the following simple rules should be carried out. (1) The cistern should be placed in an accessible position; it should be covered with a well-fitting lid; and situated so as not to be exposed to foul air, dust, dirt, or vermin gaining access to it. (2) The overflow pipe should not be connected with any part of the drainage appliances of the house, but should be carried through an outer wall or the roof, so as to end in the open air, and serve as a "warning" pipe—a pipe, that is to say, which gives warning that the cistern is overfilling, and that waste of water is occurring. (3) Water-closets should not be supplied directly from the main cistern, but small flushing cisterns, each cistern containing a few gallons of water, should be used to supply the water-closets; these small flush-cisterns being themselves supplied with water from the main cistern. The rule should be enforced that every tap in a house must be regarded as a drinking-water tap. It may, at least, be so used at times, although perhaps not habitually. The cisterns supplying taps should be separate from those used to flush water-closets. (4) The cistern should be periodically cleansed, twice a year at least; and in the case of lead-lined cisterns, care should be taken that any coating lining the metal is not removed, so as to avoid the subsequent exposure of a bright metallic surface to the action of the water.

The material of which the cistern is made, is perhaps of less importance than the conditions above stated. Galvanised iron cisterns are now most largely used; stoneware has been lately introduced as a material for cisterns; whilst brick cisterns lined with cement are especially useful for the underground storage of rain-water. Slate cisterns with cement joints are employed in some places. Lead-lined cisterns are, on the whole, better avoided, although it must be stated that for waters of medium hardness, like the Thames water supplied to London, which have a comparatively slight solvent action on lead, there is no great risk in the use of old lead cisterns, whose surface has become adequately covered by a protective coating from deposited salts.

In speaking of the constant service of water, it has been mentioned that small flushing cisterns are required for the water-closets. It should be an invariable rule in every household, which has a constant water supply, that water-closets are not to be directly connected to the house water-pipe, without the intervention of a cistern. The neglect of this observance has led to outbreaks of disease, owing to liquid filth or foul air being sucked into the main water-pipes, during intermissions in the service, through pipes in houses connected direct to foul and obstructed water-closets. It is now an ascertained fact that main water-pipes under certain circumstances, as when emptied of water, tend to suck in air or water from the ground, if there are leaks in the pipes there, or from house pipes if there are no leaks in the underground mains, and so the desirability of not connecting the house-pipes with any receptacle liable to contain foul matters is evident.

Where there is a constant supply of water, it will occasionally be noticed that the water drawn from the tap in the early morning is milky looking from the presence of innumerable little bubbles of air; these gradually rise to the top of the water and disappear. They merely indicate that by some means air has found its way into the water-pipes, and has become churned up with the water. As a rule, they do not indicate any dangerous contamination; but should the water smell of coal gas or sewer gases, it should be rejected at once, and the attention of the water company's officials should be drawn to the fact.

To avoid the risk of drinking water containing traces of lead, the water which has been at rest all night in the lead pipes should invariably be allowed to run to waste. A gallon or so may be got rid of in this way, and then it will be right to assume that the water drawn off has arrived direct from the iron street mains.

Purification of Water.—When water is raised to the boiling point for a few minutes, all microbes or germs present in it are destroyed. It is possible that a few of the spores or immature forms of these microbes may remain alive in the water; but for all practical purposes the water may be regarded as sterilised. The harmful or disease-producing microbes are probably killed with greater rapidity and certainty than the harmless species. In this case, at any rate, experience coincides with theory in agreeing that boiling renders a water harmless—a water, that is to say, which if drunk unboiled might well be credited with the capacity to produce disease.

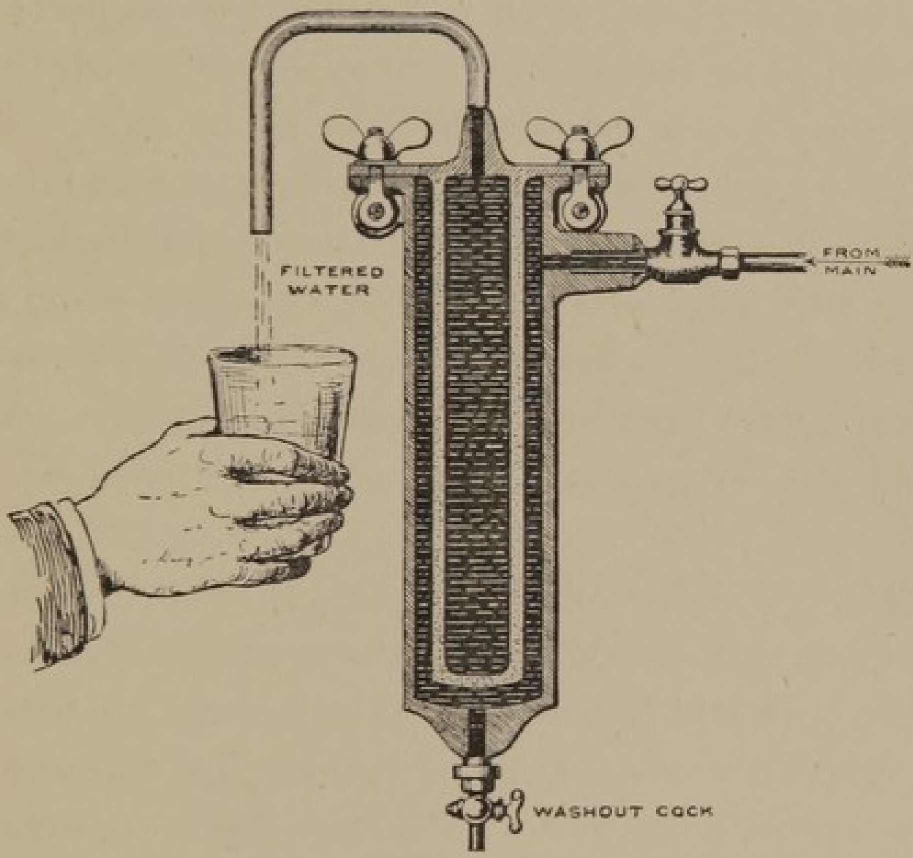
Water which has been boiled is not pleasant to drink, owing to the loss of its aëration, any gases dissolved in the water having been expelled by the boiling. This flatness may be improved by allowing the water to flow—a drop at a time—from one vessel to another. In falling through the air, the drops of water become aërated, and palatability is restored.

The softening of a hard water for domestic use is occasionally desirable. This can be accomplished by boiling and getting rid of the temporary hardness, as previously described; but far more easily by the use of one of the softening powders now prepared by several manufacturing firms. These powders consist of slaked lime with a certain proportion of soda. When added to the water, they cause a precipitation of the chalk dissolved in it, and thus get rid of the temporary hardness in the same way as boiling does. This softened water should not be used for drinking, unless special precautions have been taken to add the powder in exact proportions; otherwise some excess of soda or lime may remain in solution, which might impair the potability of the water.

Domestic Filters.—These contrivances are perhaps on the whole more often a source of mischief than of benefit. A neglected filter is likely to add impurity to a water passed through it; and it is certainly true that filters are more often neglected than kept in a proper state of cleanliness and repair. These remarks are especially applicable to cistern filters, which when once fixed are often left for years in position, their very existence being forgotten.

The general impression in the public mind is that any sort of domestic filter is capable of rendering a water fit to drink. There is no evidence to support this view except in the case of the "sterilising filters," which do undoubtedly—for a time at any rate—remove all living microbial life in the process of filtration. It is, however, conceivable that there may be existent in a water chemical poisons, the result of the activity of microbes, which the sterilising filtration does not keep back. In the case of the ordinary carbon powder, asbestos, and block filters—comprising the vast majority of the domestic filters made and sold in this country—it cannot be claimed even that there is any sterilisation, so that microbes of all kinds may be present in the filtered water to the same extent as they are in the unfiltered water.

Fig. 4.



Section of "Berkefeld" Filter

The sterilising filter was first introduced by MM. Pasteur and Chamberland ; a similar filter has since been constructed by Berkefeld (Fig. 4). In these filters water is passed under pressure through cylinders of very fine porous ware. So fine are the pores of the ware, and so intricate are the passages through it, that not even the most minute of the known micro-organisms are able to pass through. Scientific opinion is not yet in a position to assert that the sterilisation effected by this filter is as efficacious as the boiling of a water. Still the sterilisation may be regarded practically as removing the chief sources of danger from a suspicious or polluted water.

Quite recently an elaborate and very important research has been conducted by Drs. Sims Woodhead and Cartwright Wood into the relative efficiency of water filters in the prevention of infective disease. The results obtained, after careful testing of the domestic filters obtained from most of the filter manufacturers in this country, show that no protection whatever is conferred by the use of these appliances against the passage of disease germs from the unfiltered into the filtered water; and that consequently the claims advanced by the makers of these filters to the effect that their appliances safeguard their owners against "Typhoid fever, Cholera, and Blood-poisoning," are absolutely unreliable and unwarranted.

In some respects the use of these filters even enhances the danger arising from the consumption of infected water, inasmuch as many of the microbes are temporarily arrested in the filtering medium, and continue to pass through the medium into the filtered water for a week or even longer after they have been deposited. Thus a water-supply containing, suppose, infectious matter on one day only, would, if drunk unfiltered, endanger the health of the consumers on that day only; but if passed through a filter before being consumed, the use of the pure water subsequently passed through the same filter would endanger the health of the consumers for a further period of seven or more days subsequent to the day when the filter was infected, owing to the pure water washing arrested infective microbes through the filtering medium into the filtered water.

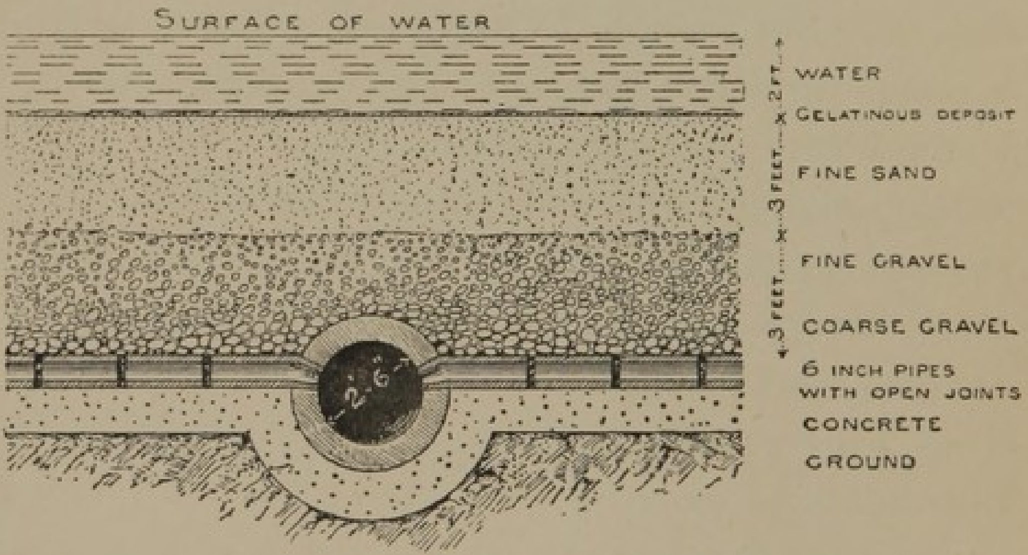
No doubt the general verdict of those who read these scientific revelations will be that domestic filters should rather be regarded as domestic enemies than as friends to health, for they promise what they cannot perform, and thus engender a false sense of security.

The process of purification carried out by the London (Thames) Water Companies, is very fairly effective in depriving the water of the microbes contained in it in its unfiltered condition. In the large subsidence reservoirs, into which the water is led from the river, much of the suspended matter is deposited, carrying with it vast numbers of micro-organisms.

This clarified water is next passed through filter-beds (Fig. 5) consisting of about three feet of fine sand lying upon layers of gravel, fine above but coarse below, in which are the mouths of the outlet pipes to convey the water to the pumping station.

Upon the top of the sand-filter, after it has been in use some days, a layer of gelatinous matter forms which is very retentive of microbes. It is to this gelatinous substance that is now attributed the

Fig. 5.



SECTION OF SAND FILTER-BED

chief effect of sand filtration in reducing the number of microbes in the filtered water—a reduction which amounts on the average to about 98 per cent.,—that is to say, only about 2 per cent. of the microbes to be found in the unfiltered water are present in the filtered. The gelatinous layer which forms on the surface of the sand, and which entangles in its meshes the microbes, is derived from the organic matter strained out of the water, and it is no doubt very largely composed of micro-organisms itself.

Inasmuch as this gelatinous layer does not form for at least two days after the sand filter-bed has been brought newly into use, it is obvious that until this interval has elapsed the purification is not satisfactory. We also know from actual experience that in times of flood, when the river water is very turbid, the filtration is not effective in removing suspended matters, including microbes, as under these conditions a cloudy and coloured water is very often distributed to the consumers.

The chief danger to the water-consumer would therefore appear to be during times of floods, or after prolonged frost, when the powers of the filtering beds are overtaxed or disturbed—these powers, as we now know, being largely dependent upon biological processes.

CHAPTER II

DOMESTIC REFUSE

Ashpits and dustbins—Privies, middens, and cesspools—Pail, ash, and earth closets—Water-closets—Soil-pipes—House-drains: Testing drains—Waste-pipes—Gullies and bell-traps—The flushing and cleansing of drains.

THE domestic refuse of houses is composed of the following matters:—Excretal refuse, *i. e.* fæces and urine; household slops or soapy water used for washing, mixed with urine; kitchen waste waters, containing organic matters from food, grease, and sand, this water being often at a high temperature; bones and scraps of food; broken pots and pans, dust, ashes, cinders, and rubbish of all kinds. Some of these matters are in a liquid condition, whilst others are more or less solid. Some, again, such as the excreta, the refuse food, fat, and bones, are prone to rot and decay; whilst other matters, such as cinder refuse, are indestructible, except by burning.

Prompt removal of the matters which are liable to decay is essential for the maintenance of a good standard of health. Organic filth in the process of rotting is attacked by the microbes of putrefaction, which are universally present in air, earth, and water. The *rôle* of these microbes is to disintegrate or resolve complex organic bodies into simpler elements; but in this very necessary process gases and vapours are given off which are distinctly injurious to human life. The function of the microbes is an important and necessary one, for without them perished animal substances would remain for ever in a useless condition, serving merely to litter up the surface of the earth. By the aid, however, of the microbes of putrefaction, animal matters are changed into those simpler substances which form the nourishment of plants, these in turn supplying food for animals, and thus the natural balance is preserved. It will now be apparent why the prompt and regular removal of refuse matters from houses is so essential for the preservation of health, and why the disposal of sewage and such like refuse on land is so largely carried out in modern sanitary systems.

In many parts of the country, at the present time, excretal matters, together with the liquid slops and waste waters, are carried away from houses by means of water, through the agency of water-closets, drains, and sewers. The great advantage of this water-carriage system is at once evident, for the foulest and most noxious of the refuse material of the house is immediately removed out of the vicinity of the dwelling by means of the drains. In many places still, however, this water-carriage system is not in operation; and here we find that the excreta are collected in pails, tubs, privy pits, or cesspools. In these receptacles excreta and other waste matters are retained for periods varying from a week to months, or even years. The odours of putrefaction are seldom absent from such dwellings or their surroundings, and the inhabitants must perforce live in an atmosphere more or less pervaded by unwholesome effluvia.

We are, therefore, in a position to affirm that the first principle of sanitation requires that all such refuse matters as are liable to ferment and decay should be removed from the neighbourhood of dwellings with the least possible delay.

Ashpits and Dustbins.—These receptacles are intended to contain the solid refuse matter of the house until such time as it can be taken away. They are not meant to receive excreta or liquid refuse of any kind. Even as regards solid refuse care and discrimination should be exercised as to the kind of matter put into the dustbin, if nuisance both to the house and its neighbours is to be avoided. Bones, fat, and waste food scraps will ferment and rot in the dustbin, especially during the warmer periods of the year. As far as possible these matters should be kept out of the dustbin, and what cannot be destroyed by heat in the kitchen fire should be placed in a galvanised iron pail with an air-tight lid, and taken away daily. Dust, ashes, cinders, and dry rubbish are the matters which the dustbin may properly contain. If great care is taken in this direction, the dustbin is little likely to become the serious nuisance so commonly experienced. But even then a frequent emptying of the contents is desirable. How often this should be carried out depends on circumstances, but in any event the contents should not be allowed to accumulate for a longer period than a week. It is perhaps hardly necessary to insist that infectious rubbish from the sickroom should be burned, and never thrown into the dustbin. Such a proceeding is now in London, under the Public Health Act, an offence punishable by fine.

A galvanised iron pail with a tight-fitting lid is far preferable to the old-fashioned brick dustbin. In the first place it is desirable to have a small receptacle, so that its contents may be frequently removed. The brick dustbin was generally made of large capacity, in order that a frequent removal might not be necesssary. Again, bricks are porous and absorptive of foul matters, so that even when empty the brick dustbin is by no means inoffensive. They are also difficult to empty; they are not easily cleansed; and the wooden cover which secures the dryness of the contents is very often out of place, or not to be found.

It is a matter of considerable importance that the contents of the dustbin should be kept dry. Fermentation and decomposition of organic matters proceed at the greatest rate when there is abundance of moisture, and when the temperature of the air is sufficiently high. We cannot alter the temperature, but it is possible to exclude moisture, and thus deprive the microbes of one of the elements necessary for their growth and life.

The advantages of the galvanised iron pail are its small cubic capacity, the non-absorptive character of the material of which it is made, and the facility with which it is kept covered and its contents sealed up. It can, besides, be carried bodily to the dust cart into which its contents are to be shot, and can be thoroughly cleansed when empty. The process of digging out the contents of the brick dustbin was always an offensive one; and when situated under the windows of a house, as they often were, the dust and effluvia were apt to find their way in through the windows.

The ultimate disposal of the dustbin refuse is rather outside the scope of this little treatise; but it may be well to remark that house refuse, with its many potentialities of mischief, ought to be cremated, *i.e.* destroyed by fire. It certainly should not be mixed with manure and sent away into the country, to be spread upon fields in the neighbourhood of villages, as is still far too frequently done. This practice has led to outbreaks of sore throat and diphtheria amongst village populations, who certainly should not be exposed to sources of danger not of their own manufacture. Nor is the process of sorting out the filthy refuse into its constituent parts, as conducted in dust-yards by both men and women, an occupation to encourage from the social or hygienic point of view.

Privies, Middens, and Cesspools.—It is unnecessary to say much about such receptacles for filth, inasmuch as they are now condemned by all sanitary authorities, and replaced by improved forms of ash or earth closets wherever found. The common form of privy, midden, or cesspool is a hole of considerable size excavated in the earth, and lined or not, as the case may be, with bricks or bricks set in cement—more usually, perhaps, the former than the latter, as the porous unlined pit allows the liquids of the sewage to escape, and so requires emptying only at long intervals. It is a noteworthy fact that the liquids of house sewage form by far the larger proportion of its bulk, consequently the solids left behind in a privy-pit after the escape of the liquids, accumulate at so slow a rate, that a long time must elapse before the pit becomes filled.

As previously described in the chapter on "Water," the foul liquids escaping into the soil frequently cause pollution of water supplies, and necessarily contaminate the ground in the neighbourhood. In addition there is contamination of the air from the large accumulation of putrefying filth, and this is invariably increased when the contents of the pits are being dug out for removal. In the case of the poorer parts of some towns, the privy contents have to be carried in pails through the houses, there being no side or back entrances to the yards where the privies are situated.

There is less objection to properly lined and constructed cesspools situated at a distance from houses, wells, or streams. Where the cesspool contents can be used on garden ground, and where there is no danger of pollution of water supplies, the cesspool system has its advantages; but still it must be admitted that the principle of the cesspoo violates the elementary rule that the fertilising matters of sewage should be returned to the soil with the least possible delay, and should not be allowed to ferment and putrefy in enclosed receptacles. If cesspools are employed in country houses with gardens, they should be situated at a distance from the house; they should be constructed of puddled clay, brick, and cement, so as to be impermeable to liquids, and they should be ventilated by a good-sized pipe carried up a tree.

In many country places it is possible to apply the sewage at once to the land, upon specially prepared filter-beds, or by means of sub-irrigation, and thus avoid any necessity for cesspools.

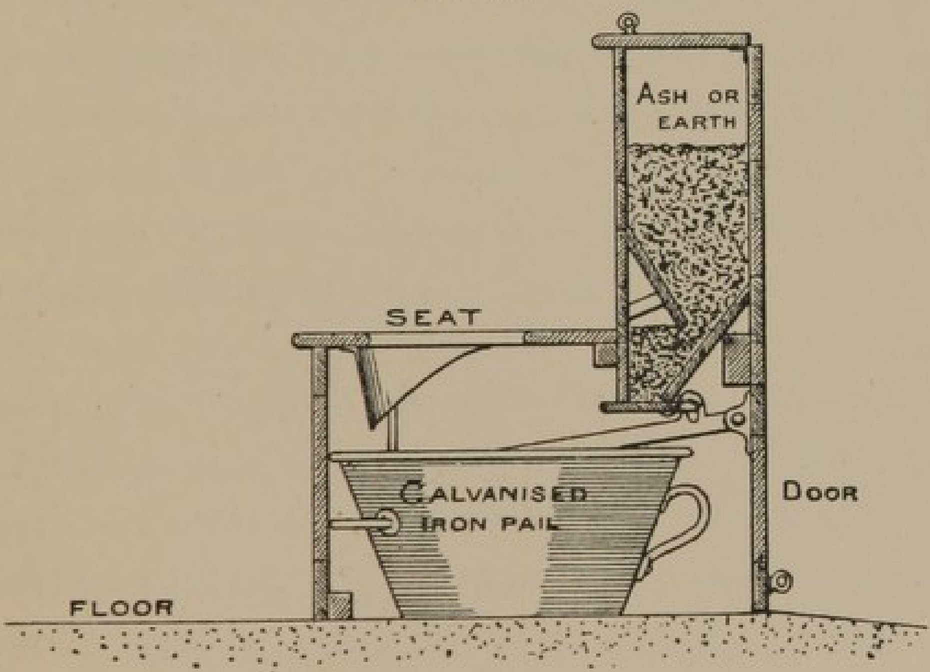
Occasionally cesspools are found under the basements of houses. Originally constructed, perhaps, before the existence of public sewers in the streets, or before these sewers were used for the reception of house sewage, they will often be found to be connected, by means of an overflow pipe, with the sewer under the street, this pipe having been introduced after the date at which it became lawful to connect house-drains to public sewers. A cesspool so situated under a house, which is never emptied or cleansed, and which is in direct connection with a public sewer, is likely to prove a very serious source of mischief, and to be productive of grave illness amongst the occupants. The evil is the greater from the ignorance of its cause, for the existence of such old cesspools under the basement is usually quite unknown and unsuspected.

Pail, Ash, and Earth Closets.—The moveable pail for the reception of excretal refuse is a great improvement on the fixed and leaky privy or midden. A galvanised iron pail or a stout oak tub is placed under the closet seat; when full it is covered with a tight-fitting lid, and its place is taken by a clean empty one, the full pail being removed bodily to the place where it is to be emptied and cleansed. It is very essential that the contents of the pails should be kept as dry as possible, to prevent fermentation and the disengagement of foul odours. For this reason slops and waste waters must on no account be thrown into pail closets—not even the urine of chamber slops.

It is best also to ensure the dryness of the contents by the use of ashes, or dried and sifted earth. Ashes and cinder refuse are very absorptive of moisture, so that a small quantity added after each use of the closet tends to keep the pail contents dry. Dry sifted earth is also very useful for this purpose. Fæcal matter, with which dry earth has been mixed, becomes not only inoffensive, but after a short time even unrecognisable as such. It is no doubt due to the micro-organisms contained in the earth that this result is secured—but, be it noted, without setting up putrefaction or producing offensive effluvia. The resulting "compost" produced by the mixture of earth with fæces, forms a good garden mould for potting out plants, but is by no means a rich or valuable manure.

Special closets are manufactured for use with ashes or dry earth. The design of these closets is to apply a measured quantity of ashes or dry earth at each use, and for this purpose the handle of the closet is in connection with a hopper behind and above the seat, which delivers the regulated quantity into the pail on the handle being raised (Fig. 6).

FIG. 6.



ASH OR EARTH CLOSET

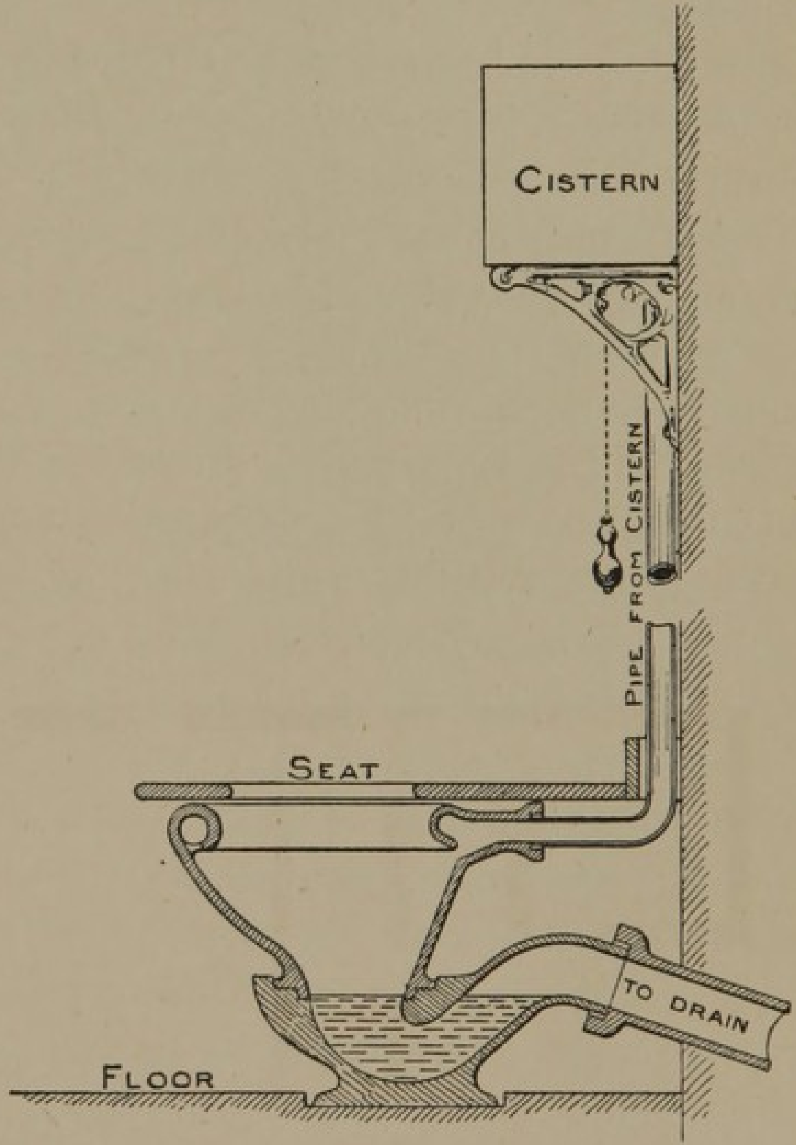
There is wisdom in not allowing pail, earth, or ash-closets to be placed inside houses. If so situated, they are very frequently made the receptacles for slops, and then become an unmitigated nuisance. There is, besides, always some odour from these closets, even under the best of circumstances. Their proper place is out of doors, where the escape of foul gases is least likely to be productive of nuisance.

Water-closets.—The essentials of a good form of water-closet may be given as follows:—The apparatus should be simple and inexpensive; all parts of the pan or basin, in which the excreta are deposited, should be capable of being easily and well flushed by water; there should be no confined air-space between two water-seals, in which foul gases can accumulate; and the pan or basin of the water-closet must be connected with an efficient trap or water-seal, to prevent the passage of foul air from the soil-pipe or drain into the house.

The form of water-seal now most largely used is that known as the *siphon trap*. This is merely a pipe bent into the shape of the letters S or P placed sideways, the curvature of the pipe retaining sufficient water to prevent the passage of air through it. Although the water-seal form of trap is cleanly and simple, it is liable to certain disadvantages. Thus, if the water-closet is not in use, the water in the trap may evaporate, and the seal be rendered no longer effectual in preventing the passage of air. Again, the water in the trap is liable to be sucked out into the soil-pipe or drain by what is known as "siphonage." It will be necessary to recur to this subject again in speaking of soil-pipes.

A good form of water-closet is that known as the "*short hopper*" or "*wash down*" *closet* (Fig. 7). The pan or basin is made of china or white-ware, well glazed on the surface, so as to present a hard, smooth, and shiny surface, readily cleansed by a flush of water. The top of the basin is provided with a flushing rim, which allows the water from the flushing cistern to flow all round the basin, and to descend with impetus into the trap at the bottom of the basin. The back part of the basin is constructed so as to be nearly vertical, whilst the front portion slopes forward. This construction secures that the fæces are deposited in the water of the trap, and not upon the sides of the basin, and thus the closet is rendered cleanly in use. A closet of this kind should not be boxed in with woodwork; the seat should be hinged at the back, so that it can be turned up, and thus expose the space between the seat and the floor, which is so often the receptacle of filth and dirt. Some manufacturers supply a closet of this class suspended from iron brackets let into the wall, so that no part of the closet apparatus rests upon the floor. By this arrangement the housemaid's broom and duster has access to every part of the water-closet floor, and cleanli-

FIG. 7.

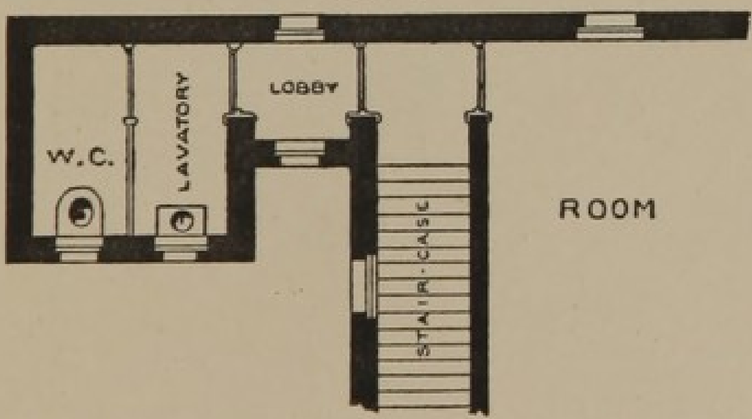


WASH-DOWN CLOSET
WITH WATER-WASTE PREVENTER

ness is possible in the place where it is most required.

Wherever it is possible, water-closets should be placed against an outside wall, so that they may be ventilated into the outer air. Water-closets without external light and ventilation are usually a nuisance, as the foul odours generated in them find their way into staircases and living rooms, and the darkness of the closet engenders neglect, and its consequence, dirt. In new buildings the water-closet should not only be placed against an outside wall, but should also be approached by a lobby with swing doors of entrance and exit, so as to cut off direct access of air from the closet to the house. This lobby should be ventilated by windows opening into the outer air (Fig. 8).

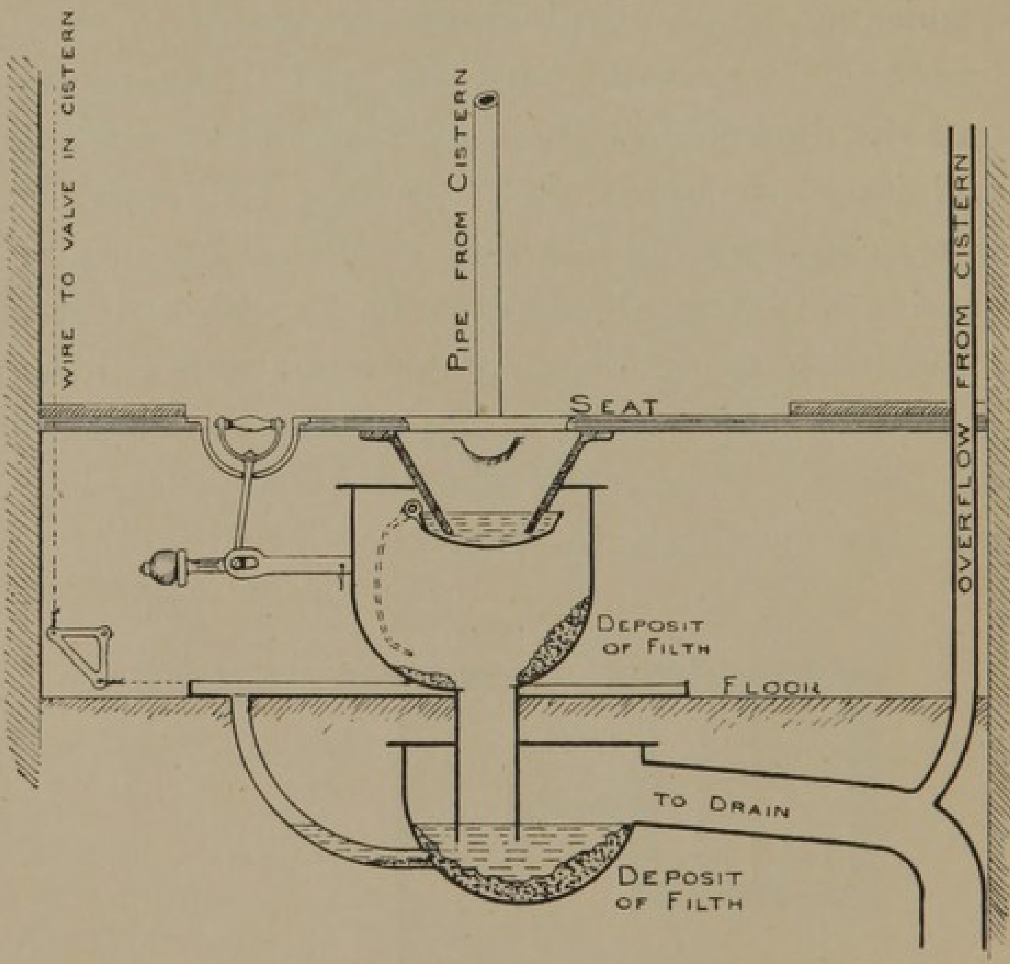
FIG. 8.



PLAN OF W.C.
IN HOUSE WITH APPROACH LOBBY

The common *Pan and Container closet* (Fig. 9), which has been so largely used, is an insanitary form, on account of the filthy condition the container gets into after prolonged use. The container is below the pan, which swings into it, and much of

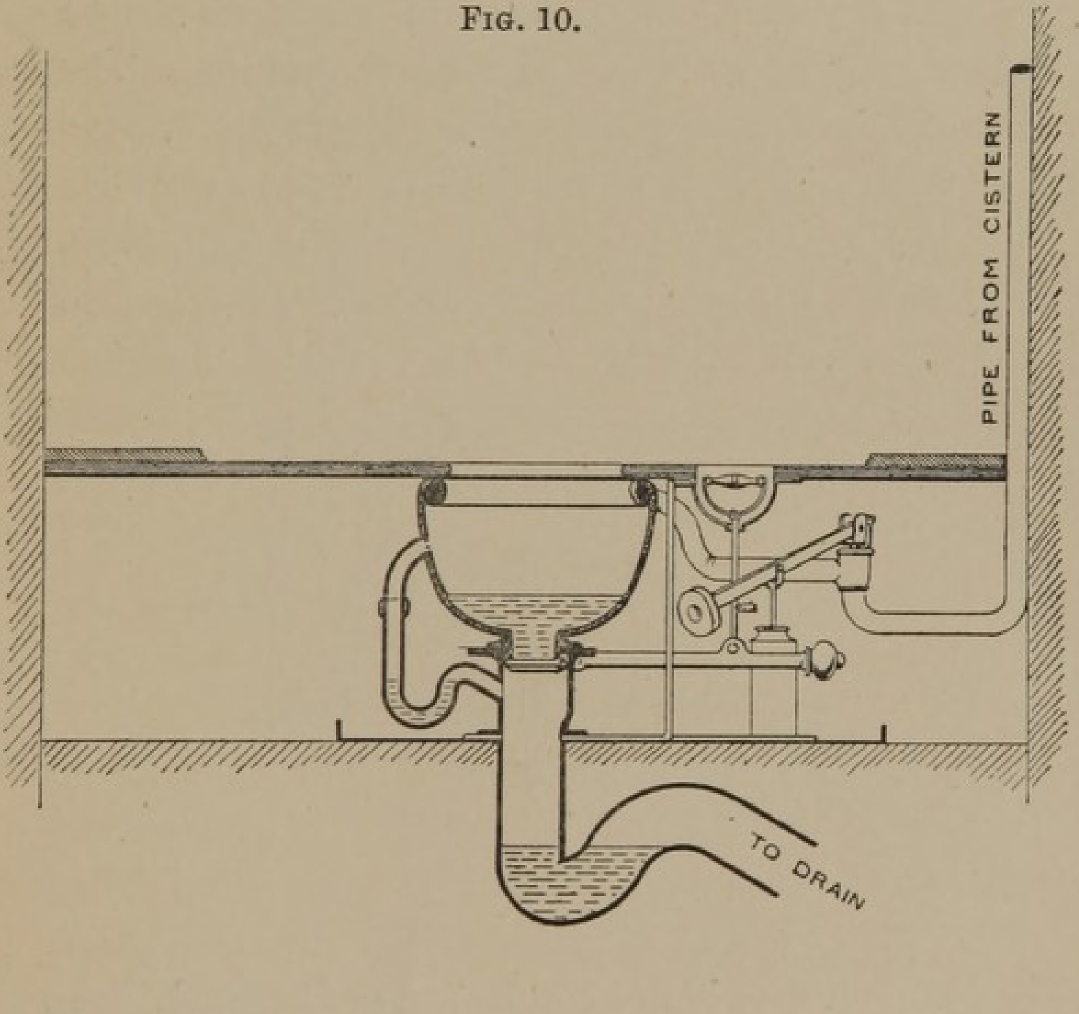
FIG. 9.



PAN AND CONTAINER CLOSET WITH D-TRAP

its interior surface is never flushed by the descending water, although it becomes much fouled by the splashings of excreta. The D-*trap* to which the outlet of the container is connected, is also an insanitary appliance. It is not properly cleansed by the flushing water, and in time becomes silted up with filth, which putrefies and gives rise to offensive gases. These pan-and-container closets are always a nuisance, for when the handle of the closet is pulled up, and the pan depressed into the container, the foul gases which have accumulated in the container and D-trap escape into the water-

FIG. 10.



VALVE CLOSET

closet apartment, and so find their way into the house.

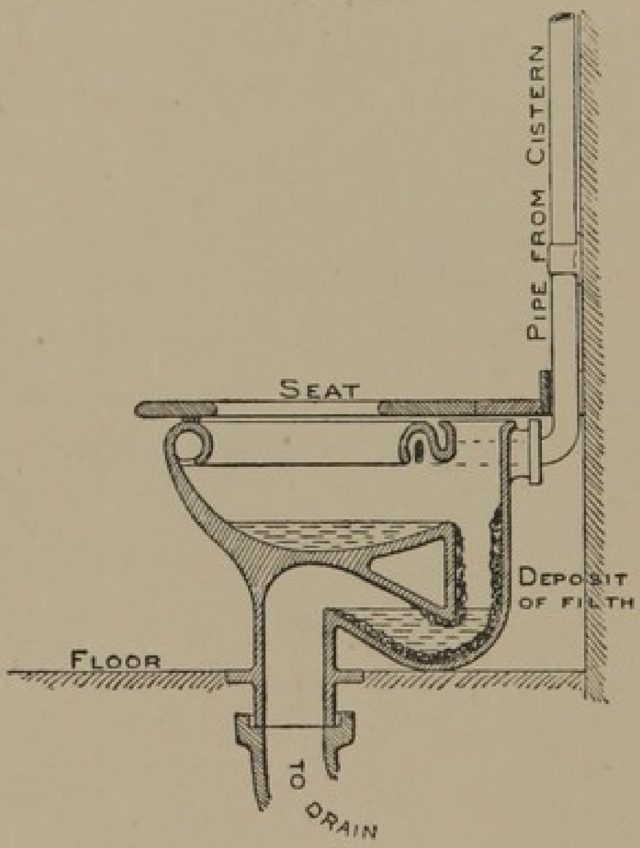
The *Valve closet* (Fig. 10) is a great improve-

4

ment on the pan closet, and is now largely used in the better class of houses. Being fitted with rather delicate mechanism it requires care in use, and is not well adapted for working class dwellings, where rough usage is often experienced.

The "*Wash-out*" *closet* (Fig. 11), another form

FIG. 11.



WASHOUT CLOSET

in common use, is not so cleanly as the wash-down or short hopper previously described. It is not so well flushed with a small quantity of water, and the entrance to the trap below the basin is apt to become much soiled.

Whatever form of closet is used, the cistern required to supply the closet with flushing water should always be separate and distinct from the main or drinking-water cistern. For closets of the short hopper type, what are known as "*water-waste preventers*" are now commonly used. They hold from two to three gallons of water, which are discharged at once into the basin of the closet by a short pull on a chain. This chain is connected to a siphon action arrangement in the cistern by means of a lever, and the pull on the chain sets the siphon in action. Water companies now insist on these "check" cisterns, as they are often called, being used, because they prevent the undue waste of water. The rapid discharge of the contents by a short pull on the chain is also an advantage, as it ensures the proper flushing of the closet at each use by a regulated amount of water. These water-waste preventers should be fixed at a good height above the seat of the closet, and the supply-pipe should be at least 1¼ inches in diameter, in order that the water may enter the closet basin with sufficient impetus and velocity to cleanse it and the trap below it.

Soil-pipes.—The soil-pipe receives the discharges from the upstairs water-closets, and conveys them by a greater or less length of vertical pipe to the underground drain. The best material, on the whole, for soil-pipes is rolled and drawn lead, the joints between different lengths being made with solder, *i. e.* what are known as "wiped" joints. The advantage of lead as a material is that it has a smooth surface, to which the filth of sewage does not readily cling. These pipes are usually made 3½ or 4 inches in diameter, the branches to the water-closets being of the same size.

It is much to be preferred that the soil-pipe should be fixed outside the house, instead of inside, as is so often done. If there is any defect in an internal soil-pipe, the foul air from the pipe escapes into the house. If the soil-pipe is external to the house, the defect is of less consequence, as the foul gases find their way into the outer air. Internal soil-pipes are generally protected by wooden casings, but this is not always so; and it is even on record that an uncovered soil-pipe was found in the larder of a house with a large nail hole in it. The nail had been driven in through the soft lead, in order to hang meat upon it. Galvanic action was set up between the lead and the iron of the nail, with the result that the hole increased in size, and the nail eventually dropped out, thus allowing foul air to escape into the larder, and taint the meat, milk, fish, or other food put there.

The proper *ventilation of the soil-pipe* is another important matter. A soil-pipe closed at the upper end, *i. e.* unventilated, is always filled with foul air, which tends to eat into the leaden walls of the pipe, and cause perforations or small holes. Not only this, but siphonage of the water-closet traps is far more likely to occur when the soil-pipe is unventilated. The mere emptying of a pail of slops down a short hopper closet connected with a soil-pipe closed at the top, will cause the trap to suck or siphon, and the water-seal to disappear, with the result that foul air can then pass back into the house. In the case of two or more water-closets attached to the same soil-pipe, the discharge of one closet may cause the siphoning of the trap of the other, should the soil-pipe be unventilated. The ventilation of the soil-pipe is also necessary to give exit to foul air in the drain with which the soil-pipe is connected.

The ventilation of the soil-pipe should be effected by carrying the pipe full bore to the top of the house, to a position remote from any windows or chimneys, and there leaving its end freely open to the air. Particular care should be taken to avoid the proximity of windows. It is not at all an uncommon experience to find that the foul air from a soil-pipe ventilator is making its way into the house through an open attic window. It is especially for this reason that pipes taking rain-water from the roof should not be allowed to act as ventilators to the soil-pipes, for the ends of these pipes are often in close proximity to dormer windows. Points at which defects in soil-pipes are very frequently found are:—the joint between the foot of the soil-pipe and the drain, and the joint between the china trap of the water-closet and the branch of the lead soil-pipe.

Cast-iron pipes are cheaper than lead, and are in consequence very largely used as soil-pipes. Their disadvantages are that they are not so smooth as lead on the surface, and that the joints, where the different lengths of iron pipe are connected together, are not nearly so secure as the soldered wiped joints on lead pipes. In addition, lead T pieces, as they are called, must be used to receive the branches from the water-closets; and the joints between lead and iron pipes are very seldom secure and sound.

Anti-siphonage Pipes are now rather extensively employed to obviate any risk of sucking or siphonage of the water-closet traps. They are made of lead—two inches in diameter being the usual size of the pipe,—and after being connected with the soil-pipe branches near the water-closet traps, they are taken through the outer wall, and carried up to a place remote from windows, or to be connected to the soil-pipe ventilator above the branch from the highest closet.

They are certainly not required in all cases, but are found of especial value where the soil-pipe branches are long, as it is in these cases that siphonage is most apt to occur. They also serve to ventilate these long branches, which otherwise would become reservoirs of foul air.

House-drains.—House-drains are the underground pipes conveying the sewage and waste waters away from any premises (domestic) to a sewer or cesspool. Being hidden from view, underground drains are more often defectively constructed, *i. e.* "scamped," than any other class of sanitary appliance.

The following are some of the chief rules which should be observed in the construction and laying of drains:—(1) Wherever possible the drain should be laid outside the house, and not in the ground beneath it. (2) The drain should be laid with a proper and even fall throughout its whole length, the usual gradient being a fall of from 1 in 20 to 1 in 60 for houses of average size. (3) The drain should be laid on a bed of concrete for its whole length. (4) Glazed stoneware socketted pipes should be used, the joints between the pipes being made of Portland cement. (5) For small houses 4-inch pipes should be used, for larger houses 6-inch pipes may be necessary, but it is very seldom that pipes 9 inches in diameter are required. (6) At a point near the sewer or cess-pool a siphon disconnecting trap, with fresh air inlet, should be fixed, to break the direct connection between the house drain and the sewer, and also to provide for the entrance of fresh air into the house drain. (7) The upper end of the house drain should be ventilated by a pipe carried full bore up to the ridge of the roof, this pipe being not less than 4 inches in diameter, and having as few bends and angles in it as can be attained. The soil-pipe and soil-pipe ventilator are usually made to serve this purpose. (8) The main drain and all its branches should be laid in straight lines; where the main drain changes its direction, or where branch drains join the main drain, inspection chambers should be fixed, so that each straight length of main or branch drain may be under control. (9) Inspection and disconnection chambers should not be placed inside the house, but in yards, areas, or other open spaces adjoining the house. They should be covered by "air-tight" iron manhole covers.

The most serious defects in house-drains are those that permit sewage to percolate into the soil beneath or around a dwelling. Defects which allow foul air to escape into the house are little less serious. Houses in which such defects exist are notoriously unhealthy to their inmates. The evil effects of living in a damp and vitiated atmosphere are sure to manifest themselves sooner or later.

Defective drains may be first indicated by illness amongst the occupants of the house, but perhaps it is more common, in the first instance, for the defects to become manifest through the agency of disagreeable odours. These may not be noticeable at all times or seasons, nor in every room of the house; but at certain times, and in certain spots in the house, it is probable that foul smells will be perceived. It is certainly the fact that during, or immediately preceding rain, the smell of drains is often most distinct; and this would appear to be due to the lessening pressure of the atmosphere accompanying or preceding rainfall, as indicated by the falling barometer. In cases where the house drain is in direct connection with the sewer, there being no intercepting or disconnecting trap, the direction of the wind may have some relation to the occurrence of bad smells in a house—certain winds causing a strong current of air in the sewer, which passes into the house drain and, through defects in it, into the house, carrying foul-smelling gases with it.

It will be as well to point out that bad smells in a house are not always due to drains. Slight escapes of imperfectly purified coal gas, owing to leaky gas-pipes or gas burners; dead and rotting mice or rats under the floor boards; wooden joists and woodwork rotting from damp and deficient supply of air; disused and uncleaned chimney flues, may all give rise to the odours characteristic of decaying organic refuse, and may, therefore, be mistaken for sewer or drain gases.

Long-continued dampness of floors or walls in the basement of a house is often originated by a defective drain beneath, from which sewage escapes into the soil around, and thence rises by capillary attraction to neighbouring walls or floors. Of course this state of dampness may be due to a naturally water-logged condition of the soil on which the house is built, and not to any defects in the drainage.

The most effective tests for drains are the water and the smoke tests. These are best carried out by sanitary inspectors or other experts in drainage matters, but every householder can carry out a fairly searching test for himself with oil of peppermint.

Half an ounce of this oil and a large can of hot water are carried to the top of the house by an assistant, and the oil followed by the hot water is thrown down the highest water-closet, or if the roof can be reached, down the open end of the soil-pipe ventilator, which is then plugged with a cloth. The assistant must remain outside the house, or shut up in the water-closet, until the search for leaks has ended, as his clothes will retain the smell of peppermint for a very considerable time. Peppermint being a very volatile substance, its aroma will be perceptible to the sense of smell in the vicinity of any leaks in the soil-pipe or drain, especially if these pipes are fixed within the walls of the house. Should the underground drain be at a considerable depth below the surface, defects, even if they exist, may not always be discoverable by the peppermint test; and in some cases it happens that rat-runs convey the vapour of peppermint, after a certain lapse of time, to considerable distances away from the exact spots at which the leaks are to be found.

The presence of rats and rat-runs in or near a house is usually evidence of bad drains, as these animals—in towns at any rate—nearly always come from the sewers. Where there is an old brick drain, the rats displace a loosened brick, and burrow in the ground in search of food, often finding their way eventually into the house larder. Rats, too, sometimes force a passage through a pipe drain at a place where a hole has been made to clear an obstruction which has choked the drain, and the hole has been subsequently "made good" by a piece of slate or tile loosely embedded in cement.

Drain grenades, consisting of little closed glass capsules containing oil of peppermint or a composition of assafœtida and phosphorus, which explodes on contact with water, giving rise to very pungent and peculiar smelling gases, are now largely used by sanitary inspectors, a dozen or so being carried easily in a pocket-case.

Waste-pipes.—These are the pipes which carry away the dirty water from baths, sinks, and lavatory wash-hand basins. These pipes should invariably be *disconnected* from the drains or soil-pipes of the house. This is a rule to which no exception should be made. By disconnection is meant that the waste-pipe should discharge by an open end in the outer air, the water discharged being received into a trapped gully, which is itself in connection with the drain. The waste-pipe should be trapped with a siphon trap immediately beneath the bath, sink, or wash-hand basin, to prevent the passage of air from outside through the dirty pipe into the interior of the house (Fig. 12).

During the winter months of the year, the cold outside air constantly tends to be drawn into a warm, occupied house. The warmer air inside the house, due to the burning of coal in fireplaces, the heat of gas burners and lamps, and the warm bodies of the inmates, is lighter bulk for bulk than

FIG. 12.

TRAPPED WASTE-PIPE

DISCHARGING OVER GULLEY

the colder outer atmosphere. The warm air rises and escapes up chimney flues, its place being taken by the cold air outside, which finds its way in through any and every opening. Consequently untrapped waste-pipes form a very convenient means of access of cold air to the house. But it is not desirable that houses should be ventilated by means of pipes coated inside with grease and dirt from the surface of the human body, or from the washings of dirty plates, dishes, and household utensils. The dirty lining to these pipes ferments and produces foul gases, which would be drawn back into the house with the entering current of cold air.

Sore throats and even diphtheria have been attributed to trapless waste-pipes, more especially in the case of bath-rooms adjacent to bedrooms, or of baths actually in the bedrooms, with long lengths of trapless, unventilated waste-pipes.

Waste-pipes should be of stout lead, three quarters to two inches in diameter, according to the size of the sink, basin, or bath. The advantage of a large waste-pipe is that the dirty water runs rapidly away, leaving the bath, sink, or basin in a cleanly condition, and the rapid flow of water helps to flush the drain and keep it clean. The siphon trap should be provided with a screw cap at the bottom of the bend, which can be opened to remove grease or other accumulations, which tend to choke it; and in most cases it is desirable that a ventilating pipe should be taken off the waste-pipe just beyond the trap, and carried through the nearest external wall, to prevent siphonage of the trap, which is very apt to occur in pipes of this small calibre.

The waste-pipes on the ground floor should be made to discharge over stoneware gully-traps in the ground outside the house. Those on the upper storeys of the house (above the ground floor) should discharge into the open head of a rain-water pipe, or cast-iron pipe, which is itself disconnected at its foot over a stoneware gully.

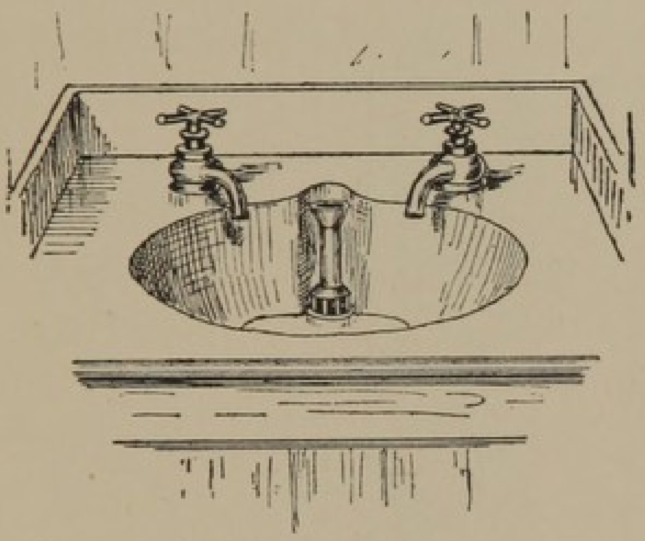
During severe frosts the external position of waste-pipes and soil-pipes may give rise to trouble, the water in the pipes freezing, and the ice so formed causing an obstruction. Frosts of such severity are not of frequent occurrence; and the tendency to freeze may generally be counteracted by pouring hot water, in which common salt is dissolved, down the pipes two or three times a day.

Kitchen and scullery sinks on the upper floors in mansions and flats should have their waste-pipes connected directly with iron or lead waste-pipes outside the house, without open heads; but these main waste-pipes should be carried up full bore to the roof for ventilation, and should be disconnected on the ground surface below in the usual manner over stoneware gullies. These sinks discharge very dirty water at a high temperature, and the steam escaping from the ordinary open heads is found to be a nuisance; besides, the outside pipes become lined with filth, and it is not desirable that the upper ends of these dirty pipes should be situated close to living or sleeping rooms, as would probably be the case in buildings occupied as flats and mansions.

Porcelain baths, though expensive, are preferable to metal baths, which require to be boxed in with woodwork. The space within the woodwork contains a lead or zinc safe-tray on the floor to catch any overflow of water or drippings from leaky valves, and is usually in a dirty condition owing to its inacessibility. There is a great advantage in having every portion of a bath-room or water closet easily accessible to broom, duster, and soap and water. The overflow pipes of baths and lavatory wash-hand basins should also be easily accessible for cleansing, instead of being, as they so often are, "concealed." A standing waste outlet, which also serves as an overflow, is now made by some firms, which can be unscrewed at the bottom, and lifts out, so as to be readily cleansed before being replaced (Fig. 13).

Sinks of glazed stoneware, or whiteware, are preferable on the score of cleanliness to the old-fashioned stone sinks with rough surface, or to the lead-lined wooden sinks which present a very ridged and uneven surface after some years' use. Glazed ware sinks require care in use, as they are apt to chip and to crack from rough usage.

Fig. 13.

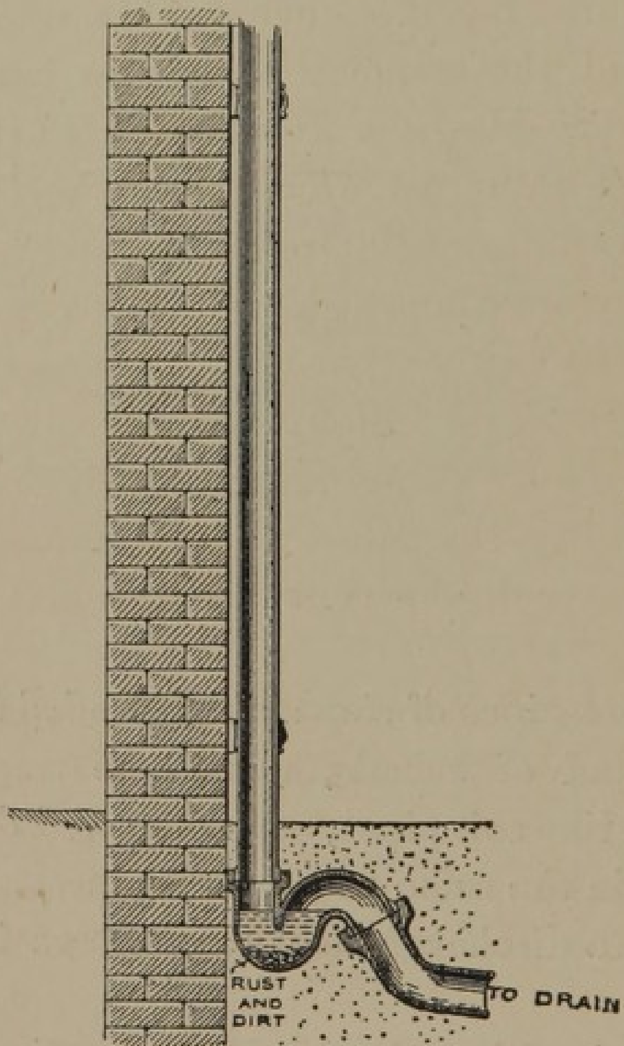


LAVATORY WITH
LIFTING STANDING WASTE OUTLET

The waste-pipes of slop sinks intended to receive excreta, and of urinals, should be trapped and ventilated like soil-pipes, and connected directly to the drain in the same way as soil-pipes. It is not desirable to discharge urine and fæces into open gullies.

Rain-water Pipes should always be disconnected from the drains by being made to discharge over gullies. If this is not done there may be risk of foul air escaping at the top of the pipe beneath an attic window, or under an overhanging eave in proximity to a bedroom window. In addition, the joints between the different lengths of rain-wate pipe are sometimes leaky, very often not caulked at all, so that foul air may escape through leaky or

Fig. 14.



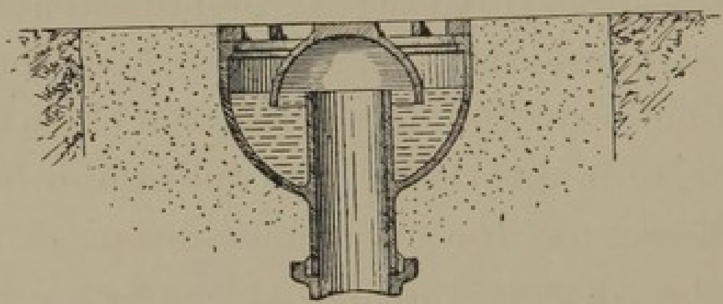
RAIN-WATER PIPE
DISCHARGING
INTO CONCEALED GULLEY

open joints on the face of the wall at various points, near windows or living-room ventilators.

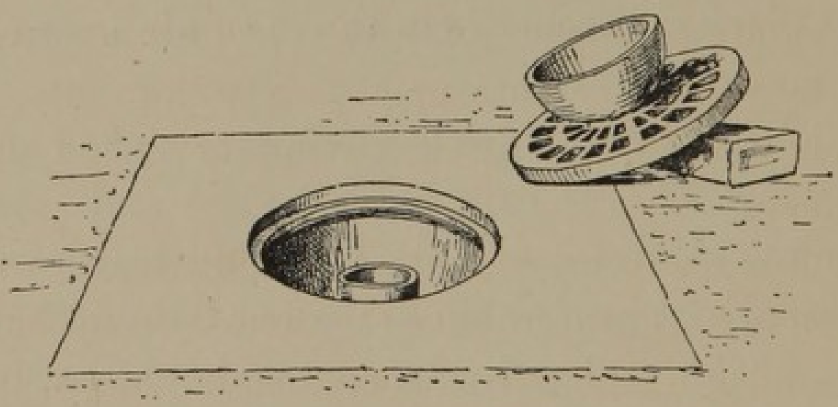
It may happen that on examination it will be found that there is a concealed siphon trap (Fig. 14) at the foot of a rain-water pipe, and that there is not a free passage for drain air when the trap holds water. But it is obvious that when rain is long absent, the trapping water may have evaporated; and besides, it is often found that these traps are choked with rust which has fallen into them from the interior of the iron rain-water pipes with which they are connected. The traps being inaccessible, can neither have the rust and rubbish accumulations removed from them, nor can they be replenished with water very easily in times of drought. It is the safest plan to cause all rain-water pipes to discharge in the open air over open gullies.

Gullies and Bell-traps.—Stoneware siphon gully traps (Fig. 12) for carrying off yard and surface water to the drain, and for receiving house waste waters, are far preferable to the old-fashioned bell-traps. The gulley holds a considerable volume of water, whilst the bell-trap (Fig. 15) contains only a relatively small quantity, which is quickly evaporated. In consequence bell-traps are often found dry, and useless. Inasmuch as there is considerable obstruction to the flow of water through them, the "bell," which is removable, is often taken off to facilitate the passage of water. With the bell part detached, the bell-trap is no longer a trap, and presents an opening in direct aërial communication with the drain.

FIG. 15.



SECTION OF BELL TRAP



BELL TRAP WITH COVER REMOVED

Bell-traps were formerly extensively employed both inside and outside houses. Inside, they were placed over sink waste-pipes, and in the floors of kitchens and sculleries to carry away to the drains the water used for washing the stone floors.

They formed the only protection against the passage of foul drain air into the house, and being often broken, and with the "bell" detached, were at best of very little use in doing that for which they were designed. In the highly-heated basement rooms of a house, there is, as before explained, a great tendency for the inward passage of currents of cold air, to supply the place of the lighter heated air, which escapes up the chimney flues. There is besides the direct "aspirating" effect of the kitchen fire, which, removing large volumes of heated air, causes strong draughts to set in towards it. These draughts and currents of air were often "laid on" so to speak, from the drains into the basement, by means of leaky drain-pipes and of bell-trapped or untrapped openings into the drains, within the kitchen itself or its adjoining scullery.

Bell-traps in yards, outside the house, for carrying off surface water, have the same defects, but are less objectionable than when inside houses, being in the open air.

Gullies cannot be untrapped except by removal of the water in them. When they receive very dirty, greasy, kitchen waste waters, they should be provided with an inlet below the iron grating, as the collection of grease, tea leaves, and filth on the grating, when the waste-pipe of the scullery sink delivers over it, is objectionable. Gullies should be occasionally cleaned out by hand, to remove the silt which collects in them.

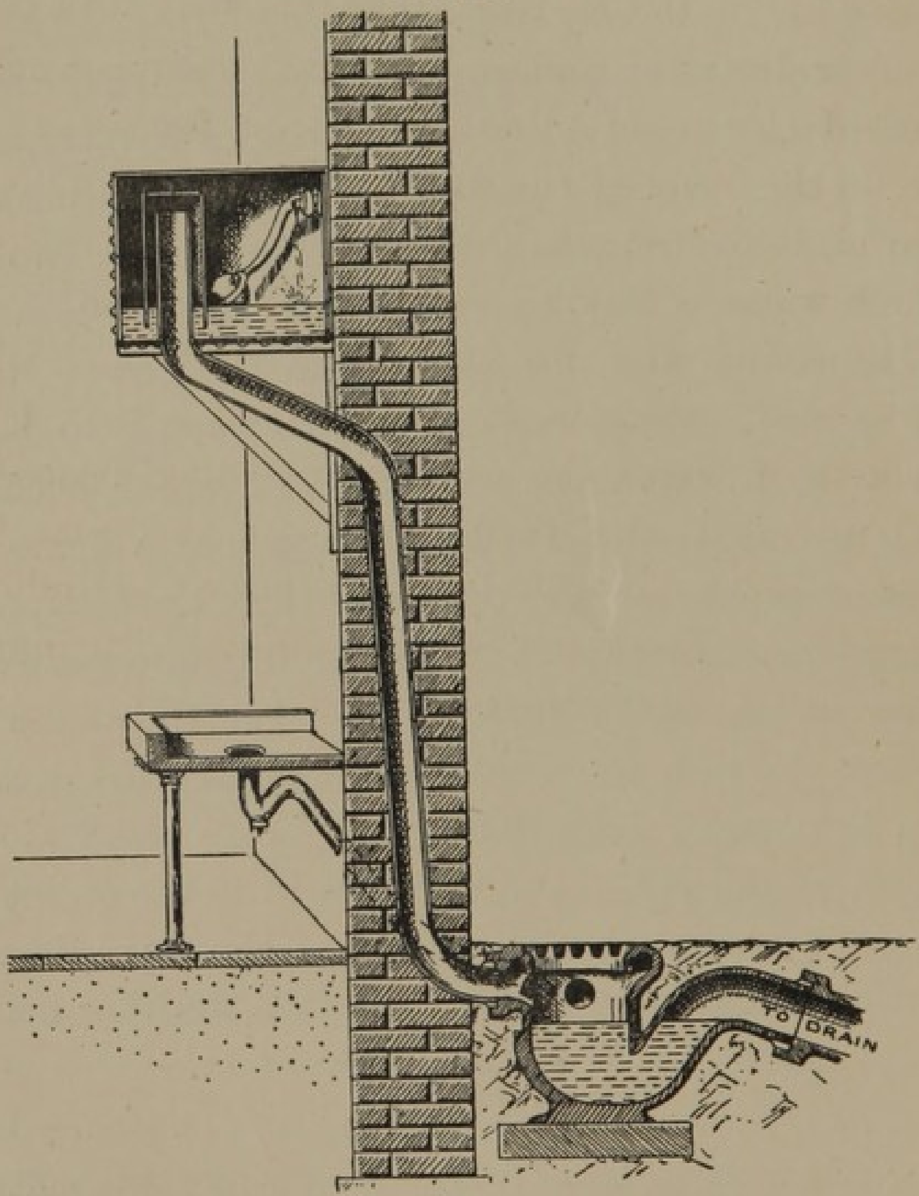
Grease-traps and Flushing Grease-gullies.—The waste water from kitchens contains very usually a considerable amount of grease or fat from the washings of plates and dishes. This grease is liquid in the waste water owing to the high temperature of the latter; but when discharged into the drain the hot water cools, the grease solidifies, and forms a coating or lining, which not only decomposes in the drain, giving rise to foul gases, but also tends to accumulate, and eventually choke the pipes. This is especially liable to happen in large mansions, hotels, and restaurants, where cooking operations are carried on upon a large scale.

The older form of grease-trap, designed to prevent grease from getting into the drain, is, however, as great or a greater nuisance than the condition of things it is intended to remedy. The scullery sink is made to discharge into a large receptacle containing sufficient cold water to cool the entering hot water, and so cause solidification of the fat, which rises to the top of the water, being relatively lighter than water. The accumulation of fat continues until the cover of the grease-trap is taken off, and the fat removed. The disturbance of a large collection of putrid fat causes a most abominable odour, and the principle of conserving putrefiable refuse in or about houses is, as before explained, radically unsound.

In the flushing grease-gully, the grease in the sink water is also cooled by contact with cold water, and solidifies. But the collection of grease is broken up and carried away through the drains, two or three times a day, by the rush of water from an automatic siphon flush-tank into the grease-gully (Fig. 16). These tanks are constructed to hold from 10 to 100 or more gallons of water, according to circumstances, and the whole volume is discharged, as soon as the tank is full, by the siphon arrangement inside the tank coming automatically into action. The rush of so large a volume of water through the grease-gully breaks the grease up into small fragments, and bears them along through the entire length of drain to the outlet in sewer or cesspool. The drain at the same time is flushed, and the regular periodical flushing maintains the drains in a cleanly condition.

The Flushing and Cleansing of Drains.—The periodical flushing of drains is an important matter in the health interests of the inhabitants, especially where the gradient is not as good as it should be. Drains laid with little fall are very apt to become silted up with filth. An automatic flush-tank should be connected to a gully at the head of a drain with deficient gradient, and the tank should

Fig. 16.

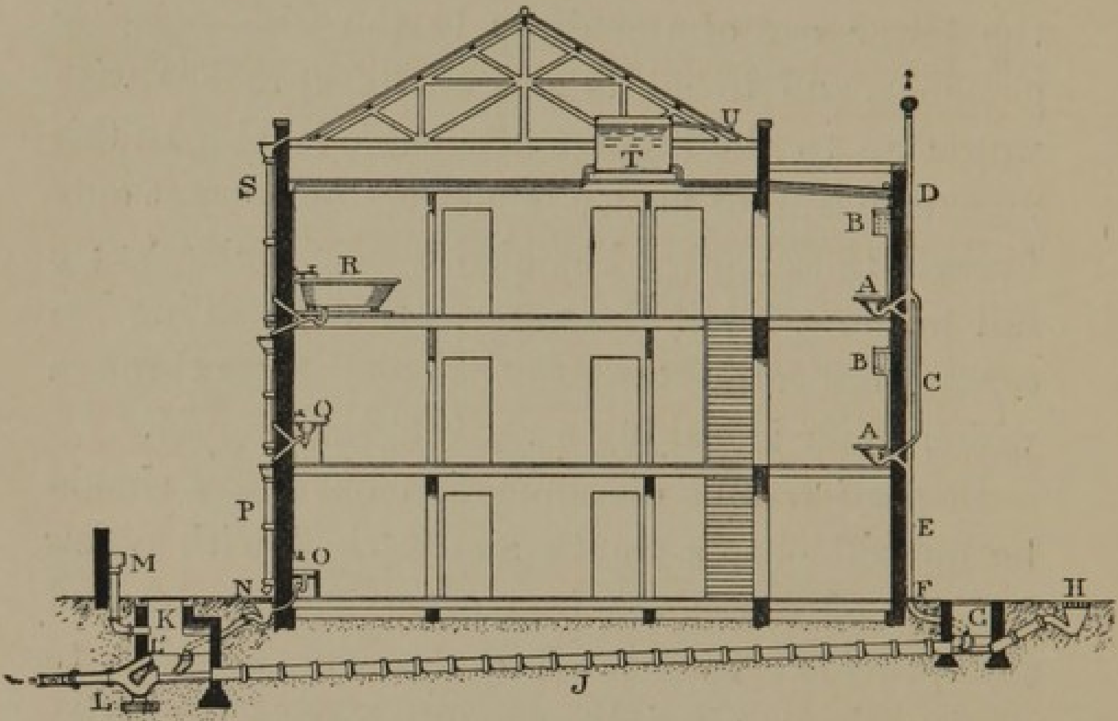


FLUSHING GREASE CULLEY
WITH
AUTOMATIC SIPHON FLUSH TANK

be occasionally inspected to ensure its regular action. It is desirable once a year or so to plug the lower end of the drain in the disconnecting chamber, and to fill it and all its branches with water up to the highest attainable level. In this manner drains of modern construction are not only flushed thoroughly, but also tested for leaks; a fall in the level of the water, after the filling has ceased, indicating the presence of defects through which water is leaking away into the ground.

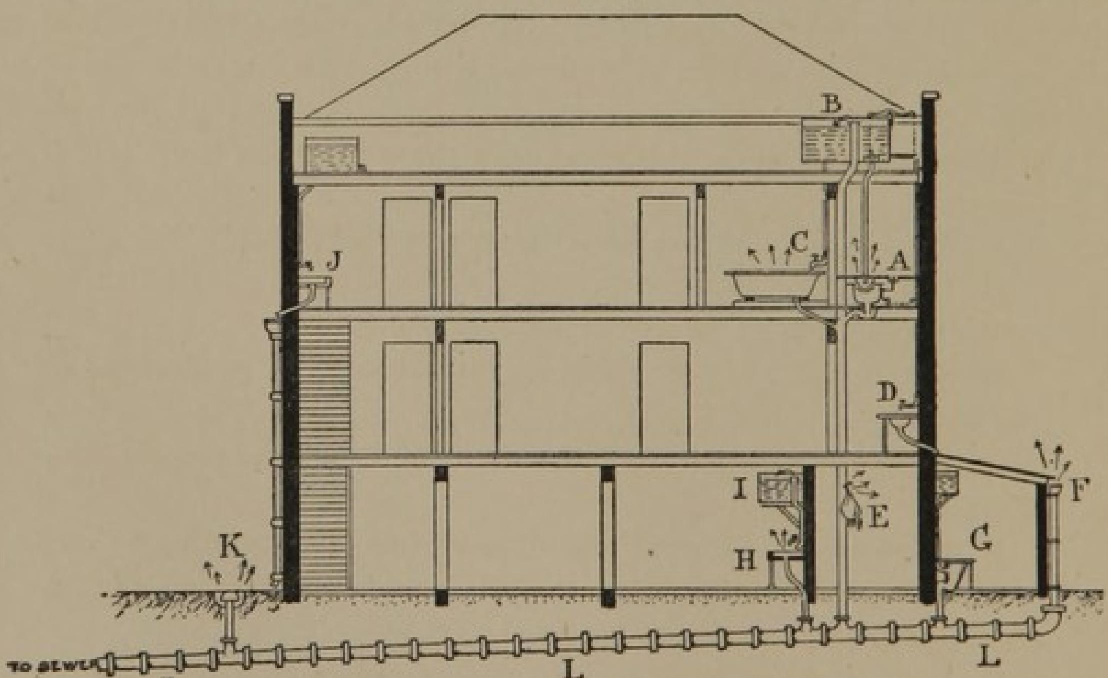
Inspection and disconnection chambers should be opened once a month and flushed with a few buckets of water, the iron covers being cleansed and provided with fresh grease on the rims to render them air-tight when replaced. Gullies should be cleansed and the silt removed from them at about the same intervals—once a month.

FIG. 17.



SECTIONAL DIAGRAM OF SANITARY HOUSE

FIG. 18.



SECTIONAL DIAGRAM OF INSANITARY HOUSE

FIG. 17.—*Sectional Diagram of Sanitary House.*

A. Short hopper closet with siphon trap.

B. Three-gallon water-waste preventer with 1¼-inch supply-pipe to closet basin.

C. Two-inch lead anti-siphonage pipe, carried from the trap of the lower w.c. to the soil-pipe ventilator, above the branch from the top w.c., which is also provided with an anti-siphonage pipe.

D. Four-inch lead soil-pipe ventilator, surmounted by open wire-work dome.

E. Four-inch drawn lead soil-pipe with wiped soldered joints.

F. Connection of foot of soil-pipe with 4-inch drain above surface of ground. A brass ferrule is soldered on to the lead pipe, and the joint between the brass ferrule and stoneware socket is made with Portland cement.

G. Inspection chamber receiving 4-inch branches from soil-pipe and gully H, and closed above by an iron air-tight cover.

H. Stoneware siphon gully trap for carrying off surface water.

J. Six-inch drain of glazed stoneware socketed tested pipes, with Portland cement joints, laid in a straight line, at a regular gradient, from inspection chamber G to disconnection chamber K.

Note.—The inspection and disconnection chambers should be built on concrete, and the main and branch drains should be laid on beds of concrete at least 6 inches thick. The drain is shown passing under the house, as would be necessary in the case of a row of town houses, where the sewer is in the road to the front of the house.

K. Disconnecting chamber with air-tight iron cover.

L. Disconnecting trap with raking arm or clearing eye L′.

M. Fresh air inlet to disconnecting chamber.

N. Stoneware gully discharging into main drain in disconnecting chamber.

O. Scullery sink with trapped waste-pipe connected to side inlet of gully N.

P. Rain-water and waste-pipe discharging over gully N.

Q. Lavatory basin with trapped and ventilated waste-pipe discharging into open head outside house.

R. Bath with trapped and ventilated waste-pipe discharging into open head outside house.

S. Rain-water pipe receiving water from roof.

T. Main cistern of house supplying all taps and water-waste preventers.

U. Overflow or warning pipe of cistern carried through roof to discharge in the open air.

FIG. 18.—*Sectional Diagram of Insanitary House.*

A. Pan-andccontainer- loset with D-trap, supplied with water for flushing from house cistern overhead.

B. House cistern supplying pan closet below by means of a service-box on which is a valve, connected with the handle of the closet by wires. The standing waste or overflow pipe of the cistern is directly connected with the soil-pipe.

C. Bath with waste-pipe directly connected to soil-pipe.

D. Lavatory wash-hand basin with untrapped waste-pipe, discharging on to roof of outbuilding.

E. Internal lead soil-pipe. In the larder a nail has been driven into the pipe to attach a joint of meat, as described in the text.

F. Rain-water pipe from roof of outdoor water-closet, in direct connection with the drain.

G. Outdoor water-closet.

H. Scullery sink with waste-pipe in direct connection with drain.

I. Basement house cistern with overflow pipe discharging over sink below.

J. Draw-off sink with untrapped waste-pipe discharging into open head.

K. Bell-trap for carrying off surface water to drain. This trap is supposed to be dry.

L. Underground house-drain in direct connection with sewer (not shown), and without any disconnecting trap.

Note.—The arrows show the points at which foul air from the common sewer, after passing through the house-drain, gains access to the house. This foul air would not pass through the pan closet unless the D-trap was dry from siphonage of the water in it; the arrows here may be supposed to represent foul air escaping from the D-trap and container.

CHAPTER III

AIR AND VENTILATION

Composition of air—Fouling of the air by respiration—Fouling of the air by combustion—Fouling of the air by rotting organic refuse—Ventilation—Cubic space and floor space—Introduction of fresh air into rooms—Exhaustion of fouled air—Practical examination of the ventilation of rooms—Measurement of cubic and floor space.

ATMOSPHERIC air has a remarkably uniform composition at every part of the earth's surface. Air is not a single gas, but is a mixture of two gases—oxygen and nitrogen. Oxygen forms about one fifth by volume of the air, and nitrogen constitutes the remaining four fifths of any volume of air.

Oxygen is the active gas in air—the gas which supports animal life and the combustion of fuel. Nitrogen only serves to dilute the more active oxygen. If the atmosphere consisted entirely of oxygen, animal life and the processes of combustion would be carried on at far too great a rate, and there would be an immense waste of energy. Besides these two principal gases there is another called carbonic acid, which is present to the extent of four parts in every ten thousand volumes of air, even the very purest air containing approximately this quantity of carbonic acid. Carbonic acid is a compound gas, a molecule consisting of one atom of carbon combined with two atoms of oxygen.

The exact percentage composition of air by volume may be stated as follows:

Oxygen . .	Symbol O .	20·96
Nitrogen . .	„ N .	79·00
Carbonic acid .	„ CO_2 .	00·04
		100·00

In addition to these gases the air is never absolutely dry, but contains a greater or less quantity of watery vapour; and there are present organic and mineral matters, chiefly suspended in the air as dust, which are found more especially in the air of inhabited places.

The atmosphere is constantly being polluted in a great variety of ways all over the earth's surface. The respiration of men and animals, the exhalations from their bodies, the combustion of fuel, the various industries disengaging noxious gases or effluvia, and all the fermentative and decomposition changes to which organised matter is liable, tend to pollute and vitiate the atmosphere. But the balance is restored and purification is accomplished by the forces of nature, which are of immense power and of universal distribution and application. These are :—The winds, which dilute and sweep away impurities, both gaseous and suspended, bringing pure air in from mountain, moor, or sea, to supply the place of that dislodged. A second agency of great value is the rain, which in its fall from the clouds washes the air, carrying down to the earth dust and vapours, to become incorporated with the soil and rendered innocuous. A third agency is that of growing vegetation, the green leaves of all plants having the power, in the presence of sunlight, of absorbing carbonic acid gas, fixing the carbon to form the woody structure of the plant, and liberating the oxygen, which is thus restored to the atmosphere and the balance preserved.

The influence of sunlight in destroying fungi and bacteria, their germs and spores—in other words, microbes of all kinds—must not be lost sight of. The sun's rays are powerful germicides.

Traces of another gas are found in the air of all parts of the earth's surface, except in the neighbourhood of inhabited places. This gas is called ozone ; it is a modified form of oxygen, being even more active than that gas in oxidising organic matters. It is believed to be generally absent from the air of towns and cities.

Except as regards this supposed absence of ozone, the air of towns does not differ very materially, as regards the principal gases, from the air of the thinly peopled country districts. There may be a very slight deficiency of oxygen, or a slight increase of carbonic acid, but the differences from pure country air are very small. There is, however, a vastly greater quantity of dust in the air of towns, and much of this dust is organic, consisting of organic vapours, bacteria, fungi and their spores. The almost infinitesimal alteration in the constituent gases exerts probably very little influence on the health of town dwellers, but the breathing of organic dust is certainly injurious to health, and is one of the causes of that excess of mortality of urban over country districts which the Registrar-General's statistics demonstrate.

The pollution of the atmosphere is especially noticeable in the crowded courts and alleys of our large cities, in the narrow winding lanes and streets, which are enclosed on both sides by blocks of lofty houses, and in all places which are excluded from the purifying influences of sun and air.

Wide and airy streets, sufficient open spaces at the rear of houses, the limitation of the height of houses according to the width of the street upon which they front, the planting of trees and shrubs in the wider thoroughfares, and the setting apart of open spaces as parks, gardens, and recreation grounds, are all factors of first-rate importance if the purity of the atmosphere in our great cities is to be maintained. It is certainly true that a proper standard of health cannot exist if no attention is paid to the enforcement of those municipal regulations by which alone can nature's forces for the purification of the atmosphere be allowed their proper sway. The effects of living in vitiated air are especially marked in the case of children. The proper growth of the body, the attainment of a good physique and of a sound constitution, are difficult under such conditions, and the strength and stamina of the race deteriorate.

Fouling of the Air by Respiration.—An adult man in a position of rest breathes at the rate of about seventeen respirations a minute. At each act of respiration about thirty cubic inches of air pass in and out of the lungs. Maintaining his posture of rest for twenty-four hours, about 425 cubic feet of air will have passed in and out of his lungs in this period. This quantity of air will be contained in a room 10 feet long, 4¼ feet wide, and 10 feet high.

Expired air as it leaves the lungs is found to have lost about 4 per cent. of the oxygen contained in pure, unbreathed air, whilst it has gained 4 per cent. of carbonic acid. The nitrogen remains unaltered in amount. The oxygen is absorbed from the air by the blood in the capillary blood-vessels of the lungs, and the blood in exchange gives up carbonic acid. The oxygenation of the blood is necessary in order that the oxygen may be conveyed to every tissue of the body by the circulation, and so enable every process of vital activity to be properly performed; whilst the carbonic acid is one of the waste materials consequent upon vital activity, which must be removed from the tissues by the circulating blood, to be got rid of in the lungs, and so to escape finally into the general atmosphere.

The composition of expired air is as follows:

Oxygen . . .	17	per cent.
Nitrogen . . .	79	„
Carbonic acid . .	4	„

The air escaping from the lungs is also at very nearly the same temperature as that of the human body, viz. 98·4° Fahrenheit. It is saturated with watery vapour, and contains besides a certain quantity of organic matters in the form of vapour, of solid minute particles of *débris*, and of bacterial micro-organisms. This organic matter in the breath very rapidly putrefies, even if it is not actually in a putrid condition as it leaves the mouth. It is very readily absorbed by such things as clothing, curtains, carpets, rough wall-papers, and porous walls or hangings, and is difficult to dislodge from these substances even by free ventilation. The stuffy, close, and disagreeable smell of a crowded or dirty room is entirely due to the organic exhalations from the lungs, skin, and dirty clothes of the occupants, and it is to the presence of this organic matter that must be ascribed the injurious influence upon health which the breathing of air fouled by respiration undoubtedly produces.

The necessity of ventilation—by which we mean the proper supply of fresh air into enclosed places, and the removal of fouled air out of them—is evident, when we consider that if a man was shut up in a room of the dimensions above given, namely, 10 feet long, $4\frac{1}{4}$ feet wide, and 10 feet high, containing 425 cubic feet of air, and if this room was hermetically sealed up, so that no air could pass into it or escape from it, the man would be found dead or dying at the end of twenty-four hours, for he would have passed the whole volume of air in the room through his lungs; and long before this point was reached, the fouling of the air by organic filth would have caused blood-poisoning, or, as it has been termed, "putrid fever," which must have a fatal termination unless the patient is taken out into a pure atmosphere. Such at any rate was the cause of death amongst the victims of the Black Hole of Calcutta incident of infamous memory, and probably in such other examples of death from overcrowding in confined spaces (prisons and ships) as are on record.

Individuals casually subjected for an hour or two to an atmosphere fouled by a crowd of people, as in theatres, churches, drawing-room entertainments, and at public meetings, often experience headache, weariness, nausea, or fainting—symptoms which rapidly disappear upon removal to a better atmosphere. Those who by force of circumstances are compelled to remain, often in cramped attitudes, for many hours day after day indoors, in offices, shops, workrooms, and factories, and to breathe an air constantly polluted in perhaps a minor degree, but still distinctly recognisable as "stuffy" to the sense of smell on first entering from the outer atmosphere, are liable to suffer in health, although the exact form which such disturbance of health assumes will depend very much on the constitutional peculiarities of the individual.

In some people there will be complaint of constant weariness, headache, indigestion, and loss of appetite, followed by anæmia, or deficient nutrition of the blood, with its train of symptoms. The lassitude leads in some to a craving for stimulants—alcohol or tea—and habits of excess in these directions often originate in this manner. People in this lowered condition of health are more prone to suffer from colds or catarrhs, from bronchitis, pneumonia, and acute lung attacks, than are those more constantly in the open air. This proneness to inflammatory diseases of the air-passages is aggravated by a highly-heated and over-dried condition of the air in the room where the day is passed, such as may result from the burning of gas, or the use of hot-water pipes or close stoves.

Destructive lung diseases, included for the most part under the term consumption or phthisis, are far more common amongst those engaged in sedentary indoor occupations than amongst those leading essentially out-of-door lives. We know now that these are "tubercular" diseases, dependent upon the presence in the tissues of the bacillus of tubercle, as first discovered by Professor Koch, the great German pathologist. This bacillus is contained in the breath and expectoration from the lungs of consumptive patients, and it is easy to understand how it may be conveyed through the air from the lungs of the sick to the lungs of apparently healthy people, who are, however, predisposed either constitutionally or by defective hygienic surroundings to fall victims to this dreaded complaint. In saying this it must not be supposed that phthisis is infectious in the same sense as is scarlet fever or measles. Facts disprove any such conclusion, for it is a matter of general agreement that phthisical people rarely, if ever, prove infectious under conditions of ample cubic space and efficient ventilation, such as are to be found in well-regulated consumption hospitals. But there is evidence to show the contagiousness of phthisis under conditions of overcrowding and insufficient ventilation, especially when conjoined with excessive dampness in the air. But even here it need not be assumed that the bacillus of tubercle is directly transferred through the air from the lungs of the sick to be implanted in the lungs of the healthy. It is more probable that the bacilli remain for a time in the dust and *débris* of overcrowded, damp, and filthy houses, and in this congenial soil acquire more virulent infective properties than they were in possession of at the time of escaping from the lungs.

Children suffer from foul air as much, if not more, than adults. For the first six months or year of life the state of the air in the nursery is perhaps of less importance than the maintenance of warmth and the giving of the proper food, but after this period the breathing of pure air is an essential for proper growth and nourishment. Living constantly in over-heated stuffy rooms leads to anæmia, rickets, and certain "wasting" diseases, such as scrofula in its various forms, which is in reality a form of tuberculosis.

Fouling of Air by Combustion.—In most inhabited rooms there are chimney flues to carry off the products of combustion from open coal fires to the outer air, but such is not the case as a rule with the products of combustion of coal gas. It is quite the exception to meet with special flues provided for the purpose of carrying away the products of combustion of gas burners used for lighting; and even in many instances open gas fires, gas cooking stoves, and gas water geysers for baths are fixed in houses without any provision of flues. Uneducated men of the plumber class, and even some of the manufacturers (or their agents) of these very appliances will assert either that there are no injurious gases given off in the combustion of coal gas, or that, being invisible, they must necessarily be harmless.

Such is not the case, however, as the following figures show :—One cubic foot of coal gas of average quality, on combustion, unites with from 1 to $1\frac{2}{3}$ cubic feet of oxygen. This means that all the oxygen of from 5 to 8 cubic feet of air is used up in the combustion, and is therefore withdrawn from that volume of air. About 2 cubic feet of carbonic acid gas result from the combustion of 1 cubic foot of coal gas; and if the combustion is at all imperfect, as when the flame is smoky, small quantities of carbonic oxide are also given off. Nearly half a grain by weight of sulphurous acid is also produced by the burning of 1 cubic foot of average coal gas. An ordinary gas burner for lighting a room burns from 3 to 5 cubic feet of gas per hour.

To take an illustrative example. Suppose a room 10 feet long, 10 feet high, and 10 feet wide, and therefore containing 1000 cubic feet of space, with two gas burners in it burning each 4 cubic feet per hour. If the room is hermetically sealed, so that no fresh air can enter or foul air escape, at the end of one hour the oxygen of at least 40 cubic feet of the air in the room will have been destroyed, and the oxygen remaining, instead of forming 20·96 per cent. by volume of the air, will only form 20·12 per cent. At the same time 16 cubic feet of carbonic acid gas are added to the air of the room, and the volume of this gas in the air at the end of one hour, instead of being 0·04 per cent., becomes 1·64 per cent. It is thus seen to what extent the air of such a room is devitalised. The air is not absolutely poisonous from deficiency of oxygen and excess of carbonic acid, but it would certainly be injurious to remain in such an atmosphere for any length of time.

Another example of even a worse state of affairs may be given as possible under certain conditions, and believed, indeed, actually to have occurred.

Take the case of a bath-room 10 feet long, 10 feet high, and 5 feet wide, and containing, therefore, 500 cubic feet of space. Suppose the room to have its door and window tightly closed, so as to reduce the communication with the outer air or with the air of the rest of the house to a very low limit. An "instantaneous water-heater," which burns 30 cubic feet of gas per hour, has been fixed to heat the water of the bath, but no flue has been provided. Now, about half an hour is the time required to obtain by means of this apparatus a bath full of hot water at a temperature of 100° F.—a little over blood heat. In this time (the bath room being kept tightly closed) there will be added to the air 30 cubic feet of carbonic acid gas, and the oxygen of 75 cubic feet of air will have been consumed. Carbonic acid will be present in the air to the extent of 6 per cent., instead of only 0·04 per cent., and the oxygen will be reduced from 20·96 per cent. to 17·91 per cent.

Very much the same effect might be produced by the use of an open gas fire burning 30 feet of gas per hour, in a small unventilated room, without any flue being provided to carry off the products of combustion.

The atmosphere of a room containing 6 per cent. of carbonic acid and only 18 per cent. of oxygen might, and probably would, produce fainting, cessation of the heart's action, and death. The fatal accidents which have occurred from the use of bath-heaters without flues are, in the light of these figures, capable of an easy explanation.

Carbonic oxide—the gas which is the result of imperfect combustion—is not often found in determinable quantities in the air of living rooms. It is an exceedingly poisonous gas, less than 1 per cent. of it in the air causing a form of asphyxia which rapidly proves fatal. This gas results from the combustion of coke with a limited supply of air; and, as is well known, asphyxiation by the burning of charcoal in pans in small rooms is largely resorted to on the Continent by suicidally disposed persons to ensure an easy and painless death. It is also the gas used in the lethal chamber for dogs at Battersea, owing to this property of destroying life with the minimum of suffering.

If coke is used as a fuel for warming inhabited rooms, care should always be taken that the coke fire has an abundant supply of air, and that all the products of combustion pass up the chimney flue.

Coal gas itself contains about 6 per cent. of carbonic oxide, and the poisonous effects of "gas escapes" into houses are largely due to this very deadly component of illuminating gas. Small escapes of gas into houses from defective pipes and fittings, when long continued, seem occasionally to produce relaxed and ulcerated sore throats amongst the occupants. The irritants here are, no doubt, the sulphur compounds (especially the bisulphide of carbon, which has a very disagreeable and penetrating smell), and which are, or should be, largely removed in the process of purification which coal gas undergoes before distribution to the gas-holders.

The sulphurous acid gas given off in coal gas combustion also tends to have an irritating effect on the throat, which is heightened by the dryness of the air produced by gas burning. For although water vapour or steam is one of the products of combustion, yet the temperature of the air being raised by the heat of the burning gas, the relative humidity is lessened, and a sensation of dryness results, which is irritating to the air-passages leading to the lungs.

The sulphurous acid gas is the product of combustion of coal and coal gas, which exerts such destructive effects on vegetation, mortar, and some kinds of building stones out of doors, and which damages pictures, frames, book coverings, and gilded or metallic articles indoors.

Lamps and candles are, perhaps, on the whole less injurious than gas as illuminants. An ordinary oil lamp burns about 150 grains of oil hourly, consuming the oxygen of rather more than three cubic feet of air, and producing just over half a cubic foot of carbonic acid in the hour. A candle burning 320 grains per hour produces rather less than half a cubic foot of carbonic acid in the hour. Both lamps and candles require more attention than gas-burners, in order to secure perfect combustion and to prevent the burning of the wicks with a smoky flame, which causes the dissemination of foul-smelling and injurious gases in the apartment where they are in use.

The town fog, by which is meant the fog of a yellow, dense, and sulphurous character, is very largely the result of the almost universal use of coal as a fuel. In the late autumn and early winter months, owing to certain meteorological conditions, the air becomes supersaturated with the vapour of water, which in country districts produces a white mist of greater or less density. In the air are suspended innumerable particles of water of inconceivably small dimensions, which in bulk produce the opacity characteristic of mists. In smoky towns, however, the soot in the air, consisting of fine particles of carbon given off from the chimneys—domestic and manufacturing—condenses on the water particles, and each becomes coated with a greasy, sooty envelope. Here we have, then, the thick, yellow fog, which shuts off the light from the sky and envelops every object in a grimy, sooty pall of moisture. The choking and irritating effect upon the nose, eyes, and throat is due to the sulphurous acid with which the fog is charged, itself also the product of combustion of coal.

In London of late years two kinds of fogs can be recognised. The high fog, which exists above the level of the houses, and which causes a profound darkness by cutting off the light of the sun; and the ground fog, which invades our streets and dwellings, and is by far the more disagreeable visitor.

Fogs are seldom if ever possible when the air is in brisk movement, *i. e.* when there is any wind (except at sea, and on the sea-coast). Consequently fogs prevail most in calm weather, when the barometer is high, and the type of weather is termed anti-cyclonic.

There is no cure for yellow fogs, except the abolition of bituminous or smoky coal as a common domestic fuel, and the substitution of smokeless anthracite coal, coal gas, or other means of heating which do not throw off daily into the air huge volumes of unconsumed carbon.

Fouling of Air by Rotting Organic Refuse.—Under this heading we may consider the effects upon health of what is commonly called "sewer gas." As a matter of fact there is no special gas in sewers to which the name sewer gas can be given. The air of sewers and drains does not differ very materially from the outer air, except in the case of choked and obstructed sewers and drains containing stagnant and putrefying sewage. In such cases the sewer or drain air may be loaded with foul and injurious gases to such an extent as to cause serious and even fatal illness amongst workmen engaged in opening and cleansing the sewer.

Whilst deprecating the use of the word "sewer gas," and recognising that the air of sewers does not differ very much, as a rule, from ordinary atmospheric air, we must still allow that the air of even well-constructed and well-ventilated sewers and drains is liable at times to contain substances or gases which are distinctly inimical to health. There is positive evidence as to the truth of this statement, and no amount of negative evidence can outweigh reliable evidence of a positive character. Our knowledge is at present insufficient to enable us to say exactly what these gases or substances are in every case—whether they are living, organised germs or microbes, or alkaloidal vapours of almost unknown chemical constitution.

This, however, can be said, that the offensiveness of the smell of sewer air must not be accepted as a criterion of the activity of the poisonous substance in it. It may well be that sewer air which is little offensive is as dangerous as the most foul-smelling sample; and inasmuch as the attention is not aroused by the usual disgusting and nauseous odour, it is easily conceivable that the danger may be enhanced. Nature's warning by the sense of smell is generally reliable, but it does not always follow that the absence of distasteful odour is a sign of safety.

It being granted that the breathing of air from drains or sewers is likely at times to prove injurious to the health of some, at least, of the individuals exposed to the emanations, it follows that every precaution should be taken to prevent the passage of air from drains and sewers into the atmosphere we breathe. As the chapter on "Refuse Disposal" shows, the object of modern sanitary arrangements in houses is to make impossible, as far as may be, the escape of drain air into the house. The ventilator for the exit of foul air from the drains is always carried to the top of the house, away from windows.

In the streets, however, of most towns we still find ventilators for the sewers opening at the level of the road, and on occasion pouring forth volumes of bad-smelling air in the faces of passers-by. It is true that in this position the air from the sewers escapes into the outer atmosphere, and not into the interior of houses. The danger, therefore, of the production of injurious results is lessened by the possibility of the rapid dilution of noxious matters by a copious supply of fresh air. All the same it is conceivable, and is indeed probably the fact, that open roadway ventilators do at times and upon certain susceptible people exert an influence which originates ill-health or disease; and it certainly seems desirable that the same steps should be taken to protect the public from inhaling injurious gases, as are taken by the householder to protect himself and his family. Dust-carts and the vehicles that remove offal and offensive refuse through the streets are now required to have covers, or to be so constructed as to prevent the escape of noxious effluvia to the annoyance of the public, but little or nothing is done to remedy the obnoxious open sewer ventilators.

It may be as well here to draw attention to another matter under municipal control, which very probably affects injuriously the public health. It has become very much the custom of late years to lay wood pavements in the most frequented thoroughfares of our large towns. In a very short time the surface layers of the wood become saturated with organic matters from horse-droppings, and this organic filth putrefies in warm weather, the gases of putrefaction passing into the general atmosphere of the streets. The condition of the air of the main thoroughfares of London in warm and dry weather, when the cleansing effect of water upon the wooden roadways is absent, is distinctly unwholesome—to use no stronger expression. In many cases the great height of the houses abutting on these streets accentuates the evil by hindering the proper access of wind currents, and promoting stagnation of the atmosphere.

Unless wood pavements can be regularly flushed with water, so as to sweep away the accumulated surface impurities, they are not sanitary, whatever other advantages they possess, and are far inferior to asphalte.

The organic vapours given off from brick-burning, bone-manure works, fat-rendering, soap-boiling, and other offensive trades, are very often a source of nuisance and the subject of bitter complaint, but it is not always possible to prove that such emanations are injurious to health. They, no doubt, at times excite feelings of nausea and disgust, and tend to embitter the existence of residents in the immediate locality. Fortunately the Public Health Act enables local sanitary authorities to deal with such nuisances, and the law can always be put in operation in flagrant cases.

The object of the sanitary laws of the country is to protect the public from nuisances of this character, and it is the duty of the sanitary authority to enforce the law, so that the private persons aggrieved may not be put to the expense of procuring a remedy which is for the protection of the public generally.

The effects upon the bodily health of breathing air mixed with putrefactive products are very much dependent upon the individual, and his state of health for the time being. Many people, those perhaps of robust constitution, in sound bodily health, are not adversely affected. Even a short exposure in people less happily constituted may produce sickness, headache, and diarrhœa. Very severe forms of sore throat—ulcerated or diphtheritic—may result from exposure to drain or sewer air. Typhoid fever is certainly occasionally spread by the air of drains and sewers which have received the evacuations of patients suffering from this disease. In some cases of prolonged exposure to drain emanations, such as may occur in houses where the drains are defective, the symptoms produced are those of debility and anæmia, and the system appears to become to a certain extent habituated to the poisonous matters. It certainly seems that persons suffering from wounds are liable to contract erysipelas or blood-poisoning, if living in an atmosphere contaminated with sewage emanations; and women recently confined are often the subject, under such deleterious surroundings, of forms of blood-poisoning which go by the name of "puerperal fever" or "puerperal septicæmia." It has been convenient in this connection to allude more especially to the effects of drain or sewer air, but no doubt illnesses of a somewhat similar character may be originated by the emanations arising from other sources in which organic matters are being subjected to fermentation and putrefaction.

Ventilation.

The science of ventilation is concerned with the supply of fresh air to an enclosed or inhabited place, and the withdrawal of used-up, foul, or vitiated air from that place.

In practice there are two main points to which attention is usually directed, namely, (1) the amount of cubic space available for each individual in an inhabited room; and (2) the quantity of fresh air entering the room from outside in a certain period of time.

Cubic Space.—It is necessary that each individual should have a certain amount of cubic or air space around him, in order that he may not have to breathe the expired air of his neighbours before this has been properly diluted with fresh air. People who are very closely crowded together inhale each other's breath, *i. e.* the air which has just left the lungs; and in addition they absorb the exhalations from each other's persons and clothes. In densely packed halls and assembly rooms, the audience are subjected to a slow process of respiratory poisoning from the effects of the inhalations of air loaded with organic matters.

It is, therefore, essential to health that every individual in an inhabited room should have a certain amount of air space available for himself, to draw upon for his own air supply, and also to separate him from his nearest neighbour. Now the cubic space of any room is obtained by multiplying together the three dimensions of the length, breadth, and height of the room; and inasmuch as the rooms of ordinary-dwelling houses are pretty well proportioned as to their dimensions in accordance with their size, the cubic space so obtained need only be divided by the number of occupants in the room, in order to get the air space or cubic space per head.

It will be apparent from what has been said of the primary object of a sufficiency of cubic space per individual, that very great height in a room is of less use than a sufficiency of *floor area* (length of room multiplied by its width); for it is the relative size of the floor area that serves to separate the individuals in a room from each other; and the height of the room above 5 or 5½ feet only provides air space above the heads of the people, when in an erect attitude. As a matter of fact any height of a dwelling or sleeping room above 12 feet is comparatively worthless as air space to the individuals in that room; and contrary to the popular notion, very lofty rooms are not more airy and healthy than rooms of average height, say 10 to 12 feet.

It is true that the gaseous products (carbonic acid) of respiration may diffuse into the air in the upper part of a lofty room; but the organic matters do not so diffuse, and tend to accumulate in the lower portions of the apartment; and it is to these matters that are now ascribed the deleterious effects of breathing air vitiated by respiration. It has been said that the whole or a great portion of the inhabitants of our globe could find standing-room on the Isle of Wight; but if they were so congregated together they would undoubtedly perish, even with the open sky above them, for the close crowding would cause a condition of atmosphere in the lower strata available as an air supply, which could not support life.

In public buildings, such as churches, chapels, concert rooms, assembly halls, &c., a much greater height is given to the fabric than 12 feet, and the space above this height is no doubt useful as forming a reserve of air. But still in such places the air is considerably more vitiated near the floor than it is in the neighbourhood of the ceiling; and if it were not that the congregation or audience does not stay in the building for a prolonged period, it is probable that the effects of crowding would manifest themselves even more than they do.

Before giving any figures as to the amount of floor space and cubic space desirable in the case of ordinary living or sleeping rooms for the maintenance of a proper standard of health, it may be useful to give the figures adopted under various conditions in State or municipally regulated establishments, in public schools, and in hospitals.

English Education Department for Public Elementary Schools:—Floor space, 10 square feet; cubic space, 100 cubic feet per scholar.

Metropolitan Common Lodging-Houses under the control of the London County Council:—Floor space, 30 square feet; cubic space, 240 cubic feet for each adult over twelve years.

Metropolitan Sanitary Authorities' regulations for dwelling rooms:—Cubic space, 300 cubic feet per adult; 150 cubic feet for each child under twelve years.

Factories and Workshops under the Public Health (London) Act, 1891:—250 cubic feet per adult in the daytime; 400 cubic feet after 8 p.m. Two gas burners to count as one adult.

Workhouse Dormitories under the Poor Law :—300 cubic feet for each adult.

Military Barracks :—600 cubic feet per head.

Prison cells in H.M.'s Prisons :—800 cubic feet (with artificial ventilation).

Public Schools (average), in dormitories without cubicles :—600 to 700 cubic feet per scholar, and 50 to 60 square feet of floor space. With cubicles a larger amount should be allowed, as the partitions obstruct free ventilation.

General Hospitals with cross-ventilated wards :—100 square feet of floor space, 1200 cubic feet of air space.

Infectious Disease Hospitals :—150 square feet of floor space, 2000 cubic feet of air space.

It is certainly true that the amount of air and floor space allowed in public elementary schools, in common lodging-houses, and in the houses of the poor is very insufficient, and is not adequate to maintain a good standard of health. But it is, perhaps, impossible at the present time, having regard to the social condition and wage-earning power of the labouring classes, to insist upon any larger amounts.

The lowest amounts really compatible, in ordinary living and sleeping rooms, with health and comfort, are 80 square feet of floor space, and 800 cubic feet of air space per adult ; and half these quantities for young children, say under ten years of age.

If a room is badly lighted and ventilated—for instance, without a chimney flue, or with a window opening into an enclosed courtyard and facing a blank wall at a distance of a few feet, or with a skylight instead of a window—the amounts of floor and air space should be increased. These conditions are often found in attic and basement rooms (cellar dwellings); and it often becomes a question whether such rooms are fit to be lived in at all. The Public Health (London) Act lays down very stringent regulations as regard the height of rooms in basements (the floors of which are more than 3 feet below the surface of the adjoining street), the size of windows, and the width of open area, which must be complied with if such cellar dwellings are used as sleeping places.

Introduction of Fresh Air into Rooms.—The two chief natural forces which effect the introduction of fresh air from outside houses into their interiors are (1) winds and (2) the differences in weight of contiguous masses of air of unequal temperature.

Winds produce an effect in proportion to the velocity with which the wind is blowing. As the air is but very seldom completely stagnant in this climate, the opening of a window is sufficient to entirely disperse the air in a room and to replace it with fresh air; and the effect is heightened enormously if windows on opposite sides of a room, or a window and door, are opened and kept open for a short time, so that the air may blow through. In a few minutes the air of the room is freshened and sweetened, and rendered again fit for occupancy.

Methods such as this are most valuable for thoroughly ventilating unoccupied living and bedrooms, schoolrooms during hours of play, churches between Divine service, &c. In summer it is usually possible to sit in a room with open windows, and if the draught can be borne, any other means of ventilation are not required.

In winter, however, we cannot sit with open windows and doors, and then reliance must be placed upon the ventilation effected by contiguous volumes of air at unequal temperatures. In the interior of the house, owing to fires, gas lights, lamps, and the warm bodies of the inmates, the air becomes heated. Heated air is lighter than the same volume of cold air, and consequently rises and tends to escape out of the room, whilst the colder air from outside the house pushes in through every available opening to take its place.

The English system of open coal fires very materially aids the ventilation. The heated air escapes up the chimney flue with the products of combustion of the coal; and the fire itself not only creates a draught of air towards it to supply the oxygen necessary for combustion, but also keeps the chimney flue hot, and so keeps up the temperature of the air escaping through it until such air emerges at the chimney top. If the chimney flue were not so heated, the hot air escaping up it would gradually cool down, imparting its heat to the cold bricks of the chimney, and at length would become as cold, or nearly as cold, as the outside air, with the result that the current would slow down or cease altogether, and the ventilation be brought to a standstill.

The English open coal fireplace with a good fire burning in it is, therefore, an excellent ventilator. It not only provides a fine exit for heated and vitiated air, but it draws air into the room to supply the place of that which has escaped; and it only remains to provide that the air which so enters shall come from unimpeachable sources outside the house, and when it enters the room shall be so distributed as to mix evenly and gently with the air already there, so as to freshen and renovate the apartment without the production of cold and draughts.

It is in this last direction, however, that we so often meet with failure. It will sometimes be found that the air to supply the fire, and renew the atmosphere of the occupied living room, is entering from the passage or staircase; and, on being further investigated, is ultimately traced to the kitchen in the basement, from which it brings the smell of cooking for delivery into the upstairs apartments. Occasionally the air is found to be proceeding from a water-closet on a landing, the window of which has been left open the better to ventilate the water-closet, but in reality to ventilate the house through the water-closet.

The cold air which enters from the passage passes underneath the loosely-hung door of the living room, and travels straight to the fire. It produces little effect in changing the air of the room for this reason, but it has considerable power to chill the feet of the occupants of the room; and, as very many people are aware from experience, to sit around the fire is warming to the face and body but chilling to the feet, which are in the line of direct draught from door to fireplace.

If the air enters—as very often it does—at the sides or between the sashes of the window, it tends to fall like a cascade upon the heads of the persons sitting in the room. For, being colder than the air of the room, it at once sinks when brought into contact with the warm air, and thence travels along the floor by direct route to the blazing fire. In a room of this description it is often exceedingly difficult in chilly weather to find a place to sit where one is not either exposed to a cold current

Fig. 19.

Badly Ventilated Room

upon the unprotected head, or to a chilling draught upon the sensitive feet (Fig. 19).

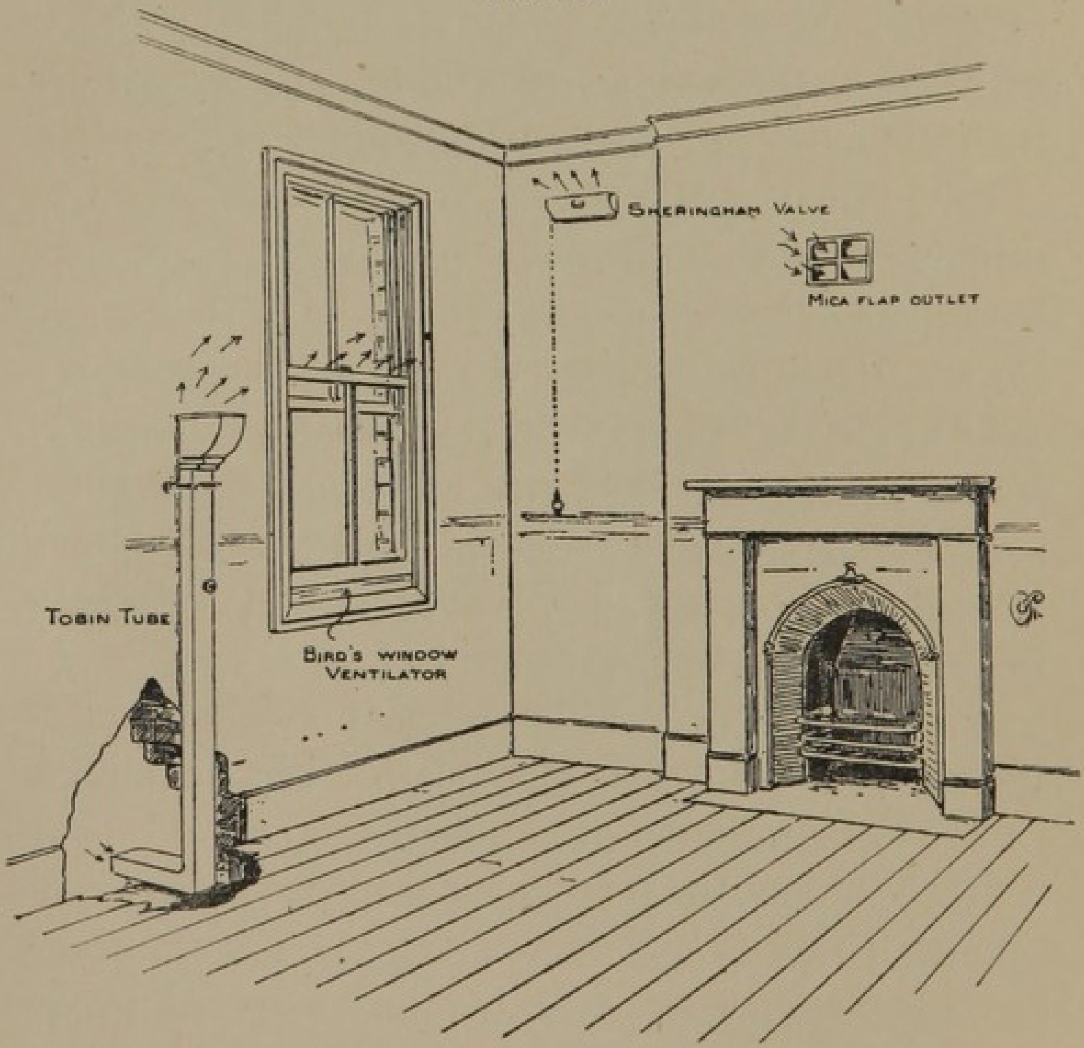
It is evident, then, that something should be done to direct the incoming air so that it may thoroughly mix with the air already present in the room, and be distributed uniformly throughout the room in such a way as to ensure the proper renovation and sweetening of the atmosphere, without the production of draughts and chills.

To a great extent this desirable result can be attained if the entering air is given an upward direction as it flows into the room. After leaving the ventilator the upward direction is continued, and the cold air mixes with the heated air near the ceiling of the room. It here becomes warmed to a certain extent, and pretty thoroughly distributed throughout the apartment. When it sinks towards the floor it is—or should be—no longer at so low a temperature as to create a sensation of cold upon the heads of the occupants; and is finally drawn away as vitiated air up the chimney flue.

It is important that the fresh air should be allowed to enter the room above the heads of the occupants, and therefore the height of the inlet above the floor should be about six feet. It is equally desirable that the inlet should be capable of being diminished in size or closed altogether, for when the outside air is very cold, or the wind is blowing directly into it, the amount of cold air entering may create draughts and lower the temperature of the room to an undesirable extent.

Some simple and effectual methods of ventilating a room in this way are (Fig. 20)—

FIG. 20.



ROOM FITTED WITH VARIOUS VENTILATORS

(1) Hinckes-Bird's plan, in which a solid block of wood is placed under the entire length of the lower sash frame of a window, and thereby raises the top rail of the lower sash above the bottom rail of the upper sash. Air passes into the room

between the two sash frames in the middle of the window, and above the heads of people sitting down in the room, and takes an upward direction towards the ceiling.

(2) The top sash of the window may be a little lowered, and a venetian blind let down over the opening, with the laths so arranged as to direct the entering current of air upwards.

(3) Louvred panes may be employed to replace one of the upper squares of glass in the window; or an arrangement may be adopted for allowing a square of glass in the upper portion of the window to fall inwards upon its lower border, at the same time providing side checks, and a cord by which the ventilator may be closed.

(4) Wall-inlet ventilators may be employed. Tobin's tube is now largely used. It consists of a vertical tube standing up to a height of about $5\frac{1}{2}$ or 6 feet in the room, and connected underneath the floor boards with an opening through the outer wall to the open air. The upward direction given to the entering air causes it to travel to the ceiling of a moderately sized room before it begins to descend. The opening under the floor should be capable of being closed by a valve when desired; and when the tube is fixed on an inner wall of a room, and a shaft is carried under the floor from the external to the internal wall, there should be

some means of access to this horizontal shaft for removing soot and dirt which may collect in it.

(5) The Sheringham valve is, perhaps, less commonly employed than the Tobin tube. Air passes through an opening in the wall near the ceiling, and then meets a valved plate placed at an acute angle, so that the air may be directed upwards. The plate is hinged at its lower border, and is provided with side checks, and can be opened or closed by means of a balanced weight.

By such means as these, or by the use of similar contrivances, it is usually possible to arrange for the satisfactory ventilation of occupied rooms. Of the two evils—stuffiness and draughts—most people will choose the former, and perhaps with reason; for sedentary living, heated rooms, and little exercise out of doors render the system extremely liable to chills, which may develop very rapidly into catarrhs, bronchitis, rheumatism, or other complaints commonly attributed to "taking cold." It is certainly the fact that for at least six months of the year ventilation is far more agreeable and easy to carry out if the entering air is first of all warmed up to a temperature of 65° F., but in the great majority of houses no means exist for securing so desirable a result.

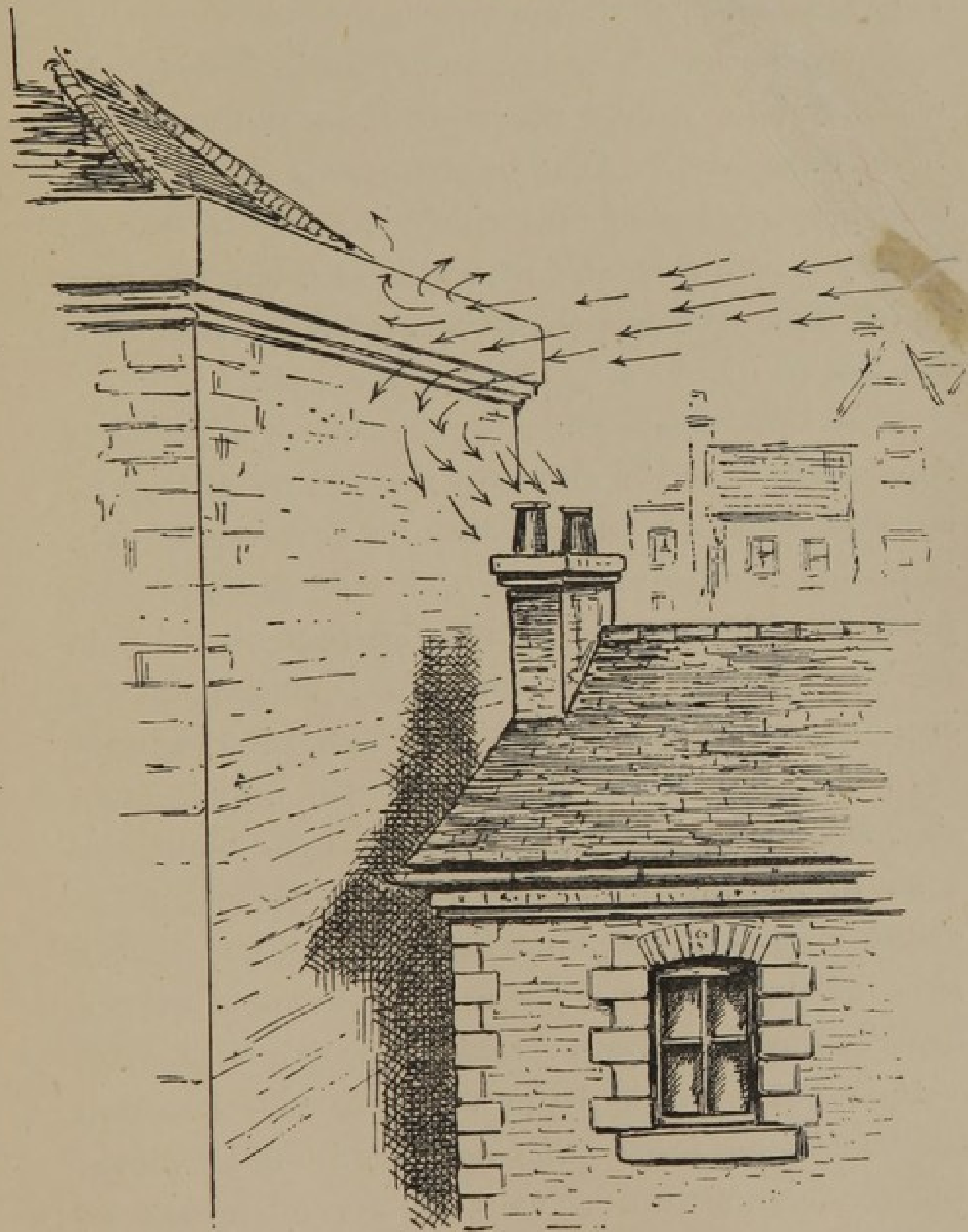
Exhaustion of Fouled Air.—As already said, the chimney flue serves, on the whole, very efficiently as a means of exit for used air, when there is a fire burning in the grate. The time of year when the family living room is most stuffy is the season—spring or autumn—when it is too cold to have the window open, but not cold enough for a fire. Without the fire, the chimney flue is but of little use, unless it happens to run up in the same stack with the kitchen flue, so that the air in it is maintained in a warm condition.

If there is gas burned in a room, it is generally desirable to have an additional exit for hot, fouled air near the ceiling. Perhaps the best is the chimney-breast ventilator (Fig. 20), which is an opening into the chimney flue near the ceiling, and is protected by little mica flap valves against the issue of smoke into the room. The mica valves open inwards towards the flue, but are pressed against their seatings when the pressure in the chimney flue exceeds that in the room. These valves very often make a disagreeable clicking noise, and do not always, after a time, prevent the regurgitation of smoke; but they are certainly useful in providing an exit for the heated, vitiated air which collects near the ceiling of a gas-lighted room.

Smoky Chimneys are not only a serious nuisance, but they sometimes render a room uninhabitable in cold weather. One cause of a smoky chimney is insufficient supply of air to the room from which the chimney leads. To feed the fire with air, a puff descends the chimney carrying smoke with it into the room; the amount of air available from other sources being insufficient to support combustion, and enable the fire to burn. The remedy for such a state of things is evidently to provide an opening to the outer atmosphere, through which the fire may be fed with the amount of air necessary.

More often, perhaps, the cause of the smoky chimney is that the chimney top is overshadowed by higher buildings (Fig. 21). The wind striking these obliquely, rebounds upon the chimney top, and drives air and smoke back into the room. This is especially likely to happen in stormy, squally weather. Here the remedy is to carry the chimney top, if possible, to above the level of the overshadowing buildings—a feat, however, which is not always capable of execution. A cowl will sometimes be of service under these circumstances, because it prevents rain getting into the chimney, and may mitigate the down-draught. Too much reliance should not be placed upon cowls, as they very often fail to effect much improvement. Sometimes good may result from narrowing the chimney throat, and so lessening the volume of cold air escaping up the chimney, which tends to decrease the up-draught; but perhaps the sweeping of the

FIG. 21.



WIND STRIKING DOWN CHIMNEY FROM HIGHER BUILDING chimney to clear it of soot is, as often as not, the true remedy.

There is considerable advantage in having the chimney flue carried up in an inner wall, and not in an outer wall. In the inner wall the flue not only preserves its heat, which is essential for its proper working as an exit ventilator, but the heat which does escape goes to warm the house, and is not lost as it would be on an outer wall.

Exit Ventilators for carrying off gas-products separately from the chimney flue should always be covered by cowls to prevent the entrance of rain into them. This class of exit ventilators often prove troublesome, owing to their becoming inlets for the entrance of cold air upon the heads of the occupants of the room, and not serving the purpose for which they were designed. It will often happen that when a strong fire is burning in a room, the rush of air up the chimney causes every other opening into the room to become an inlet, so that exit ventilators in a room usually occupied with a fire burning must be recommended with caution.

It is not possible to enter upon the question of *ventilating large buildings,* such as hospitals, theatres, halls, and concert rooms by means of artificial methods of ventilation; but it may be said generally that it is often useless to trust to natural ventilation in such cases, and that a proper air supply in sufficient quantity and at a suitable temperature is only possible by artificial methods, such as the use of fans driven by power for propelling air into the buildings, or for extracting the vitiated air. The entering air in these cases can be readily warmed by allowing it to pass over coils of hot-water or steam pipes.

Practical Examination of the Ventilation of Rooms.—The simplest test of the state of ventilation of an occupied room is afforded by the sense of smell. On entering directly from the outer air into a room, the nose is able to differentiate with considerable accuracy varying degrees of stuffiness. A feeling of repulsion is experienced, which, however, soon passes off if the stay in the vitiated atmosphere is prolonged. If the ventilation of the room is effectual, no sense of stuffiness is experienced on entering from the outer air. It is certainly extraordinary how sensitive the olfactory organs are to foul air, and how absolutely they may be relied on to give true indications; but it is only right to mention that above a certain limit of impurity the nose is unable to discriminate greater degrees of pollution. As a matter of fact, however, these higher degrees of impurity are not very often reached in inhabited rooms. The essential point to remember is that the sense of smell can only be trusted when entrance from the outer air has immediately preceded the testing, and that the length of stay in the open air should have lasted at least ten minutes.

Measurement of Cubic and Floor Space.—Where the room is of regular outline, the measurements are effected without difficulty. To obtain the floor space, the length and breadth of the room must be multiplied together; and to know the cubic space, this result must be multiplied by the height.

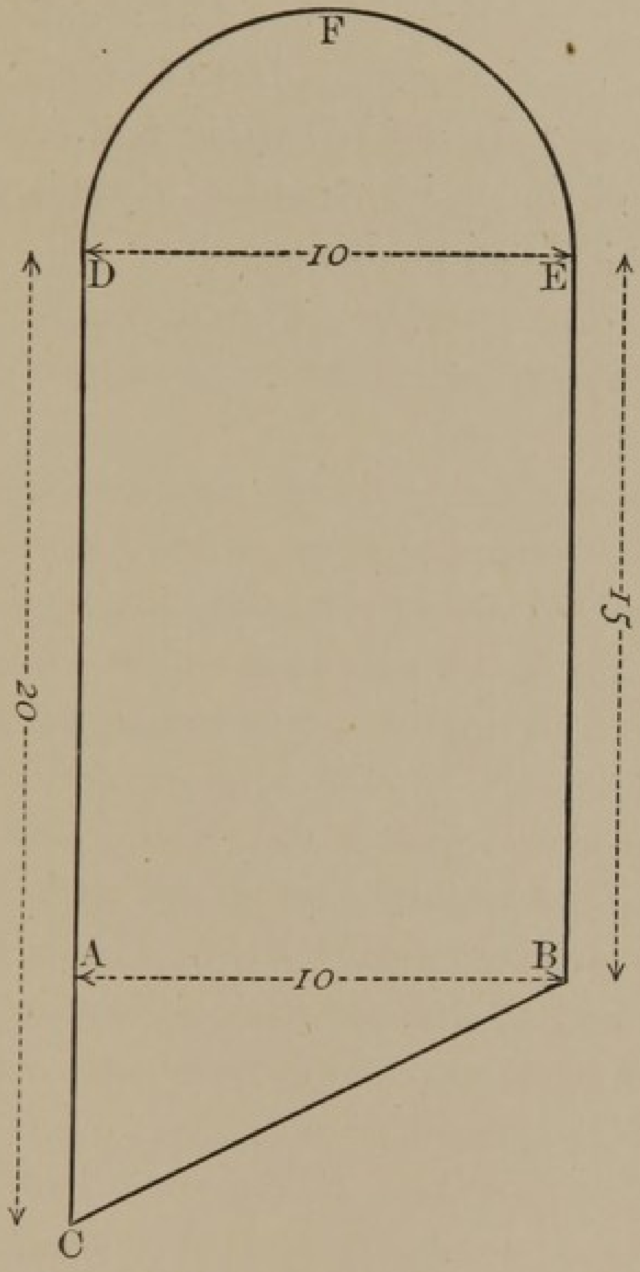
Difficulty is likely to be experienced where the room is of irregular shape, with a portion of the ceiling raised above the rest. In these cases it will usually be found the simplest rule to divide the floor area up into a number of simpler forms, multiplying each by its appropriate height, and finally adding together the totals so obtained.

Example.—Find the cubic contents of a room of the shape given in sketch (Fig. 22), having a semicircular bay 10 feet in diameter? The height of the room over the bay is 12 feet, and over the remaining portion 10 feet.

*** The floor area of the room may be divided into three portions, viz.: (1) A rectangular space, A D E B, whose superficial area is 15×10 feet $= 150$ square feet. (2) A triangular portion, A B C, whose superficial area is 5×5 feet $= 25$

square feet (the area of the triangle A B C is equal to the base A C [5 feet] × half the height

FIG. 22.



A B [5 feet]). (3) A semicircle, D F E, whose superficial area is $\frac{10^2 \times 0{\cdot}7854}{2} = 39{\cdot}27$ square feet. (The area of a circle = the square of the diameter multiplied by 0·7854.)

The cubic contents of the semicircular bay are $39{\cdot}72 \times 12 = 471{\cdot}24$ cubic feet; and the cubic contents of the remainder of the room are $(150 + 25) \times 10 = 1750$ cubic feet. The cubic contents of the entire room are, therefore, $1750 + 471{\cdot}24 = 2221{\cdot}24$ cubic feet.

CHAPTER IV

WARMING

Open fireplaces—Coal and pollution of the air by smoke—Gas fires—Ventilating fireplaces—Ventilating and close stoves—Hot-water pipes.

In all cold climates houses must be provided with some means of producing artificial warmth, as it is neither healthy nor comfortable for people to be at rest for any long period in cold rooms. A suitable temperature for day rooms is from 60° to 65° Fahrenheit, whilst bedrooms may be occupied at a considerably lower temperature without injury to health, and, indeed, with advantage to soundly-constituted people.

In the very great majority of the houses in this country, open fireplaces for the burning of coal are fixed in the living and bed rooms to supply the heat necessary to maintain an agreeable temperature. These open fireplaces heat objects around them by radiation, by which is meant the passage of air in straight lines from hot bodies to cold ones, the rays of heat passing through the air, but without warming it. Such sources of heat are extremely wasteful, as, on the average, more than half the heat given out by the burning coal escapes up the chimney flue; but the open fireplace is eminently a healthy appliance, because it acts as a ventilator, causing a current of heated air to pass away by the chimney, and so inducing the entry of cold, fresh air to supply the place of that withdrawn.

Open coal fires are perhaps, on the whole, the most suitable form of heating appliance for houses in this country, where we habitually enjoy, for the most part, a mild and equable winter; but in times of frost and great cold their inadequacy to maintain a proper degree of warmth is very quickly experienced. There is, besides, the smoke difficulty—a problem for large towns becoming year by year one of greater magnitude and less capable of solution.

Bituminous coal—the kind used for the manufacture of illuminating gas, and everywhere employed for consumption on the domestic hearth—when burnt in an open fireplace gives off three times its weight of carbonic acid gas, small quantities of carbonic oxide, sulphurous acid, bisulphide of carbon, and sulphuretted hydrogen—all these being poisonous and injurious gases—and, in addition, steam (water vapour). No less than one per cent. of the coal is given off as fine solid particles of unconsumed carbon and tarry matters, commonly called soot.

The example of London will show how vast are the polluting effects of smoke upon the atmosphere. In this great city it is computed that on a cold winter's day as much as 40,000 tons of coal may be consumed in the twenty-four hours. The smoke given off from the 800,000 houses constituting modern London will carry into the air in this one day some 400 tons of soot, and probably an equal amount of sulphur as sulphurous acid; also 120,000 tons of CO_2 gas will be added to London's atmosphere. It is true that these polluting ingredients are spread more or less over a large area (seventy to eighty square miles); but in stagnant conditions of the atmosphere (anti-cyclones) there is also the cumulative effect—the pollution of one day not being carried off before the fresh accession of smoke on the following day or days. These figures, at any rate, help the ordinary observer to realise the origin and continuance of yellow fogs, and the factors upon which they depend.

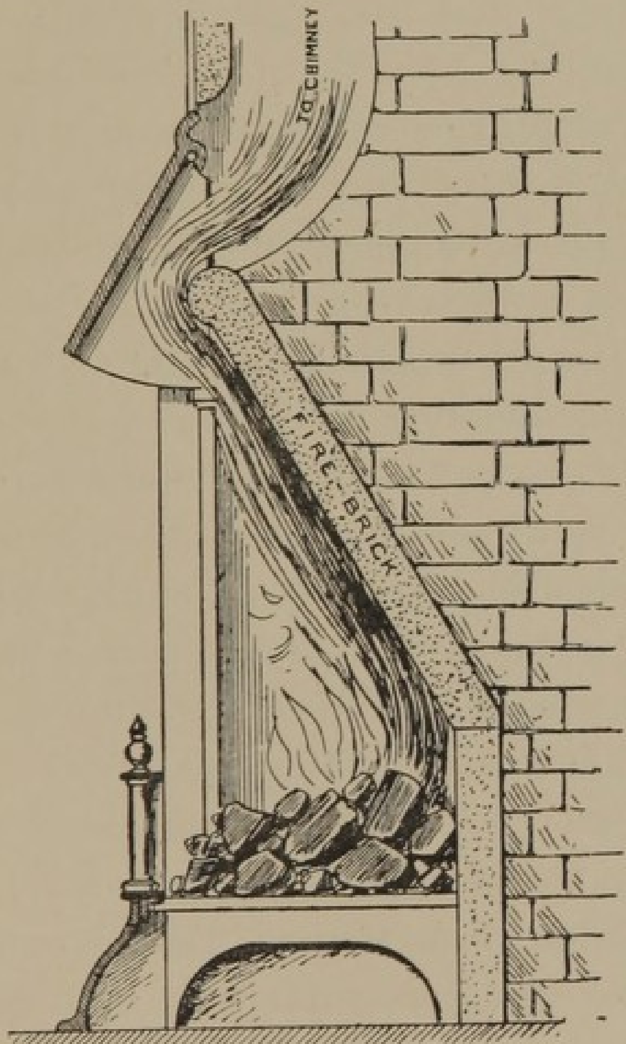
The common form of open fireplace is a good deal more wasteful of fuel and heat than there is any necessity for. The open space under the lower bars admits cold air to the burning fuel and chills it, causing at the same time imperfect combustion and waste of fuel. The sloping back to the grate throws a vast quantity of heat up the chimney, which might, under better management, be radiated into the room; and this result is contributed to by the too great depth of the grate and the too large opening into the chimney flue.

Certain improvements have been carried out in the construction of open fireplaces, many of the suggestions here detailed originally emanating from Mr. Pridgin Teale, of Leeds (Fig. 23).

(1) The width of the grate facing the room should be considerable, whilst the depth is curtailed. In this way the radiating surface is increased, and more heat is utilised. (2) The back and sides of the grate should be made of fire-clay, which, being a very bad conductor, does not permit the escape of heat in undue quantities into the wall of the room. (3) The back of the grate should be curved forward, "rifle-backed" as it is called, to permit of the flames playing upon the curvature, which in turn radiates its heat towards the room. (4) The floor of the grate should either be formed of a solid slab of fire-clay, or, preferably, the lower fire-bars may be retained, and a hot-air chamber contrived under them by fixing an iron shield on the hearth to cut off all access of air to the fire from beneath the fire-bars. The grate is thus ren-

dered "slow combustion," whilst the space beneath the fire-bars is useful in forming an ashpit, into which the consumed ashes fall, and from which they can be removed by pulling forward the shield.

Fig. 23.



Slow-combustion Open Fire-place

It is wonderful how completely in these slow combustion grates the coals are consumed. A little reddish-grey ash results, but no large cinders are seen. Cinders mean incomplete and wasteful combustion. The grate with the solid fire-clay bottom gives equally good results as regards combustion, but the fire is apt at the end of the day to become clogged from the accummulation of ash, which in the other arrangement falls into the ashpit.

To economise heat, the fireplace should stand as far forward in the room as possible. The chimney throat should be limited in area to prevent the undue escape of heated air; and the fireplace should, wherever possible, be fixed in an inner—not an outer—wall of the house.

So much for economy of fuel and utilisation of heat; and it may here be stated that a modern open firegrate on improved principles very quickly pays for its cost in a diminished coal bill, not to mention the increased comfort.

As regards the avoidance of smoke or its limitation, this is a matter which greatly concerns the urban householder, but which, of course, individual effort is unable to cope with. The use of hot-water pipes, steam pipes, and stoves on the Continental system for the heating of houses is repugnant to the tastes and feelings of most of the inhabitants of these islands, and neither have such methods any hygienic advantages. By some the use of anthracite, or smokeless coal, is recommended, to be burnt in specially designed grates, as the common form of fireplace is not very suitable for this form of coal. It is doubtful, however, whether the anthracite collieries now working have sufficient of this coal for the supply of domestic fireplaces on a large scale.

Others recommend so-called smokeless or smoke-preventing grates. In one form of these grates the fire is "underfed," that is to say, the supply of fresh fuel is introduced beneath the incandescent coal, which forms the top of the fire, and through which the gases arising from the fresh coal must pass, thus securing a more complete combustion than is possible where the fresh fuel is placed on the top of the fire. These grates are undoubtedly economical, and continuously expose a clear fire free from smoke, but they require more care and attention and greater trouble in stoking than the ordinary firegrate, and for this reason are never likely to become very popular; or, if used, to be properly attended to.

The third remedy, and the one in which there is most promise, if only coal gas were half its present price, is the replacement of the open coal fire by an open gas fire. In the usual form of this appliance the flames from a row of atmospheric burners, *i. e.* burners in which air is allowed to enter and mix with the gas before it is burnt, so as to produce a non-luminous blue flame—play upon asbestos in lumps or fibre, which becomes highly heated, but is otherwise unaffected, being indestructible by heat. With coal gas at 3*s.* per 1000 cubic feet, gas fires are certainly more costly than coal fires; but they possess the great advantage of being smokeless, causing no accumulation of soot in the chimney, and no dust and ashes in the dust pan. No fire has to be made with paper and sticks; they are immediately lighted when wanted, and at once extinguished when their use is no longer required.

Although they give out no coloured smoke, it must always be remembered that there are products of combustion which, although invisible, are highly injurious; and a flue to carry off these products to the open air must invariably be provided.

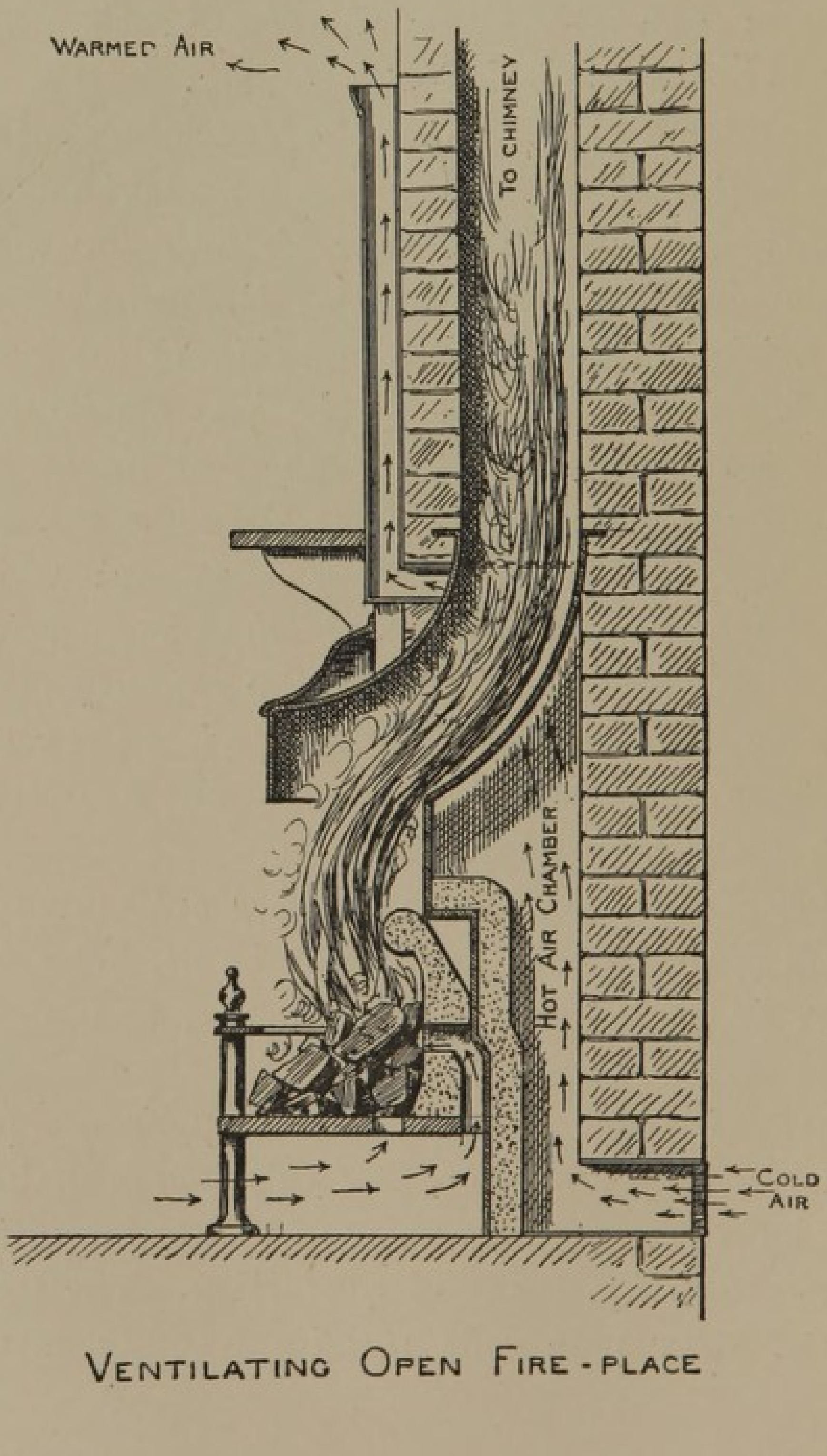
The coke and gas fire is a cheaper substitute for the continually burning gas fire. A row of gas burners need only be fixed under the lower fire-bars of an ordinary coal grate, in which is placed coke as obtained from gas-works. The coke is lighted by the heat of the gas flames playing on it from below; as soon as it begins to be red-hot the gas can be extinguished, and the coke continues to burn until it is consumed. Fresh coke can be placed on the red-hot coke in the grate without any further use of the gas. In fact, the gas is only required to set the coke, at first starting, thoroughly alight. As already said, the products of combustion of coke contain carbonic oxide gas—a most deadly gaseous poison—and for this reason coke fires should be recommended with caution.

In Galton's (Fig. 24) and the Manchester School Fire Grate an open coal fireplace is made the means of introducing fresh warmed air into the room. A chamber lined with fire-clay is constructed in the brickwork at the back and sides of the grate, which becomes warmed by the heat of the fire. An opening is made from the bottom of the chamber to communicate with the outer air, and introduce the latter into the chamber; whilst another opening is made from the chamber into the room above the level of the chimney-piece, to allow the warmed air to escape into the room, and thus effect the ventilation of the apartment with warmed fresh air.

Other means of heating houses are stoves in which coke, coal, oil, or gas is burnt, hot-water pipes in connection with a boiler, and steam pipes.

Heat is radiated from these appliances just as from open fireplaces, but this source of heat is of but little account compared with the warming of the room by means of convection. The stvoe or hot-water pipe coils stand out bodily in the room, and are not placed in the face of one wall with an open tube to the outer air above them

FIG. 24.



VENTILATING OPEN FIRE-PLACE

as open fireplaces are. The room is warmed by currents of warm air. The air passing over the stove or coils of hot pipes becomes heated, rises towards the ceiling, imparts its heat to surrounding cooler objects, becomes cooled in consequence, and sinking towards the floor, again flows towards the source of heat, to undergo the same round of movement. The room is therefore warmed by circulating currents of heated air, that is, by convection.

The warmth is very much more evenly distri buted throughout all parts of the apartment than is the case with radiant heat, the intensity of which is inversely as the square of the distance from the source of heat; by which is meant that an object 6 feet from an open fire, or other source of radiant heat, receives only one-fourth the amount of heat that an object only 3 feet distant from the source of heat receives—namely as 9, or the square of 3, is to 36, or the square of 6.

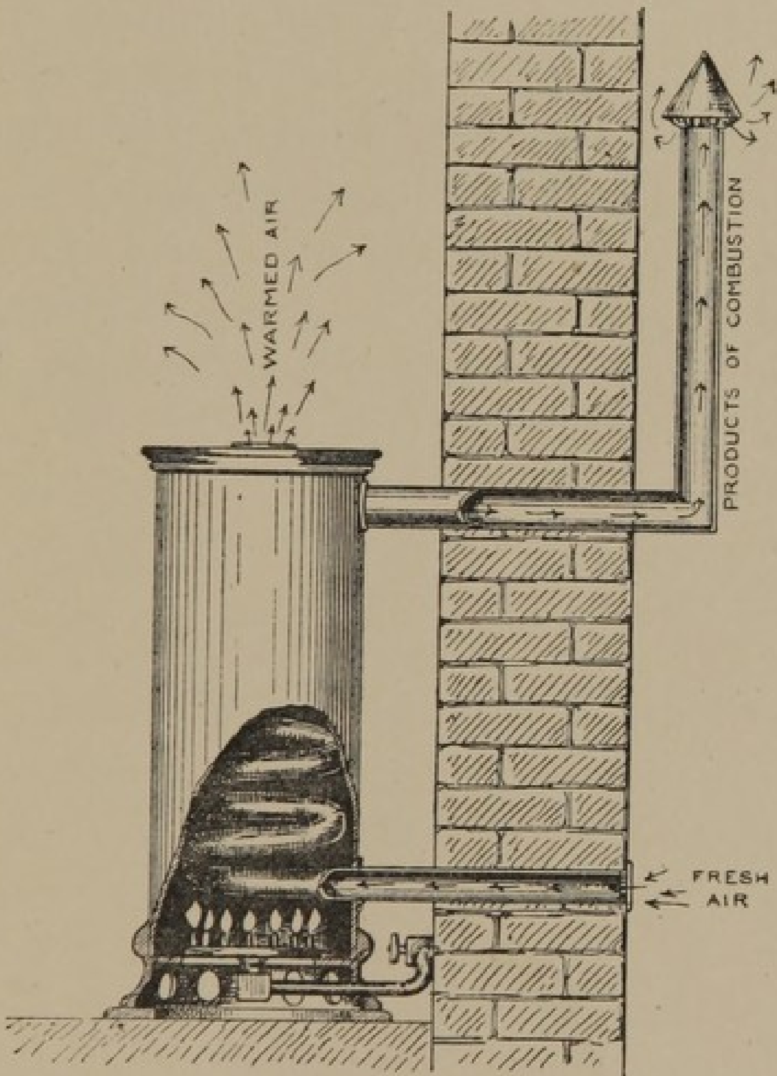
With stoves there is always great economy of fuel, for the heat is utilised in the room, and only sufficient air is supplied to the burning fuel to support combustion, there being no open chimney, with its continually changing column of heated air to be maintained at a high temperature, in order that the latter may escape.

Notwithstanding these advantages there is the great sanitary drawback that stove- or pipe-heated dwelling-rooms are generally close, stuffy, charged with overdry air, and occasionally evil-smelling. The closeness and stuffiness are due to want of ventilation; the overdrying of the air is due to its high temperature, the moisture present being insufficient to produce the proper amount of relative humidity; and the smell is commonly caused by charring of the organic matter in the air, as it passes over the highly heated surface of the stove.

Stoves and hot-water pipes are not, therefore, to be recommended for use in ordinary dwelling-houses. They are, however, useful for warming the halls and staircases of large mansions; and in churches, chapels, concert rooms, public halls, and assembly rooms, the maintenance of a proper standard of temperature without their employment is hardly possible.

There are several desiderata with regard to stoves which may be mentioned. (1) "Ventilating" stoves (Fig. 25), which introduce a supply of warmed fresh air into the room in which they are fixed, are preferable to "close" stoves. A pipe from the outer atmosphere conducts air into a compartment in the stove, separate from the combustion chamber, in which it is warmed, and then escapes into the air of the room. (2) A vessel of water should be placed on the stove, to supply moisture to the air by evaporation. (3) Stoves of china

FIG. 25.



VENTILATING CLOSE STOVE

or fire-clay should be preferred to cast-iron stoves, unless the combustion chamber of the latter sort is lined with fire-clay. The metal of the cast-iron stoves becomes too highly heated as a ru' with the result of the charring of the organic matter in the air, and the production of a "burnt" smell.

There is no objection to heating large buildings with hot-water pipes on the low pressure system, in which the water does not rise above 200° F., but means should always be adopted for the introduction of fresh air over the coils, and its continuous supply to the room; and the pipes should never be placed in chased depressions in the walls, or in channels in the floor, but should be so fixed that the duster and broom have access to the spaces beneath and behind them.

CHAPTER V

LIGHTING

Daylight illumination of rooms—Artificial lighting: Electric light, Gas, Lamps, Candles.

ABUNDANCE of light and air are essential for a healthy dwelling. Houses in which the dwelling-rooms are dark and sunless, are not only cheerless and dismal, but are also undesirable on the score of health. The dark places of a house are those where dirt is most likely to accumulate, and least likely to be removed.

Modern research shows that there is no greater sweetener of foul matters in the atmosphere than sunlight and fresh air. Direct sunlight is capable of destroying microbes of the most pestilent species, and of the most persistent forms. It follows, therefore, that the rooms of a house which are most freely exposed to the sun are likely to be not only more cheerful, but also more healthy than those which the sun's rays rarely visit.

A south aspect is to be recommended for the living-rooms of a house, as the sun's rays must penetrate at some time or other of the day. In summer, a room with an unobstructed south aspect is likely to be too highly illuminated, and at this season, of course, sun-blinds or venetian blinds must be used to darken the room when necessary. For certain classes of work, a room with a north aspect is to be preferred, as the light proceeds from the sky, and not directly from the sun, and is consequently more subdued and steady.

The area of the windows of a room should bear some proportion to the size of the room, that is to say, to the floor area. The window area should not be greater than one-fourth the floor area, and not less than one-tenth that area. If the windows are too large, the room is difficult to warm in winter, as the great expanse of thin glass allows of an undue escape of heat. If the windows are insufficient in size, the room is badly lighted, dark, and cheerless. The window should reach nearly to the ceiling of the room, so as to allow of the light playing upon the ceiling, from which it will be reflected to all parts of the room ; and also to permit of the ventilation of the higher parts of the apartment, where foul and heated air is especially likely to accumulate.

Window-glass in the smoky atmosphere of our large towns speedily becomes coated with soot and dirt, and much of the light may thus be cut off. The thorough cleaning of the outside of the window is not always possible, unless the person engaged in the work is willing to assume a position of some danger by sitting or standing upon the window-sill. It would be well if all windows of rooms at a height above the ground were fitted with reversible window-frames, which can be revolved upon an axis, so as to present the outer surface to the interior of the room. All cleaning can then be done from the inside of the house. In Millar's patent the sashes can be taken off the stiles altogether, and replaced without taking off any of the beads, or disturbing any of the woodwork about the frame.

The best position for writing is to sit with the window on the left-hand side, so that the light may fall on the paper, and no shadow be cast by the hand or pen, if the writer is right-handed. It is better not to face the light directly, and thus the dazzling effect of strong light in the eyes may be avoided.

The artificial lighting of a room is a matter of considerable importance, as the eyesight is likely to be damaged by bad arrangement, or insufficient quantity, or quality of the light. What is required is that the object we are regarding should be steadily and sufficiently illuminated, whilst the eyes themselves are protected from strong rays of light.

On the whole, perhaps the incandescent electric light answers these requirements best; but oil lamps, gas, and candles may be made to give satisfactory illumination. One great advantage of the electric light is that there are no products of combustion to pollute the air of the room, the incandescent filament of carbon being enclosed in a glass globe containing nitrogen gas, which does not support combustion.

If gas jets are used, care should be taken that the supply of gas is regulated, so that flickering or jumping of the flame may be avoided. A flame of this character is very trying to the sight. This result may be attained by the use of the so-called "regulating burners," or by having a gas governor attached to the gas main close to the meter. It is also not advisable to have the gas jet or burner too near a wall, ceiling, or other cold surface, as the unconsumed carbon particles from the flame will be deposited on such cold bodies, causing them to become coated with a layer of soot.

The Welsbach incandescent gas burner is a very suitable one for dwelling-rooms, as it gives out a very steady white light. The light from the incandescent asbestos gauze mantle is not nearly so yellow as the light from an ordinary gas jet. The Regenerative gas burner of Siemens is more suited for large halls, and gives out a strong and brilliant light for the gas consumed. In this appliance the air and gas, previous to their union, are heated in chambers surrounding the flue by the waste heat of the combustion.

Lamps are more dangerous than gas jets, as the latter as a rule are fixtures, and not liable to overturn; whilst the lamp, being a movable object, is liable to this form of accident. A danger also arises in lamps from the fact that it is very often the custom with careless people to blow the flame out, and subsequently to depress the smouldering wick into the reservoir holding the oil; the vapour of the oil becomes ignited, and an explosion ensues. The best duplex lamps are now provided with extinguishers, to obviate the blowing out of the flame; and in all safety lamps there is a mechanical arrangement by which, if the lamp is upset, the flame is immediately extinguished. The sale of highly inflammable and dangerous oils is now prohibited by Act of Parliament, and there is practical safety if only care and reasonably good lamps are used.

Candles are dangerous, if only for the fact that there is a naked flame; but it is often the custom to provide the candle flame with an ornamental shade, which is apt to catch fire if not attended to, or if the candle is exposed to a draught. The risk is thereby very greatly increased.

CHAPTER VI

HOUSE CONSTRUCTION IN ITS SANITARY ASPECT

Damp houses and disease—Subsoil air and subsoil water—Pollution of the subsoil—Prevention of dampness in houses—Ventilation under floors—Bad design in the planning of houses—Household dust—Floors, walls, and ceilings.

WARMTH and dryness in a house are as essential to health as good drainage and adequate ventilation. If the house walls are damp or the site is water-logged, the dwelling cannot be otherwise than unwholesome.

The atmosphere of a damp house is not only moist, but cold also, the warmth of the interior being utilised, not to warm the air of the house and objects in it, but to evaporate the water contained in damp walls and floors. A large amount of heat is absorbed in the process of evaporation of water by reason of the change of condition from fluid water into vaporous steam, and this heat, thus rendered latent, is in consequence lost to the house. It is the universal experience of medical men that many diseases of the lungs (bronchitis, pneumonia, pleurisy, and phthisis or consumption), rheumatism, and ague are very often associated with residence in damp houses on moisture-laden sites, and excessive mortality from diphtheria, measles, and whooping-cough is very commonly observed under similar conditions.

In certain low-lying situations, such as river valleys, the subsoil water—that is to say, the rain which has percolated from the surface through porous soil—is found at a depth of only a few feet from the surface of the ground. This subsoil water fills all the interstices of the porous earth, and the vapour which arises from it by evaporation is found in the air occupying the layers of soil above the underground water-line.

Various natural causes such as winds, changes in the pressure and temperature of the atmosphere, and a rise in the level of the subsoil water, cause the displacement of this ground or subsoil air, and its escape at the surface of the earth. It is, of course, in freely porous soils such as loose sands and gravels that the ground air is largest in amount relatively to the soil, and most easily set in motion. In the dense and less permeable soils, such as clay and heavy marls, the ground air is of less consequence.

Owing to the above-mentioned natural causes, aided very often by the in-suction caused by fires within the house, the ground air finds its way through the surface of the earth into the interiors of houses; and holding, as it may, watery vapour to saturation, it introduces into the house much undesirable moisture.

Ground or subsoil air is not only unduly moist, it is also charged with impurities of an unwholesome character. In the surface layers of the soil are found the various microbes that cause the fermentation and putrefaction of organic matters. These matters are changed in the surface layers of the subsoil, as if it were a laboratory, into simpler inorganic constituents that become the food of plants. The importance of this natural function of the surface soil is at once apparent, as without its beneficent action waste and useless organic substances would litter up the surface of the earth, and plant life would languish for want of the mineral salts necessary for its maintenance.

All the same, however, the processes of disintegration carried on in the soil are productive of gases and vapours which pollute the air, and are of a character prejudicial to health. This being so, even in virgin soil,—that is to say, soil which has not been disturbed for building, drainage, or other purposes,—it follows that the precautions necessary to prevent soil emanations finding their way into houses from ground which has been long built upon, or which has become contaminated with filth and rubbish, must be even more necessary.

In towns where the streets and the general surface of the ground are largely covered with impermeable paving, which prevents the escape of air from the soil, there is a very great tendency for the displaced ground air to find its way into buildings. The contamination of the ground air in inhabited places is most commonly due to the filth which escapes from leaky cess-pools, drains, and sewers, but this air may also become mixed with coal gas from defective underground gas-pipes. Serious and even fatal coal-gas poisoning has been known to afflict the occupants of houses into which such polluted air has found an entrance.

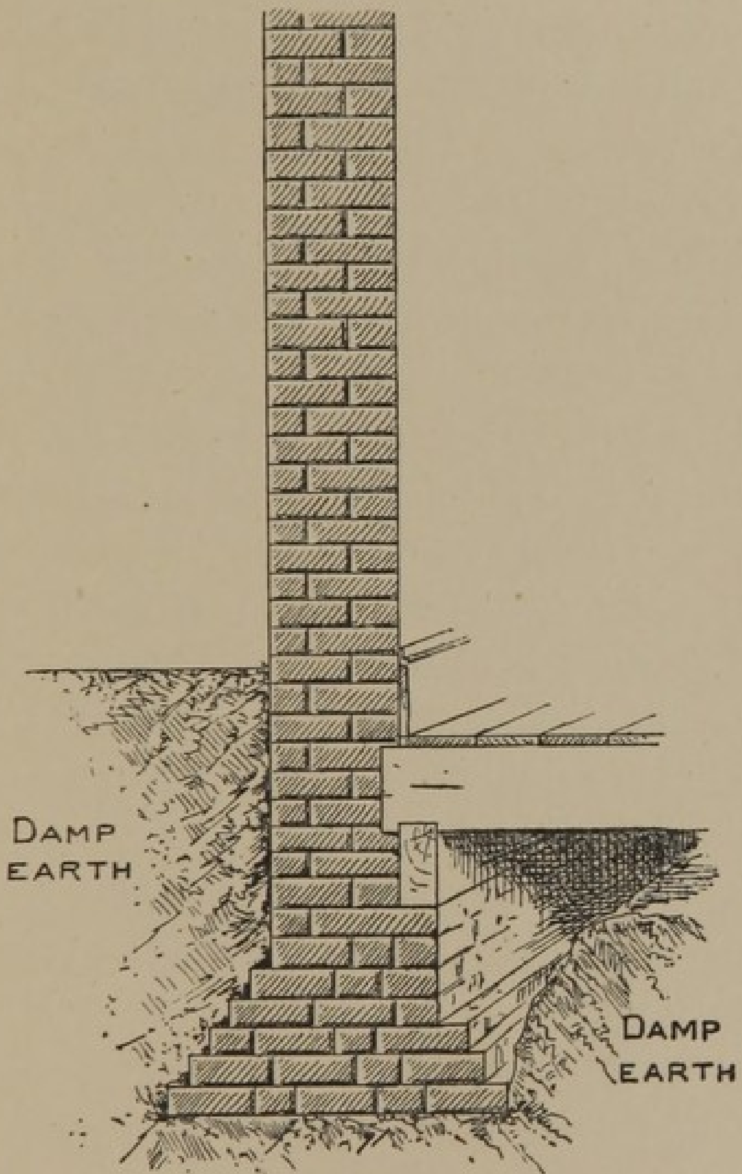
Another serious cause of pollution of the subsoil is the presence of crowded graveyards and cemeteries in the midst of inhabited districts. The enormous amount of decomposing material contained in the soil of many of our urban cemeteries can be realised when it is understood that it used, years ago, to be the custom to bury numerous bodies in one grave—one above another, until but a foot or so of earth rested upon the last-placed coffin. Overcrowding of burial places still continues, but not to the same extent as prior to the Burials Act of 1855.

In some outlying districts around towns much of the virgin gravel is removed by builders, and the excavations so made are filled in with house refuse collected from domestic dustbins. These plots of so-called "made ground" are subsequently built upon, and the dwelling-houses so erected rapidly become notorious as being "never free from fever and illness."

It is, then, a very important sanitary desideratum, when houses are being erected, to prevent the possibility of the entrance of ground air by covering the entire site under the building with a bed of good, thick cement concrete, at least 6 inches thick, rammed solid. Especially necessary is this when houses are erected on impure or moist ground. Although so important a measure from the health point of view, the concreting of the site is seldom effectually carried out, even in the case of houses which will command a large rental.

Houses are rendered damp not only by the evaporation of moisture from the subsoil water, but also by the property that water has of ascending in porous substances by what is known as "capillary attraction." If the end of a porous substance, such as a brick, is just dipped in water, the water soaks into the pores of the brick, and rises vertically until the whole of the brick is moistened. This is the result of capillary attraction. Consequently, if the footings of a brick wall are resting upon or surrounded by damp earth (Fig. 26), the moisture in the earth will invade the

FIG. 26.



DAMP WALL
FROM
DEFECTIVE FOUNDATIONS

porous bricks, and will gradually rise in the walls, rendering them cold and clammy. The large amount of water that may be contained in a damp wall will be realised when it is understood that a brick of ordinary size—measuring 9 inches by $4\frac{1}{2}$ inches, and 3 inches deep—will hold some 16 ounces of water.

Dampness is usually visible in brick walls, the moist bricks being darker in colour than the dry ones. The surface, too, will often feel wet to the hand. Should the bricks be covered by plaster and wall paper, the paper will discolour and eventually peel off the wall. In time various growths of fungus are visible on the damp surfaces—usually seen as white, black, or reddish-coloured spots or masses, consisting of very fine gossamer-like filaments. The timber and woodwork of a damp house are very liable to decay owing to the attacks of similar fungoid organisms.

To prevent dampness in a house owing to excessive moisture in the subsoil, several precautions must be observed in its original construction, and in the preparation of its site. As regards the site, subsoil drains should be laid at a depth which will be below the level of the foundations, in order to carry off subsoil water and to prevent its rising to the footings of the walls. These drains should be formed of unglazed, porous earthenware pipes laid end to end, without sockets or joints, so as to permit the water in the soil to percolate readily into them. The drains should be carried through the ground to discharge, at a lower level, into a ditch or stream. They must not, of course, be directly connected with any sewer, cesspool, or drain used for the reception of house sewage.

In some places a naturally damp subsoil may be effectively rendered dryer by this system of drainage, and the level of the subsoil water be permanently lowered.

To prevent the house walls becoming damp from contact with moist earth, the footings of every wall should rest upon a bed of concrete; and above the footings a *damp-proof course* should be inserted in the brickwork, which will effectually prevent moisture ascending from below upwards (Fig. 27). The damp-proof course must consist of some material which is impervious to moisture, such as slates laid horizontally and embedded in cement, a horizontal layer of asphalte from half to one inch thick, or a course of glazed stoneware slabs.

To prevent dampness in the cellars or basement of a house, in addition to the damp-proof course which is usually laid above the ground level, the external walls should be separated from the ground by an open area, extending upwards from the house foundation to the ground level (Fig. 27); or in cases where there is no space available for an open area, the walls of the house below the ground should be double, so as to enclose a vertical air

Fig. 27.

WALL WITH DRY AREA & DAMP-PROOF COURSE

space, which prevents the transmission of moisture from the outer to the inner wall. The two walls are bonded together by iron ties, to secure the proper stability.

It is very important in ground floor rooms that the joists supporting the floor boards should not be laid on the earth. There should always be a space of about 2 feet left between the ground and the joists, and this space must be well ventilated by openings through the external walls, which may be covered outside by iron gratings to prevent the entrance of vermin. If the space under the floors is not well ventilated, dry rot is pretty sure to attack the woodwork and cause its destruction.

The space between the floors in the basement storey and the earth is very apt to harbour cockroaches, ants, mice, and other objectionable vermin. The basements of some houses in towns are rendered almost uninhabitable from this cause. The only effectual remedy is to remove the flooring, and the top layers of earth, and to lay a bed of concrete over the entire surface. The top of the concrete can be floated with cement, and finished to form the flooring, thus getting rid of all woodwork, and depriving vermin of every possible place in which they can shelter.

The ground around and in the immediate vicinity of dwelling-houses should be paved with impermeable material, so as to prevent the formation in wet weather of stagnant liquid pools, the water of which soaks into the ground around the house foundations. Areas and yards may be paved with cement concrete, asphalte, blue glazed bricks, or York flagstones; and the surface should be sloped to carry away storm waters to gully traps and the drains. Cement concrete and asphalte are preferable to bricks and flagstones, as in the latter there are the joints between the bricks and flags, which are apt to become in course of time open or unsound.

Dampness may arise from other causes than from the ground. It will be sufficient merely to indicate them. (1) Driving rain in exposed situations, especially where the mortar joints between the bricks are laid bare from defective or worn-out pointing. (2) A water-pipe which is embedded in a wall may be leaking. (3) A cistern may be overflowing, and the water soaking into adjacent brickwork. (4) A rain-water gutter or a rain-water pipe may be choked or defective, and in consequence the rain-water drips down the walls, instead of running away at once to a drain.

The dampness due to leaky soil-drains under a house has been already mentioned. In some instances the dampness has been traced to an old cesspool in the ground under a house, the contents of which soak away into the soil.

Not only must the walls of a house be dry, but they should also be of proper thickness, to protect the inmates from those seasonal changes of temperature incidental to our climate. A wall of proper thickness will protect from cold in winter, and from heat in summer. When the house is warm, a thick wall minimises the escape of heat by radiation from inside to outside; and in hot weather the interior of the house is maintained at a cool temperature, the rays of the sun being unable to raise the interior of the wall to a high temperature owing to its thickness. The material of the wall—brick, stone, or concrete—is of less importance in this respect than its thickness.

A good deal more might be done than is generally attempted at present to make the roof of the house a better non-conductor of heat. The attics of most houses are unbearably hot in warm weather, and the reverse in cold. If the inside of the roof under the slates were lined with matchboarding and a thick layer of felt, the attic storey would be a more comfortable abode than is generally the case now.

Bad design in the original planning of a house may render it an undesirable residence from the health point of view. Architects and builders of the present day are very much more conversant with the sanitary principles of house design and construction than were their predecessors of thirty years ago. It will be sufficient to enumerate some of the more important desiderata, hygienically speaking, of house design and planning.

(1) The floors of the ground floor rooms should always be raised well above the level of the outside adjoining ground. In former days cottages and small country houses very commonly had the ground-floors depressed below the level of the adjourning ground, with the result that the walls were often damp, and there was no ventilation under the floors.

(2) The staircases, passages, and landings should be well lighted and ventilated. A central staircase lighted by a skylight in the roof is very commonly seen in large mansions, but its ventilation cannot be so satisfactory as where the staircase is lighted and ventilated by external side windows. In many houses now occupied by the poorer classes, the staircase is in the centre of the house, and is absolutely dark and unventilated. Many of these are tenement houses, *i.e.* occupied by several families; and not only does the staircase form a shaft for the conduct of foul air from one tenement to another, but the risk of infection

spreading in houses of this class is very greatly enhanced, should one of the occupants be attacked by a communicable disease.

(3) The rooms intended for occupancy by day or night should have windows opening into wide open spaces, not overshadowed by surrounding buildings. The non-observance of this rule is most markedly developed in the construction of mansions let in flats and artizans' dwellings in our large towns. In very many cases inhabited rooms will be discovered which are exclusively lighted and ventilated from narrow enclosed courtyards or shafts hemmed in by buildings of colossal height, which render impossible the access of the necessary light and air.

(4) The height of the rooms should not be less than eight feet. In many of the older class of cottage buildings, rooms of seven feet or even six feet six inches are to be found. In this class of two-roomed cottage property it is not unusual to enter the ground floor room directly from the street, and to find an open stairway or ladder running directly from the lower room to the upper room, the latter receiving as a consequence the used and vitiated air of the former.

(5) The sanitary conveniences of a house—the water-closet, bath-room, lavatories, &c.—should not be situated in the centre of a house, but

should be placed against an outer wall, in order to secure light and ventilation direct from the outer atmosphere. This is a matter which has already been discussed.

(6) Every living room of a dwelling-house should have through light and ventilation; that is to say, there should be windows on opposite sides of the room, or window and door on opposite sides, in order that the air of the room may be thoroughly renewed by allowing air currents to pass right through. Houses built back-to-back, or so constructed that the rooms are lighted and ventilated from one side only, are less healthy than those in which the design secures through ventilation.

A dwelling-house should not only be sound in design and strong and dry in structure, but the internal fixtures and furniture should be such as to permit of the interior being kept clean and wholesome with the least expenditure of time and energy.

Household dust is the *débris* resulting from household life and activity. If some of this dust, which has been deposited from the air in an inhabited room, is examined microscopically, it will be seen to consist of soot particles in abundance, sand particles, cotton and wool fibres, starch grains, pulverised straw or vegetable matter, epithelium from the epidermis of men and animals, spores of fungi and bacteria, &c. Much of it is evidently organic refuse, and therefore a waste product to be removed from our habitations with the greatest possible frequency and regularity.

Whilst the production of this dust may be regarded as inevitable in all inhabited houses, still the internal fittings may be so arranged as to render its collection as easy as possible. It is well, first of all, to remember that the dust represents the suspended matters that settle out of the air, when at rest, upon all objects in a room; therefore every part of the walls and floor of a room, and every surface of objects in the room, should be accessible to the housemaid's broom and duster.

Any surface which is inaccessible, but yet affords a resting-place on which dust is deposited, is to be deprecated. As such may be mentioned cornices and beadings or other projections upon ceilings and above doors and windows; cumbersome articles of furniture, as sideboards, bookcases, and wardrobes, which collect dust on their upper surfaces, and are too heavy to be moved to allow dust to be swept out below. Besides these, dust collects to a considerable extent in rough or flock wall papers, in carpets, curtains, canopies, and draperies; and in consequence all such dustholders should be frequently removed to the open air to have the accumulated dust beaten out of them.

Rough or flock wall-papers are decidedly objectionable, and should be replaced by papers having a smooth non-absorbent surface. Whilst the room is being re-papered, particular care should be given to ascertain that the old paper, and any papers of still more ancient date, are peeled off until the plaster is exposed, before the new paper is applied.

Floors with crevices between the shrunk and warped floor-boards are an especially bad form of dust-trap, as dust and dirt fall through the crevices into the space between the floor and the ceiling of the room below, from which position no measure short of taking up the floor can remove them. Defective floors of this kind can be entirely covered over with linoleum or oil-cloth, or, preferably, with thin oak parquetry, kept well polished with oil and beeswax, as the use of oil-cloth tends to produce rotting of the woodwork below. Solid wood-block flooring, in which the blocks are dovetailed, without chinks or crevices, are now much used. With such flooring, or with parquetried floors, carpets to cover the whole area of the room are not required, and the use of squares of carpet, rugs, and mats is encouraged—that is to say, of articles of small size which can without inconvenience be frequently shaken and cleared of dust.

Bedroom walls should be planned with recesses, to be utilised as cupboards, drawers, and shelves, and thus render unnecessary cumbersome wardrobes and chests of drawers. The actual bedroom furniture can then be reduced to the necessary bed, washstand, dressing-table, and chairs, and no surface is presented for the deposition of dust which is not readily accessible. Distemper colouring is better for bedroom wall surfaces than wall-papers; and especial care should be given that the floor surface is in sound condition, without chinks and crevices for the lodgment of dust; and that its surface is not covered with carpet. A few mats are permissible in a bedroom; but a carpet, which merely receives an annual shaking or beating, should not be tolerated.

In choosing wall-papers for a house always insist on being supplied with papers which are guaranteed free from arsenical or other poisonous pigments, as the use of arsenical papers has been credited rightly with the production of severe illness amongst the occupants of rooms so papered.

Parian cement coated with paint laid on to a fine, smooth surface, forms an excellent wall; but the room so painted should not be inhabited until the paint is thoroughly dry, and all "smell of paint" has departed. Nearly all paints contain lead salts as a basis, and in drying some of the lead salt is evaporated, or as a powder mixes with the air of the room, and may be productive of symptoms of lead-poisoning.

Where expense is not a consideration, the walls and floors of water-closets, bath-rooms, and lavatories should be either lined or covered with glazed tiles set in cement; or the floor may be formed of tesselated pavement, consisting of small chips of marble set in cement, whilst the walls may be cemented and subsequently painted.

CHAPTER VII

SITE AND SITUATION OF HOUSE

Varieties of soil — Exposure of site — Elevation — Bracing and relaxing localities—Influence of vegetation and water.

To most people it is not given to be able to choose the exact locality where they shall live. Their choice is limited at any rate to the district in which they find employment; and such questions as are involved in considerations of climate, site, and situation are necessarily subordinated to those of convenience and proximity to employment.

It may be generally stated that there are but few localities in this country which are centres of any industry which cannot be rendered wholesome and healthy by efficient drainage, sewerage, and water-supply, and by insistence on the observance of sanitary principles in the construction of the houses. To those who have a wider range of choice in the selection of where they shall live, the following observations may be of service.

The warmest and driest soils to live upon are the gravels and sands, because they are the most absorbent of heat, and the most porous to water. In this moist and fickle climate of ours it is certainly healthful to reside on a warm and dry soil.

The porous soil must, however, be of considerable depth, and not underlaid at a short distance from the surface by a bed of clay, which prevents the passage of water. Porous soils which are water-logged in this way are often extremely damp and unhealthy; and it would appear that when the underground conformation is such as to pond, or enclose the subsoil water, as it were, in a dish, so that it is rendered stagnant, the unhealthiness is very considerably accentuated. In many river valleys there is a good bed of gravel on the surface, and although the underground water is not far from the surface, yet with proper precautions the site is healthy, because the underground water is not stagnant, but is continuously though slowly moving with a defined current in the direction of its natural outlet.

Marshy and alluvial soils (the latter to be found near the estuaries of rivers) should be avoided on account of their dampness and the impurity of their ground air. Containing as they do much vegetable organic matter, which is in a continual state of change and fermentation, they are credited with the production of malarious diseases and rheumatism, and are not fit sites for human habitations.

It is needless to observe that houses should never be chosen to live in which are believed to have been erected upon excavations filled in with refuse and rubbish, or upon the sites of disused burial grounds.

Clayey soils are colder and damper than gravel and sand of considerable depth. They are cold because less absorbent of heat, and damp because they are impervious to a considerable extent, and yet retentive of moisture.

Chalk, when of considerable thickness, is usually very dry, but being little absorbent of heat is cold.

Mixtures of these soils, and other varieties of soil, are cold or warm, dry or damp, more or less, according to their absorptive powers for both heat and water; but rocks which, like granite and slate, are quite impermeable to water, are of course only affected by heat and the rays of the sun, and are uninfluenced by moisture.

Those who suffer from catarrhs, bronchitis, rheumatism, or other diseases attributed to cold and damp, should choose dry, warm soils to live upon. To many people, however, soils which are warm and dry prove too relaxing, especially in summer, and better health is enjoyed on a more bracing soil.

It is difficult to say why some localities are *bracing* and others *relaxing*, these qualities no doubt depending very largely upon different circumstances in different places and at different seasons of the year. As a general rule it may be stated that places which are considerably elevated, which are exposed to winds from the north and east, and of which the soil is cold, are bracing; whilst those which are sheltered from the north and east, which are low-lying, and stand upon thick beds of gravel or sand, are relaxing.

It is, then, to a considerable extent a question of cold and heat. Cold is bracing and invigorating all over the world; heat is relaxing and enervating. In summer the bracing places on the east and north-east coast are most sought; and such places as possess a dry and sandy soil, which becomes much heated by the sun, rendering the air over-hot, too dry, and enervating, are avoided. In the winter the warm dry soils of the south coast, with their shelter from cold winds and their exposure to the south and the sun, are the resorts of those in search of health and pleasure.

What is healthful and desirable in the hot season is not equally so in the cold months of the year. High elevations, bleakness of site, and exposure to cold and wet winds are often trying in winter, even to the robust; whilst in hot weather such places are healthful and restorative for the weak and debilitated.

For a house which is intended to be used as a residence all the year round, it is generally advisable to choose such a situation as will afford the happy medium between the extremes. If a south aspect sheltered from the north by rising ground, cliffs, or trees is chosen, and the soil is sandy or gravelly, it is usually advisable to cultivate trees and vegetation to temper the summer heat. Vegetation and herbage protect the soil from the sun's rays, and cool the air by the evaporation of moisture from green leaves.

On cold and damp soils trees and vegetation are less necessary, except as a protection from cold winds. It is certainly not advisable in any case to have trees so close to the house as to interfere with the free circulation of air around it. Where there is excessive moisture in the soil, vegetation is of use in evaporating large quantities of water and so drying it; but where the ground is cold and not damp, absence of vegetation and exposure to the sun is most effective in warming the surface, and so avoiding extremes of temperature.

The immediate proximity of ponds and lakes should be avoided, as such collections of stagnant water are apt to render the air in the neighbourhood of a house unduly cold and moist at certain seasons of the year.

A situation on a slope is generally considered advantageous, favouring as it does natural drainage both on the surface and in the subsoil. Elevation above the surrounding country is also considered an attractive quality, as it gives an extended view, and ensures as a rule purity of air.

CHAPTER VIII

FOOD

Classification of foods—Composition of foods—Animal and vegetable diets—Digestibility of various foods—Cooking—Variety and admixture—Meal-times—Appetite: mastication of food—Excessive meals—The digestive process—Soups, broths, and jellies — Meat, fish, tinned foods — Oysters, eggs — Milk: Mother's milk and cow's milk, Suckling and hand-feeding, Infants' foods, Sterilisation of milk, Storage of milk—Butter and cheese—Bread—Farinaceous foods—Fresh vegetables and fruits—Condiments—Alcoholic beverages: Malt liquors, Wines, Spirits—Tea, coffee, and cocoa—Mineral waters.

Food is necessary to repair the wasted tissues of the body, and to enable growth to go on during the period of immaturity and development.

There are six chief classes of food, namely, *Proteids, Fats, Starches and Sugars, Vegetable Acids, Mineral Salts,* and *Water.*

All these six different food substances should be adequately represented in the diet of man, and inasmuch as no one food contains all the substances in the proper proportions, a variety of different kinds of food is for this reason alone a necessity. Hence the proper diet of man is essentially a "mixed diet."

The proteids are the only food substances containing nitrogen, and as this element enters into the constitution of every tissue of the body, and some of it is excreted daily as a waste product of the wear and tear of the tissues, it follows that a certain proportion of nitrogen-containing food must be given in the diet, to repair the bodily waste. Until growth is completed, nitrogenous foods have another function besides that of repair, namely, the formation of new or additional tissue, and the gradual evolution of the mature and perfected structure from its immature and imperfect condition.

The proteids are contained in both animal and vegetable foods. The flesh or muscles and the blood of animals contain albumen, fibrin, syntonin, myosin, and globulin; whilst milk contains casein, and the white of an egg is nearly pure albumen: all these substances belonging to the class of proteids. Vegetable foods also contain proteids: thus gluten exists in wheat, barley, maize, oats, and rye flour; and legumin is found in peas and beans—both gluten and legumin being nitrogenous substances.

It is a remarkable fact that all these different members of the proteid class are of nearly equal nutritive value, and therefore mutually replaceable in the diet of man.

The fats of a diet are derived almost entirely from animal sources—from the fat of meat (dripping) and from the fat of milk (butter). Fats are necessary to repair and build up the fatty tissues of the body, to yield energy for mechanical labour, and to keep up the bodily temperature. The yielding of energy and the maintenance of the bodily temperature are brought about by the oxidation of the fatty food, and its conversion into carbonic acid and water.

The sugars and starches, which are derived chiefly from the vegetable kingdom, have similar functions in the body to the fats. They therefore serve, like the fats, as fuel for the body, in much the same way as coal does for the steam-engine. Although their functions are more or less identical, fats are not replaceable in the diet by starches or sugars, nor starches and sugars by fats.

The vegetable acids exist in fresh vegetables, fruit, meat, and milk—chiefly in the two former,—but not in these articles when dried or preserved in tins. They are important constituents in a diet, as in their absence the health suffers and scurvy eventually results.

The mineral salts are contained in nearly all animal and vegetable foods in a greater or less degree. They are essential for the repair, growth, and maintenance of all the various tissues of the body.

Water enters into the constitution of all the so-called solid foods, but must be taken as well separately as a drink, as the amount contained in the solid foods is insufficient for the needs of the body. The body is constantly losing water, exhaled in the breath and excreted in the sweat, urine, and fæces, and these daily losses must be made good. Water is the vehicle for the dilution and solution of the solid foods in the alimentary canal, and is necessary for the elimination from the body of most of its waste products.

The following table shows the percentage composition of some of the chief articles of food in ordinary use.

In 100 *parts.*

	Water.	Proteids.	Fats.	Starches and Sugars.	Salts.
Cooked Meat . . .	54	27 5	15·5	—	3
White Fish . . .	78	18	3	—	1
Bread (fine, white, wheaten)	36	7	0 5	55·2	1
Oatmeal	15	12·6	5·6	63	3
Peas (dry) . . .	15	22	2	53	2·4
Potatoes	74	2	0·16	21	1
Butter	6	3·3	88	—	2·7
Cheese	36·8	33·5	24·3	—	5·4
Milk (cow's) . . .	87·5	3·4	3·6	4·8	0·7
Egg (without shell) . .	74·5	12·5	12	—	1

For a man engaged in ordinary work the daily diet should contain—

Proteids . . .	4·5	oz. av.
Fat	3·5	,,
Starches and sugars .	14·0	,,
Salts	1·0	,,
	23·0	

That is to say, 23 ounces of dry, solid (water-free) food must be taken every day to enable the work of the body to be properly performed.

Inasmuch as ordinary food contains from 50 to 60 per cent. of water, the 23 ounces must be multiplied at least by 2, if the diet is to be stated as ordinary food (not water-free). And from 50 to 70 fluid ounces (2½ to 3½ pints) of water must in addition be drunk to supply the needed quantity. This quantity will of course vary with the amount and nature of the exertion, and the temperature and moisture of the atmosphere. During arduous exertion in a hot climate very large quantities of water may be needed.

As before stated, all the different classes of food substance should be adequately represented in a diet; and it is certainly a matter for congratulation that the costliness of the various kinds of food bears no very great proportion to their nutritive values, otherwise the poorer wage-earning classes would be unable to supply their wants, and would be in a continual state of semi-starvation. The vegetable foods, bulk for bulk, are far cheaper than the animal foods, but the proteid substances they contain, although smaller relatively in amount, are just as capable of maintaining life as the proteids of the higher-priced butcher's meat, fish, game, and eggs. The diet of the lower wage-earning classes is largely composed of wheaten bread, potatoes, dripping, cheese, and occasionally bacon or the cheaper kinds of butcher's meat. Taking bread, potatoes, dripping or margarine, and cheese alone, we see that a daily consumption of bread 2 pounds, potatoes $\frac{1}{2}$ pound, dripping or margarine 2 ounces, and cheese 8 ounces, would provide the labourer with nearly 5 ounces of proteids, $3\frac{3}{4}$ ounces of fat, nearly 20 ounces of starches, and nearly 1 ounce of mineral salts. The cost of this daily food with bread at 5d. the 4-pound loaf, potatoes at 1d. per pound, margarine or dripping at 8d. per pound, and cheese at 6d. per pound, would amount to 7d.

A diet of this character might be suitable for an agricultural labourer, whose entire day is spent in laborious work in the open air, and whose digestive powers are of the keenest, but would prove very distasteful to the town mechanic, the factory hand, or the person engaged in any sedentary indoor occupation. Not less important than the theoretical nutritive value of the food is its capacity for easy digestion and assimilation in the alimentary canal; and there can be no doubt that the diet above given would be of little real value to the class of town mechanics and factory operatives on account of its want of variety, its sameness, and monotony.

Putting aside the state of health of the individual in its bearing upon the processes of digestion, the digestibility of food depends partly upon the nature of the food in its raw state, partly upon the effect produced upon the food by the operation of cooking, and to some extent upon its admixture with other foods and accessories.

In the first place the proteids derived from the animal kingdom are more completely digested than those obtained from the vegetable, although it does not follow that the vegetable proteids—such as may be capable of digestion—give more work to the digestive organs than the animal proteids do. It is no doubt, however, the fact that animal fats are more easily digested than vegetable fats. The fat of cocoa, for instance, is much less easily digested than the fat of butter.

The flesh of different kinds of animals varies in the rapidity with which it is digested, and probably also in its capacity for easy digestion.

Figures are sometimes given of the number of hours various kinds of food remain in the stomach before passing into the small intestine. No great reliance can be placed upon these figures as being capable of general application, inasmuch as the experiments have been limited in number, the observations being necessarily only possible in the case of gastric fistulæ in man—a gastric fistula being an artificial opening into the stomach through the abdominal walls, by which its interior can be examined. These experiments show that veal and pork remain longer in the stomach (over 4 hours) than mutton or beef (3 to 4 hours); and this coincides with the everyday experience of the comparative indigestibility of pork.

Cooking is necessary to increase the digestibility, palatibility, and appetising qualities of the food, and to destroy parasites or noxious microbes that may be present. The various kinds of starchy foods such as potatoes, wheat flour, rice, peas, &c., are extremely indigestible in an uncooked condition. These starchy foods consist of minute grains, each grain having an outside coating of cellulose protecting the starch within. The cellulose coat is comparatively unaffected by the digestive juices, but when heated to a sufficient degree in the process of cooking the cellulose envelope bursts open and the digestible starch within is set free. Most vegetable foods gain weight in the process of cooking by absorbing water.

Animal foods taken raw are little less digestible than when well cooked, and are more digestible than when badly cooked. But cooking renders meat more savoury, various aromatic vapours being generated which are distinctly appetising, and the warmth of recently cooked food is also an advantage and an aid to digestion, not to mention the destruction of possibly existing parasites and noxious germs. Animal foods lose weight in cooking owing to the loss of moisture they sustain.

If meat is cooked too long or at too high a temperature it becomes hard, tough, and indigestible. Most of the proteids in meat—fluid or semi-fluid in raw meat—coagulate or solidify between the temperature of 155° F. to 165° F. and in so doing they render the meat fibres hard and solid, whilst the juices escape, with the result that the food becomes dried up, tough, and indigestible. In cooking joints of meat, whether by roasting, baking, or boiling, the primary object is to rapidly coagulate the outside of the joint by submitting it to a high temperature for a few minutes, and so by forming an external protective coating prevent the undue escape of the internal juices and thus leave the interior of the joint in a semi-coagulated state, the remainder of the cooking being conducted at a temperature insufficient to cause the interior of the joint to rise above 155° F.—the coagulation point of the proteids. During the process of cooking, the connective tissue between the bundles of muscular fibres is broken down and converted into gelatine, which escapes in a liquid condition with melted fat, and some of the salts of the meat, to form the gravy. This destruction of the connective tissue loosens the fibres of the meat from each other, and renders it more easy to chew and masticate in the mouth.

The admixture of different classes of foods greatly aids their digestibility. The common custom of eating meat with vegetables and bread is a sound one. If meat was eaten at one meal and vegetables alone at another, the digestive powers would be much more severely taxed. The various food accessories and condiments also have an important effect upon digestion, chiefly by stimulating the flow of saliva and gastric juice.

We have seen that man should live upon a mixed diet, consisting of proteids, fats, starches and sugars, vegetable acids, salts, and water in certain definite amounts and proportions. The weighing of definite quantities of foods, and the apportionment of definite weights of the chief foods daily to each individual, is not usually undertaken outside barracks, prisons, and public institutions, nor is it necessary in ordinary households. Amongst the poor the question of meals is chiefly one of expense, whilst with the better-to-do classes it must be chiefly one of convenience and appetite.

In order that the full benefit of food may be obtained, it is important that judicious selection of the articles of diet should be made, that they should be carefully cooked or otherwise prepared for the table, that the admixture of different kinds of food should be judicious, and that the meals be taken regularly, at intervals not too far apart for the proper recuperation of the frame and the maintenance of the highest degree of energy, but not so short as to involve too great a strain upon the digestive organs, by reason of these organs being kept in a continual state of activity. The individual can exert great influence upon his digestion of the food by the cultivation of appetite, by the proper mastication and trituration of the food in the mouth, by avoidance of excess in quantity, and by abstaining from food which is too rich, highly spiced, or otherwise undesirable in quality, and by the avoidance of very active exertion, bodily or mental, immediately after meal-times.

At every meal there should be a proper admixture of proteids, fats, starches, aud sugars. The customs of civilised society ensure this principle being put into practice; mixed food, such as bread, butter, eggs, milk, meat, vegetables, &c.,

being almost invariably associated, to a greater or less extent, at every meal. In addition to this, there should also be a certain amount of daily change and variety to obviate the distaste that is likely to arise when there is too much sameness and monotony in the articles of food offered to the palate. Bread, butter, and milk are daily indispensables, but it is not difficult to secure the desired variety by changes of meat, vegetables, and fish, the different kinds offering a large variety of choice.

Most important of all is the proper cooking and preparation of food. It is undoubtedly true that a good cook with limited resources and cheap articles of food can prepare a more appetising and digestible meal than a bad cook can with the best appliances and the most costly fare. The teaching of cookery on sound principles is now very rightly engaging a good deal of public attention, and forms a part of most technical education courses.

The number of meals each day, and the times at which they should be taken, must next engage our attention. As an average, it may be said that three meals a day is the right number for adults. Allowing eight hours for sleep, there will be sixteen waking hours in the day. If the first meal, or breakfast, is taken at the end of the first waking hour, the next meal, dinner or lunch, need not be taken until five hours after breakfast, and the final meal, supper or dinner, as the case may be, not for five or six hours later.

This allows a period for digestion of five hours between every meal; and inasmuch as there is no certainty that the food of one meal has evacuated the stomach until four or four and a half hours has elapsed after its ingestion, it is evident that five hours is by no means too long a time to allow to intervene between consecutive meals. For it is certainly not desirable to introduce fresh food into the stomach until the stomachic digestion of the preceding meal is completed, and the stomach is left in a condition favorable for the reception of fresh food.

For the man who gains his living by the work of his muscles, the midday meal should be the principal one. For the brain-worker, however, the evening meal is generally chosen as the chief meal, or dinner; and there is much to be said in favour of an arrangement which allows of digestion being carried on during hours of relaxation. If the evening meal is deferred to too late an hour, the result is not so satisfactory, for during sleep the digestive processes are more or less in abeyance, and the retention of incompletely digested food in the stomach gives rise to dyspepsia and troubled sleep.

For children, growing youths and girls, and delicate persons, four meals a day are often to be preferred to the three meals, a lesser quantity being taken at each meal to counterbalance the greater frequency.

The cultivation of appetite is more or less within the power of the individual. Want of appetite may be due to bodily illness requiring medical treatment, with which we are not here concerned. But in otherwise healthy people, a deficient appetite may be due to want of proper exercise in the open air. Where there is little muscular energy there is but little waste of tissue, and the call of the tissues for repairing food is but little felt. Again, the blood may be deficiently aërated from want of fresh air and exercise; and when in this condition its function of removing waste products from the tissues, and supplying them with nutriment for their repair, is but inefficiently performed, and the failure of the appetite is but the index of the unhealthy condition of the system. Loss of appetite may also be consequent upon over-fatigue, mental or bodily, and too long or too short intervals between meals. All these are matters usually capable of adjustment, if their importance is only understood; and that they are important is readily comprehended when we know that loss of appetite means impaired digestion and defective nutrition of all parts of the body.

The proper chewing of the food is also an important element in digestion. The object of mastication is to break up the food into small fragments, of which the component parts are easily separated, and to allow of these becoming thoroughly incorporated with saliva. The small, loosely adhering fragments are readily attacked by the gastric juice when passed into the stomach, whilst the alkaline saliva induces the flow of the acid gastric juice. To swallow or "bolt" large fragments of food which have not been masticated, is to introduce that which cannot be acted upon by the gastric juice, and which becomes instead the prey of putrefactive microbes, undergoing in time fermentative changes, with the production of foul gases—setting up in fact acidity, flatuence, gastric pain, and other symptoms of digestive disturbance.

A meal excessive in quantity may produce similar results. If more food is taken than the stomach can conveniently digest, the excess is unacted upon by the digestive juices, and is liable to undergo fermentation and cause irritation to the stomach and intestines. An excess of any one constituent of the meal may lead to similar results, *e. g.* an excess of starches or sugars, which are very readily acted upon by bacterial ferments, or an excess of fat, which rapidly decomposes into fatty acids. A diet which is habitually too rich in proteids, as in the case of excessive meat eaters, tends to produce troubles of its own. The kidneys become overtaxed in getting rid of the excess of nitrogenous waste, the blood is imperfectly purified, containing waste substances which the excretory organs are incapable of sufficiently removing from it, and liver disease, gout, and other troubles follow.

The question of the number of times a day meat should be eaten does not admit of a dogmatic answer. As a rule the wealthier classes eat too much meat at a time, and eat it too often. There are many who, after reaching middle age, would be better in health for limiting themselves to a meat meal twice a day. But no rule for universal guidance can be laid down. The tendency towards over-indulgence in eating is directly fostered amongst the wealthier classes by the large use made in cooking the food of spices, sauces, and condiments. Dishes so prepared create an artificial appetite, which is not sated when enough food has been eaten to satisfy the wants of the body—as would be the case with a natural, healthy appetite. The diversity of food also, and the excellence of the cooking which prevails in wealthy households, lead similarly in the direction of excess. It cannot be too strongly stated that food of a simple character, well cooked, and cleanly served, is more productive of healthy living than abundance of dishes, and piquant sauces which create a craving for food in excess of the bodily needs.

During the process of digestion in its earlier stages, the blood-supply to the digestive organs is largely increased. Any special activity of a bodily organ leads to an increased demand for blood, and its consequent supply. Hence the importance of rest, or at least of the avoidance of very active bodily or mental exertion subsequent to a good meal. If the muscles or the nervous system are very actively employed during the digestive process, blood is withdrawn from the digestive organs, in consequence of the increased demand for blood for the muscles and brain. The digestive process in consequence is hindered, delayed, or actually arrested, with the result that fermentative changes take place in the food instead of the normal digestive changes.

It cannot be too clearly comprehended that all food which is introduced into the stomach must be properly digested, otherwise dyspeptic troubles arise. Food which from any of the various reasons we have been considering does not undergo normal digestion, becomes subjected to the action of the putrefactive and fermentative microbes present in all parts of the alimentary tract. The fermentation of the food in the stomach and intestines is incompatible with a normal state of health; and if such fermentative action is continually supervening, changes of structure are at length induced in the secreting glands and the mucous menbrane lining the alimentary canal, which constitute actual organic disease.

Large quantities of water or other fluids should not be consumed during the progress of a meal. It is not desirable to dilute the gastric juice in the stomach to too great an extent, or to chill that organ with a large volume of cold liquid. Thirst should be relieved half an hour before the commencement of a meal; the water so introduced will have been absorbed into the blood before the food reaches the stomach.

There is no objection, but generally some advantage, in the taking of a small quantity of hot soup or broth before the heavier viands are attacked. Soups and broths contain gelatine, salts, and extractives from meat and bones, and certain aromatic products. They are, therefore, food-accessories, the extractives and aromatic products also tending to stimulate the appetite, and promote the flow of gastric juice.

Bones are rich in gelatine, fat, and salts, and are far too valuable, as producers of broth and soup, to be thrown away. Gelatine is a proteid, but is not the nutritive equal of the other members of the proteid class, as it cannot form nitrogenous tissues. It may, however, prevent excessive tissue waste, and is useful on this account in the dietetic treatment of fevers, where excessive tissue waste is in progress. Jellies largely consist of gelatine. It must be clearly understood, however, that jellies, beef tea, broths, and soups are not foods of any considerable value. They cannot build up new tissues or repair wasted tissues. They are chiefly valuable in the dietary of sickness as stimulants of digestion, enabling other foods of more constructive quality to be assimilated.

In making beef tea, broth, or soup, the meat used must be chopped into small pieces, and covered with cold water, with the addition of some salt. The heat should be applied very gradually and steadily, and the water never allowed to boil, in order to avoid the coagulation of the proteids, which would prevent the passage of extractives, salts, gelatine, and fat into the liquid, which is the object aimed at.

Meat.—Immediately after the death of an animal, the proteid body known as myosin, of which the muscles are chiefly composed, coagulates, this coagulation being known as rigor mortis. After a time, the length of which depends somewhat on the weather, the myosin again becomes soft and semi-fluid, and the meat is more fit for cooking. Meat as obtained at the butcher's has often been derived from an animal only recently killed, hence the necessity for "hanging," which should be done in a dry, clean, and airy larder. The hanging must of course be terminated before the development of any putrefactive taint. A joint of butcher's meat (beef or mutton) should be firm, elastic, and of a deep red colour on section—not too pale, and yet not purple or livid. Veal and pork are much paler than beef and mutton. The odour should be fresh, and not unpleasant, and there should be no taint of putrefaction. The joint should be free from excess of moisture, but in certain states of the weather even good meat is apt to drip with a reddish-coloured fluid.

Frozen meat should be thoroughly thawed for a day or longer before it is cooked. It takes a considerable time for the interior of a large frozen joint to thaw. If the meat is cooked before it is thoroughly thawed, the result is never satisfactory.

Meat should be cooked as thoroughly as possible in order to destroy any noxious organisms or poisonous substances it may contain, but, as before said, the cooking should not be carried to the point of rendering the meat tough and indigestible. Pork especially should be thoroughly well cooked. "Measles" is not an uncommon disorder in pigs, and unless the *cysticerci* (the little cystic bodies found in measly pork) are destroyed by heat, they may cause tapeworm in anyone who consumes them. It is a usual rule to allow at least a quarter of an hour in cooking for every pound that the joint weighs.

An important essential in all cooking operations where an oven is used, is the proper ventilation of the oven. If the oven is not ventilated, the meat becomes sodden in its own vapours, and is disagreeable to the taste. Gas cooking ovens are very cleanly and convenient, and their temperature can be regulated with great nicety by adjusting the consumption of gas; but it is most essential that the oven should be ventilated, otherwise the meat becomes impregnated with the products of the gas consumption, and decidedly injurious. There should be a flue attached to the oven to carry off these products to the outer air. With these precautions there is no perceptible difference between a joint baked in a gas oven, and one roasted before an open fire.

Tinned meats are useful supplements to butcher's meat. Great care should always be taken to reject any kind of canned or tinned provision which, on opening the tin, evolves a disagreeable or suspicious odour. Very serious poisoning effects have followed the consumption of tainted food of this character. It must also be remembered that these preserved foods do not contain any of those antiscorbutic principles which afford protection from scurvy, and which are present more or less in all classes of fresh meat, fish, and vegetables.

Fish, unlike meat, unless cured or dried, should always be eaten as fresh as possible. Tainted fish often produces severe poisonous effects. The oily fishes like herring, mackerel, salmon, and eel, are less digestible than the non-fatty fish, *e.g.* soles, plaice, cod, turbot, and brill, which are highly digestible forms of food.

Most kinds of *game* may be eaten with impunity when they have become "high," or, in other words, passed into an incipient state of putrefaction.

It must not be too confidently assumed that cooking will make tainted butcher's meat or fish harmless. It would appear that often the processes of cooking are unable to render such food edible, the poisonous bodies which have been formed in the flesh not being destroyed by the heat of cooking. Poisonous alkaloidal substances may be present in the flesh of diseased animals, and may not be rendered innocuous when such flesh is cooked. It is also believed that the unwholesomeness of certain kinds of meat and fish, which are out of season, may be due to alkaloidal poisons.

It is not always just to lay the blame for illness attributed to food upon the tradesman who supplies it. Uncleanliness in the kitchen may be productive of unwholesomely prepared food. Especial care should be bestowed on the cleanliness of cooking utensils made of copper. Verdigris—an oxide of copper—is very apt to form unless brightly polished surfaces are constantly maintained. The same remarks may be held to apply to tinned cooking utensils.

Oysters and some other varieties of shell-fish are usually eaten raw. Oysters, having relatively to their size very large livers, are largely composed of glycogen or liver starch, which is highly digestible. They form, therefore, a valuable food for invalids and people of feeble digestive powers.

There is some risk, however, in the consumption of raw oysters, as these shell-fish are frequently cultivated in water which receives sewage and human excrement. It is asserted that oysters fatten best in sewage-polluted waters, so that it may be much to the interest of the oyster-farmer, who wants to send his produce to the market in the primest condition, to fatten his fish on what probably, being a waste product, costs him nothing.

Reliable evidence has of late accumulated as to the infection of typhoid fever having been communicated by oysters, or at any rate by consumption of the polluted water contained within the oyster's shell.

With such considerations in view it would appear to be a wise precaution to cook oysters before sending them to table. Oyster epicures, who may consider their favourite dish spoilt by cooking, should at any rate submit to the oyster being taken out of its shell and well washed in clean water before consumption.

Eggs are highly nutritious. Hens' eggs contain about 12 per cent. of proteids, and the same quantity of fat. This fat is contained in the yolk of the egg, whilst the white of the egg is nearly pure albumen (proteid). Eggs are most digestible when perfectly fresh and lightly boiled. In a hard-boiled egg the albumen of the white is strongly coagulated, and less easily attacked by the digestive juices than is the partially coagulated albumen of a lightly boiled egg.

Milk is the natural food of infants and young children. For the first six or nine months of life the infant thrives best on its mother's milk; subsequent to this period cow's milk answers every purpose.

The compositions of human and cow's milk are as follows:

	Average Percentage Composition by weight. Human milk.	Cow's milk.
Fat	2·9	3·5
Proteids	3·0	4·9
Milk sugar	5·9	4·0
Salts	0·2	0·7
Total solids	12·0	13·1
Water	88·0	86·9

In all the milks secreted by different mammalian animals, the proteids, fats, salts, and water exist proportionally in much larger amount, as compared with the starches and sugars, than is the case in the ordinary food of the adult animal. The reason is that the proteids, fats, and salts are required in large amounts for the rapid growth of the body, whilst the water is necessary in equally large amount for the quick formation of tissue, and for the rapid removal from the body of waste products.

It will be seen from the above table that the composition of cow's milk is different from that of human milk. There is an excess of proteids, fat, and salts, and a deficiency of milk sugar in the former as compared with the latter. This is one reason why cow's milk is unsuitable for infants. There are, however, two other weighty reasons.

Firstly, the curd which is formed in the infant's stomach by admixture of the milk with the acid gastric juice, is quite different in the case of cow's milk from that characteristic of human milk. The curd of human milk forms a flocculent mass, the particles of which being loosely held together are readily attacked by the digestive juices; whilst cow's milk clots in dense putty-like masses, which are with difficulty digested. The curd consists of the proteid and fat of the milk, and therefore contains its most nutritive properties. The undigested curd of cow's milk gives rise to fermentative changes, flatulence, and gastric pain, and much of it may be passed unchanged in the motions. The child vomits curdled milk, and has constant diarrhœa, and although taking plenty of nourishment fails to thrive.

Secondly, human milk drawn from the mother's breast by the sucking child is sterile and free from any form of microbe life; whilst the hand-fed child usually draws its milk from a dirty feeding-bottle, the milk containing microbes and ferments, which hinder proper digestion, and are all too liable to set up mischief in the infant's delicate organs.

Ass's and mare's milk are much more nearly identical in composition with human milk than is the cow's secretion. Goat's milk is rather too rich in fats, but ass's, mare's, and goat's milk are all superior to cow's milk for the human infant, inasmuch as they form a loose, flocculent, and digestible curd in the infant's stomach.

Suckling for the first six months is not only best for the infant, but as a general rule for the mother as well. Suckling beyond the ninth month is usually disadvantageous to both—the mother's health becomes weakened by the prolonged drain upon her strength, and the child requires after this period somewhat stronger sustenance.

If an infant must be hand-fed, the cow's milk should be boiled, to destroy noxious microbes; it should be diluted with water, and should receive an addition of milk sugar to make its composition approximate more closely to mother's milk. It should be given in a cleansed and scalded bottle without internal tubes or other parts difficult to clean. The old-fashioned boot-shaped bottle is far preferable to the more modern one with a tube. To obviate, as far as may be, the formation of putty-like curds in the infant's stomach, some pearl barley water, well boiled and strained, should be added to the milk in the bottle. The gum-like substance in the barley water has the mechanical effect of preventing the particles of curd coming into too close apposition, and the curd thus formed is looser and more easily broken up than when the cow's milk is given alone.

The mother or nurse should never forget to warm the contents of the feeding bottle to the temperature of the child's body—98° F.

Some of the larger dairy companies now retail a so-called "humanised" milk, artificially prepared to resemble human milk in its composition. This is sterilised by heat, and sold in sealed bottles.

Infants and children should never be fed exclusively upon condensed milk, infant's foods, or other preserved articles. Infantile scurvy—a very dangerous disease—is likely to follow the use of a diet in which fresh food has no part. These preserved foods are deficient in the vegetable acids which are contained in new milk, and which are as essential for the maintenance of health in the young as in the adult. Many of the condensed milks, besides, are very deficient in fat, being made from "separated," that is, "skimmed" milk. They contain, too, as a rule, far too muchsugar. "Separated," "skimmed," or "butter-milk," means in its application to milk, the withdrawal of the whole or the greater part of the fat. Such milk, deprived of its cream or fat, cannot supply to a child the nourishment it needs.

Sterilised milk is now being supplied for nursery use. The process of heat sterilisation tends to cause the milk to separate into curds and whey;

and besides, such milk may have been prepared at a date long anterior to its use, and is in consequence no longer "fresh." It would appear to be better that milk should be boiled in the house immediately after its delivery, and then be consumed without delay. The importance of giving children fresh food cannot be over-estimated.

Milk is still far too largely consumed in an unboiled condition. Most people have heard of milk epidemics of diphtheria, scarlet fever, and typhoid fever, and yet the simple precaution of boiling the milk, and so destroying any possible germs of disease it may contain, is very generally neglected. There is not only the occasional risk of epidemic disease, but the ever-present possibility of the mixed milk of numerous cows containing the *bacillus of tubercle.*

Tubercular disease is comparatively a common illness of dairy stall-fed cows; and the milk of animals so suffering may contain the germ which is now regarded as the originator of the mischief. The susceptibility of children to tubercular disease in the abdominal organs is now recognised, and the death registers show that these diseases, commonly called "consumption of the bowels," cause a large mortality under the age of five years, but the public at large has shown but little disposition to avail itself of the simple precautions which this knowledge indicates as necessary.

Milk which has become sour, curdles, and is no longer in this state a fit food for children. The souring of the milk is due to the growth of a bacterium in it, which changes the milk-sugar into lactic acid, and this acid causes the milk to curdle. The bacterium is present in the air of dairies and larders, and sets up this fermentative change the more rapidly the higher the temperature of the air and of the milk. Hence the necessity for rapidly cooling milk after it is withdrawn from the cow, and also for maintaining dairies and larders at as low a temperature as possible in warm weather.

The curdling of the milk in the stomach is in part due to the acid of the gastric juice, and in part to the presence of a ferment. In some people milk always causes indigestion. For these, the milk should be curdled before being consumed, so as to save the stomach the curdling operation which causes the disagreement. A few drops of acetic acid, or the addition of a little rennet (a preparation of the gastric mucous membrane of the calf) to the warmed milk, causes the milk to separate into curds (proteids and fat) and whey (milk-sugar, salts, and water). By mixing together the curds and whey, and adding a little salt and pepper, a dish is prepared which, while extremely digestible, retains every one of the nourishing constituents of the milk.

When milk is stored in dairies, most of the cream or fat rises to the top and floats on the milk within six hours of the vessel being at rest. If the milk is not thoroughly stirred up before being withdrawn from the vessel, that which is taken off the top will contain the bulk of the cream, whilst that withdrawn from the bottom contains very little.

It is of the very greatest importance that dairies or other places used for the reception and storage of milk should be clean and dry, and perfectly secure against the entrance of air from drains, soil-pipes, cesspools, and privies. It should be an invariable rule that there should be no drain under a dairy, and no drain opening, trap, or gully inside it. Milk is very absorptive of foul gases and vapours, and affords besides an ideal breeding-place for germs of all descriptions, as it contains all the essential requisites for the nourishment of animal life. There can be little doubt that noxious germs, which have once gained access to milk, proceed at once to grow and multiply, producing in the short space of a few hours countless organisms for each individual microbe introduced. Infected or contaminated milk is therefore likely to have its powers of doing harm increased for every hour that elapses after it has been delivered. Although boiling the milk sterilises it, yet this sterile milk should not be stored for long, as, if kept in a close or foul atmosphere, the germs which gain access to it multiply at a rate even in excess of that which is usual in unboiled milk.

It has lately become a custom in the milk trade for the farmer or dairyman to add small quantities of antiseptic substances to their milk, to preserve it from fermentative changes, and enable stale milk to be sold as "new." These antiseptics are borax, salicylic acid, and boro-glyceride. Although the use of such milk preservatives is practically in many cases a fraud upon the consumer, there is no evidence that they cause, in the small quantities only which are necessary, any damage to the health of the dairyman's customers.

Butter is made from the cream of milk. It contains on an average 83 per cent. of the most digestible of all animal fats. Margarine, oleo-margarine, or butterine is prepared from beef suet or fat. It is given the flavour of butter by churning it with milk, and the yellow colour of butter by the addition of a colouring agent—annatto. This form of fat is nourishing and digestible, but less appetising than good fresh butter. The price, however, should only be half that of the genuine article.

In rancid butter the fat has commenced to undergo fermentative change, with the production of fatty acids, which render the butter indigestible and unsuitable as a food. The flavour of rancid butter being exceedingly disagreeable, it is not often consumed alone, but cheap pastry is very commonly made from flour and rancid butter, and stale eggs are used in the manufacture of cakes.

Light and well-made *pastry* is not indigestible, but pastry made "with a heavy hand" is notoriously so, probably from the starch cells of the flour being in such a condition as to resist the action of the digestive juices.

Cheese is another dairy product, being prepared from the curd of milk, which is obtained by the addition of rennet to milk at a suitable temperature, Cheese is most nutritious, but not very digestible. As a general rule, foods which contain a large quantity of nutriment concentrated into a very small bulk are not very digestible. The cheeses which are richest in fat are, as a rule, the highest priced, although a new industry has lately sprung up of making cheeses rich in fat by the addition of beef suet, such cheeses being sold at a low price.

Bread in this country is made from wheat flour, by mixing with it water, yeast, and a little salt until a consistent dough is formed. The lump of dough is placed before a hot fire to allow the yeast to ferment. In this fermentation the yeast plant attacks the starch, some of which is converted into sugar, and this again is split up into alcohol and carbonic acid gas. The alcohol altogether escapes, but the carbonic acid gas is prevented from doing so by the coherent nature of the dough. The gas, in consequence, forms for itself little cellular spaces in the substance of the dough, which gives the bread its proper spongy structure. The loaf is then placed in the oven and baked by heat. The heat destroys any yeast remaining in the loaf, and thus prevents any possibility of fermentation continuing in the finished loaf, which would cause sourness and acidity.

In aërated bread the loaf is made spongy by the forcing of specially prepared carbonic acid gas through the dough.

White bread is prepared from the flour, white in colour and fine in texture, which results from the separation from the wheat grain of all its outer envelopes. Brown bread and whole-meal bread are prepared from the whole or nearly whole wheat grain. The outer envelopes of the wheat grain are rich in proteids, fat, and salts, but being somewhat hard and horny are not easily digested.

It is not yet settled that whole-meal bread is more nourishing than ordinary white bread. The poorest classes, indeed, to whom bread is in reality the staff of life, prefer the whitest bread obtainable; and it may well be that such bread contains the largest amount of assimilable nourishment. Evidence of want of cleanliness on the part of the baker is also more readily forthcoming in the white loaf than in the brown.

Brown and whole-meal bread, on the other hand, are useful articles of diet to the wealthier classes, on account of their laxative effect upon the bowels. The food of this class of people is often so highly digestible as to leave but little residue in the large intestines, with the result of engendering hard, scanty, tenacious fæces, which are with difficulty ejected. The branny particles in whole-meal bread set up a certain amount of irritation in the lower intestines, and, increasing the intestinal secretion, promote the proper evacuation of the bowels.

There is little or no adulteration of bread at the present time, wheat being so very cheap. Even alum—an adulterant used to cause extra whiteness in the loaf, and permit the use of inferior flour—is but rarely detected now-a-days. Baking powders, used to generate carbonic acid gas, and cause dough to rise, are sometimes made with alum; but it is doubtful if alum, unless present in considerable quantity, is able to influence health adversely.

New bread, just extracted from the oven, is usually considered to be less digestible than stale bread, probably because it crumbles less in the mouth than stale bread, and so is less subjected to the action of the saliva. In the stale loaf a considerable amount of the moisture of the new loaf has been lost by evaporation. It is probably the fact that, as baking is carried out in this country, the interior of a large four-pound quartern loaf is not completely sterilised by the heat of the oven. There is no evidence, however, of the spread of infectious disease by means of baked bread.

Other grains, generally known as *farinaceous foods*, such as barley meal, rye flour, pea flour, bean flour, oatmeal, maize, or corn flour, resemble wheat flour as regards the constituent proteids, fats, starches, and salts. Oatmeal and corn flour are richer in fat than wheat flour, whilst pea and bean flour are considerably richer in proteids than wheat flour. This form of proteid, however, is not so digestible as the proteid (gluten) of wheat. Farinaceous foods are comparatively but little utilised by the poor of this country; and yet they are cheap, and can with little trouble be made into most nourishing porridges, soups, and puddings, with the addition of a little milk. They might be used with advantage to vary the customary diet of bread, dripping, or cheap butter, and meat of inferior quality (see Table, p. 203).

Rice is more of a starchy food, containing but a small proportion of proteids—less than half the proteids in wheat flour. The starch is, however, extremely digestible when properly cooked.

Arrowroot, sago, and *tapioca* are nearly pure starches, and are valuable starchy foods.

Most of the *fresh vegetables,* which form part of our daily diet, are less useful as foods of the class which construct tissue or supply heat and energy, than as being the substances which contain the vegetable acids so necessary for the maintenance of sound health, and for the prevention of scurvy. Such vegetables as cabbage, cauliflower, spinach, sprouts, turnips, and carrots contain from 80 to 90 per cent. of water, and less than 10 per cent. of starch. Besides their anti-scorbutic properties, they are also most useful in increasing the bulk of the fæces, inasmuch as they contain cellulose or woody fibre, which is totally indigestible. The fæces consist of indigestible and undigested matters, and water; and with a purely animal diet they are so hard, scanty, and tenacious, as to be ejected with difficulty from the bowel. The addition of these fresh vegetables tends to make the motions more copious and more watery (what is termed loose), with the result that they more easily pass through the large bowel to be evacuated.

Potatoes are valuable anti-scorbutics, and containing 21 per cent. of starch, they may be reckoned as valuable starchy foods. The juice of the potato is distinctly acid from the presence of the vegetable acids. When potatoes are steamed in their skins there is not so great a loss of salts as when they are boiled after being peeled. Consequently in the former state they are somewhat more nutritious.

Fresh fruits of various kinds, like fresh vegetables, are valuable food adjuncts for very much the same reasons. Although the vegetable acids are essential to healthy living, too great a quantity of them should not be taken. The introduction of an excessive amount of acid substances into the stomach causes acidity and indigestion. As is well known, acid fruits should be eaten in strict moderation.

The peel, skin, or rind of most fruits should be rejected—firstly, because these outer envelopes contain much indigestible cellulose, and secondly, to avoid the risk of introducing into the stomach what has been handled by often unclean hands. It is desirable also that all kinds of fresh vegetables should be cooked, and not eaten raw. Most of them are not digestible unless cooked, but it is the custom to eat lettuce, mustard and cress, celery, and watercress uncooked. Inasmuch as these vegetables are sometimes manured with sewage, it is certainly wise to wash them very thoroughly in clean water before sending them to the table, even if it is not considered necessary to cook them.

It is doubtful if tinned vegetables contain the antiscorbutic properties of freshly-gathered produce. Tinned peas are not uncommonly coloured green by means of a salt of copper, which is not, however, usually present in sufficient quantity to cause serious illness.

In 100 *parts.*

	Water.	Proteids.	Fats.	Starches.	Salts.
Wheat flour	15·0	11·0	2·0	70·3	1·7
Barley meal	11·3	12·7	2·0	71·0	3·0
Rye flour	13·5	13·1	2·0	69·3	2·1
Pea flour	11·4	25·2	2·0	57·2	2·9
Bean flour	10·3	23·2	2·1	59·4	3·3
Oatmeal	15·0	12·6	5·6	63·0	3·0
Maize	13·5	10·0	6·7	64·5	1·4
Arrowroot	15·4	0·8	—	83·3	0·3
Potatoes	74·0	2·0	0·2	21·0	1·0
Cabbage	91·0	1·8	0·5	5·8	0·7

Lemon juice, lime juice, and *vinegar* are chiefly valuable as antiscorbutics.

The *condiments* are the food-accessories which are added to food as flavouring agents. The principal of these are mustard, pepper, onions, cloves, cinnamon, nutmeg, caraway, cardamoms, &c.

Vinegar and common salt are also condiments, as well as valuable foods. Common salt or sodium chloride is taken at every meal, and is essentially a food, for all classes of food are deficient in this substance, which is necessary for the wants of the body.

The function of condiments is to stimulate the flow of the digestive juices, and also the peristaltic action of the stomach and bowels, by which the food is churned up, intimately mixed with the digestive fluids, and borne along from one part of the alimentary tract to another. They also contain an antiseptic substance which, whilst it may have the effect of retarding digestion, certainly in the case of a large mixed meal tends to prevent fermentative decomposition of food and consequent dyspepsia. Oil of mustard is a powerful antiseptic.

Alcoholic Beverages.—Whilst it is a matter of general agreement that the consumption of alcoholic drinks between meals, as a regular practice, is productive of nothing but harm to the system, there is no such agreement as to the dietetic value or worthlessness of alcoholic beverages taken with meals.

To the credit of such alcoholic beverages as beers and wines it may be said—(1) That the amount of alcohol they contain is not large—beers contain from 3 to 7 per cent. of alcohol, wines from 10 to 25 per cent. (2) Beers and wines have some of the properties of foods—they contain sugar and starchy matters, mineral salts, and vegetable acids. (3) If taken in very moderate quantities they promote the flow of the digestive juices, partly by reason of their contained alcohol, partly from the presence of compound aromatic ethers and bitter principles, which act as stomachic tonics.

On the other hand, both beers and wines undoubtedly retard digestion, and such retardation if habitual is probably deleterious. If, however, the meal is very large, the retardation is probably not injurious, as giving more time for the thorough completion of the digestive process; and the alcoholic liquid in the stomach checks any fermentative change which might otherwise ensue as a consequence of undue retention of food in the stomach.

Excess of stimulants, however, at meals is undoubtedly injurious, and inasmuch as no rule can be laid down as to the exact amount which should not be exceeded, individuals differing so widely, everyone should from experience form a rule for himself or herself. It may certainly be stated that if digestion and appetite are good without recourse to stimulants at meals, it is folly to initiate a practice which is unproductive of any advantage, and is at the same time a source of expense. There are, however, people to whom some form of alcohol with their chief meals appears to be more or less of a necessity. Without it, digestion is inefficient, and bodily health is not maintained.

Malt Liquors are, as a rule, not to be recommended for persons of weak digestion. For the labouring man, beer in moderation is not harmful, and may provide him with such substances as mineral salts and vegetable acids, which his diet is otherwise deficient in. To a man in active exercise also, beer in moderation does not tend to interfere with the elimination of effete matters from the blood, and the consequent production of liver disease and gout, as is frequently observed in beer drinkers of sedentary habits. Lager beer, as prepared in Germany and Austria, for home consumption and not for export, is considerably lighter and less heady than English beer. It contains somewhat less alcohol, and much less free acid, which is so frequently the cause of acid dyspepsia.

Wine is better for a weak stomach than beer, but a great deal depends upon the choice of the wine. Many of the natural wines are so fortified and sophisticated for the English market, that although wholesome enough in their natural condition, the "finished" article is to be absolutely shunned. The cheap French clarets, ports, sherries, and Marsala are fortified with spirit, and doctored with flavouring agents, to an extent sufficient to render them very far from wholesome beverages. Port, sherry, Maderia, and Marsala contain from 15 to 20 per cent. of alcohol; champagne about 10 per cent.; and clarets, hocks, and Burgundies from 8 to 12 per cent. of alcohol.

All wines, like beers, are acid, this acidity being chiefly due to the presence of tartaric acid. Very acid wines should be avoided, as liable to produce dyspepsia; as also should very new wines, which contain an excess of astringent matter in the form of tannin. In a wine matured by keeping, some of the tannin and colouring matter has been deposited, and some of the volatile acid has escaped.

As a general rule it may be said that the most wholesome wines are light, natural vintages, which contain from 7 to 10 per cent. of alcohol, and which are not too acid. Such wines are produced in Germany and Italy as well as in France. Effervescing wines like champagnes, which contain much sugar, and are very sweet, are distinctly less wholesome than the "drier" wines. It must be understood that "dryness" is no evidence of absence of sophistication. "Dry" sherry is very frequently the result of the manipulation of the merchant, and not the natural quality of the wine.

Spirits contain much more alcohol than beer or wine. The quantity of alcohol is seldom under 35 or 40 per cent. in brandy, whisky, or rum. Spirits should always be consumed with at least 4 times their volume in water, in order to avoid the injurious action of concentrated alcoholic liquids upon the delicate linings of the mouth, gullet, and stomach. Spirits should not be drunk until well mellowed by keeping. During the mellowing process, fusel oil—the common name for the higher series of alcohols,—and also furfurol —an aromatic substance,—are given off, these being substances which are not only highly intoxicating, but also very injurious to the digestive organs. A properly matured spirit, such as old whisky, adequately diluted with water, is the most wholesome form of alcoholic stimulant for a great many people, to whom any acid in their beverage is injurious. Spirits are practically free from those vegetable acids which are characteristic of all beers and wines.

Tea, coffee, and *cocoa* contain alkaloidal substances which stimulate the nervous system, increase the pulse and the action of the skin, and generally act as restoratives in fatigue. Tea and coffee taken hot are valuable both in very hot and very cold weather. The heat of the infusion gives warmth to the body in cold weather, and increases the action of the skin, causing more heat to be lost from the surface in hot weather.

Both tea and coffee retard digestion, and are not suitable beverages to be taken at meal-times. In the early morning, or for breakfast, a cup of hot tea or coffee is no doubt desirable, the nervous system so early in the day being all the better for stimulating; but to take tea at every meal of the day, as is so often done, is to retard digestion without any compensating benefit. The abuse of tea is a very frequent cause of dyspepsia, and leads also often to nervous depression and sleeplessness.

In making tea, it is advisable to prevent too much of the tannin present in the leaves passing into the infusion. Tea which has "stood" for over five minutes becomes unduly astringent, and this astringency interferes with digestion. Tea should be made with boiling water, but after standing for three or four minutes the infusion should be poured out into another vessel.

Coffee is less astringent than tea, and in some people it has an irritating effect upon the bowels, causing diarrhœa. Good coffee is more difficult to make than good tea. The berries must be fresh roasted and ground, and the infusion with hot water must not be boiled, otherwise the aroma is lost. Chicory is merely an adulterant of coffee, and has none of its stimulating and refreshing effects.

Neither strong tea nor coffee should be taken late at night, as they may cause sleeplessness.

Cocoa is much less of a stimulant than tea or coffee, and is more of a food, containing nearly 50 per cent. of oil (cocoa butter). As this fat or oil is not very digestible, cocoa is generally sold now with at least half its oil abstracted, and mixed with arrowroot. In this form cocoa is certainly more digestible than in its crude state.

Mineral Waters are either derived from natural springs, the water of which contains gases or mineral salts in solution ; or they are manufactured by forcing carbonic acid gas into distilled water, or into river, spring, or well-water, and dissolving small quantities of mineral salts in them.

These mineral waters serve a useful purpose as dietetic adjuncts, the carbonic acid stimulating the digestive organs, and the mineral salts also being useful, unless present in too large an amount. A beverage containing an excessive amount of common salt, as is well known, increases thirst and does not allay it ; and some of the natural springs certainly err on the side of excess, regarding their waters as beverages and not as medicines.

Too much reliance should not be placed on the purity of the artificially aërated waters. These may have been derived from sources open to contamination, such as polluted streams and shallow wells. It also frequently happens that these waters contain metallic lead in dangerous quantities. The lead is dissolved out of lead pipes or lead apparatus used in the manufacture of the carbonic acid. It ought to be made compulsory for all carbonic acid generators to be constructed of silver or to be silver lined, lead pipes and apparatus being prohibited.

CHAPTER IX

PHYSICAL EXERCISE

Effects of exercise on the bodily organs—Rest—Growth of the body—Kinds of exercise: Walking, Running, Jumping, Rowing, Games, Feats of strength—Training or preparation.

By physical exercise is meant the regulated use of some or all of the muscles of the body.

The importance of regular exercise will be best understood from a description of the effects it produces on the chief organs of the body.

(1) *The Heart and Circulation.*—The action of the heart is increased both in force and frequency; the blood circulates more quickly throughout the body. This result is assisted by the muscular contractions pressing the blood in the veins onwards towards the heart; this venous blood being also aided in its passage to the heart by the deep inspirations excited by the exercise.

(2) *The Lungs.*—The inspirations and expirations are increased in frequency and volume; the amounts of air inspired and expired in a given time are very much larger than if the body was at rest. In consequence the blood is supplied from the

inspired air with a much larger amount of oxygen, and gives off a corresponding excess of carbonic acid and water to the expired air.

(3) *The Voluntary Muscles.*—The muscles which are under the control of the will are brought more or less into play. The accelerated circulation brings through the arteries a highly oxygenated blood-supply to the muscles, containing abundant material for the repair of old tissue, and for the construction of new; whilst the rapid venous flow carries away the waste products of muscular action to the various excretory organs. The play of the muscles is essentially a rhythmic contraction, by which the muscles are shortened, the points of attachment and insertion of each end of the muscle being brought closer together; and this is followed within a short space of time by relaxation. In most exercises certain groups of muscles are contracting, whilst other groups are relaxing.

(4) *The Skin.*—The circulation of blood through the vessels of the skin, lying close beneath the surface, is much more rapid. The radiation of heat from the surface of the body is thereby much increased; and the excess of heat, which is produced in the body by the rapid combustion of tissue, is allowed to escape. If the exercise is severe, or the air temperature is high, water is excreted from the blood by the sweat glands in

the form of sweat, which appears on the surface, and being quickly evaporated, tends immensely to cool the body by reason of the abstraction of the large quantity of heat necessary to evaporate the water into steam. A very important function of the skin is this regulation of the body temperature, and the prevention of any rise above the normal average—98·4° F.

In consequence of the increased supply of blood to the voluntary muscles and to the skin, the tendency towards partial stagnation of the blood in the large abdominal organs, such as the liver and spleen, is overcome; and the congestion of these organs, so commonly met with in those who lead a very sedentary life, is prevented. Exercise involving the abdominal muscles is also very often effective in overcoming a tendency to habitual constipation.

Exercise should be succeeded by rest, to allow the muscles and nerves to get rid of the waste products of their action, which tend to accumulate during exertion; and in order that repair of wasted tissues, and formation of new tissues, may go on. Without suitable periods of rest, the nerves and muscles become exhausted, and the muscular contractions become gradually enfeebled.

It is thus seen that properly regulated physical exercise must cause increased appetite and thirst, and more food and drink to be consumed. The digestive organs are increased in efficiency, and all parts of the body benefit.

The muscles themselves grow larger and harder, and in consequence more powerful. Muscles which are unexercised are soft, weak, and flabby, and incapable of prolonged or arduous exertion.

Nearly all kinds of physical exercise, indulged in in moderation, are distinctly health-giving. If undertaken in the open air, the benefit to health is always in advance of that obtained by exercise within doors. There is even a greater necessity for pure air during exertion, than when the body is at rest.

Of the various kinds of exercise, walking or pedestrian exercise is by far the most common, being suited for individuals of all ages, and of every degree of development. Whilst mainly exercising the muscles of the legs and thighs, it also brings into play the muscles of the loins, back, and abdomen in order to keep the body in an erect position. In walking the body should be erect, the chest thrown out, the head thrown back, and the stride long and elastic, the legs being well swung out from the hips, and straightened as soon as the feet are planted on the ground, so as to secure the full length of the stride. The act of walking with bent head, stooping shoulders, contracted chest, and over-bent knees is neither graceful nor healthful, and is in the long run more tiring than walking in the correct attitude. Walking across country, as for shooting or playing golf, is preferable to walking on the high roads, the ground being softer and more elastic, the motion therefore more various and less monotonous, whilst there is at the same time an object constantly in view, which makes fatigue less apparent.

Running is an excellent exercise for the young and robust, but should be moderately and sparingly indulged in after the age of thirty. If it cause much panting, extreme breathlessness, a sense of oppression on the chest, a feeling of faintness, palpitation of the heart, and subsequent pain over the cardiac region, the exercise is too severe, and its continuance is likely to do much harm. These symptoms are frequently experienced by men of middle age who, without previous preparation of any kind, attempt unwonted exertion in running. The breathlessness is due to an excess of carbonic acid in the venous blood, derived from muscles out of condition and containing too large an amount of combustible matter. The lungs are unable to get rid of this carbonic acid, as soon as it is formed, with the result that they become engorged with venous blood, expiration is rendered difficult, and the train of symptoms enumerated above are produced. Running for races should never be attempted without previous systematic training.

Jumping is not an exercise much pursued except for the purposes of competition; but skipping with a rope is a form of jumping, and of this exercise it may be said that it is one of the very best for growing children. It brings into play nearly every muscle of the body, without putting undue strain upon any particular group.

Of rowing it may be said that there is no form of exercise that has so marked an effect in developing the chest if only the rower or sculler is properly taught. There is probably no form of exercise which requires such careful supervision and tuition, if the beginner is to acquire the proper style, without which nearly all the benefit of the exercise is lost. In both rowing and sculling, if carefully performed, nearly every muscle of the body is actuated, more especially the muscles of the chest, back, abdomen, and loins. To row with bent head, stooping back, and contracted chest, whilst the muscles of the arms are allowed to do all the work, is to cultivate a style which quickly develops fatigue, and fails to exercise properly the great muscles of the trunk, or increase the respiratory and vital powers. It is wonderful how greatly the chest may be developed in young men by systematic training in rowing. The capacity of the thorax is increased, and the individual gains in breathing power, whilst the muscles of the chest, back, and shoulders are greatly strengthened.

Nothing but praise can be given to such exercises as skating, swimming, riding on horseback, or to such outdoor games as cricket, lawn tennis, football, &c. Boxing, fencing, and gymnastic exercises are specially useful, under proper supervision and training, for developing muscles and senses alike.

With the exception perhaps of football, there is no reason why girls and women, as well as boys and men, should not participate in all the abovementioned exercises, games, and sports. It is certainly true that the female body cannot, any more than the male, attain its perfection of graceful development without recourse to systematised exercises; and it is a matter for congratulation that this is a truth to which the public mind is very rapidly awakening.

Mr. Treves, F.R.C.S., in his excellent article* on "Physical Education" in *A Treatise on Hygiene and Public Health* (J. & A. Churchill), is of opinion that exercises or games in which jumping takes a prominent position are not well suited for girls and women, and is also inclined to regard cycling as

* Published also separately, price 2*s*. 6*d*.

one of those forms of exercise which are best left to the male sex, the exercise involving too exclusively the use of the lower limbs and of the muscles about the pelvis to be an ideally healthy one for women, whilst the pressure caused by the saddle on the perinæum is also undesirable.

There can be no doubt whatever that for ordinary individuals, and during the period of growth, the most excellent exercises are the gentle ones, where no strain is placed upon the organs of respiration and circulation. Exercises of strength, and those involving speed or rapid movement, are best left to youths and young men who have undergone preparation and training.

Those exercises, too, which, like feats of strength, require sustained effort, are best avoided by the unprepared individual. In the making of the effort a deep breath is taken, and the chest is filled with air, and the glottis or valve guarding the opening at the top of the windpipe is then closed, so as to keep the lungs expanded. The thorax then becomes a fixed base for the shoulder and chest muscles to actuate the arms. Respiration is thus brought to a standstill, and the right side of the heart becomes over-distended with blood. Such accidents as hernia, rupture of blood-vessels, and strains of muscles and ligaments, are most apt to occur during these sustained efforts.

The subject of "training" is hardly one requiring discussion. In former times very senseless practices and restrictions were imposed upon those who placed themselves in the hands of professional trainers; but these follies are now universally abandoned in favour of training founded upon rules consonant with physiology and common sense.

For those who wish to increase their athletic powers without submitting themselves to professional training, it will be wise to keep in remembrance the following simple rules:—(1) Commence gradually, and progress by very easy stages to more prolonged or more arduous exercises. (2) Avoid any strain or very violent exertion until the body is sufficiently prepared, and always cease exercise as soon as fatigue is noticeable. (3) Be warmly clad after exercise, and avoid chills. (4) Take your accustomed food at regular meals, and be very moderate in the use of alcoholic drinks and tobacco; but do not imagine that any good can result from eating large quantities of half-raw meat, and reducing very largely the consumption of starchy foods. (5) Drink when thirsty; small quantities of fluid at a time are far more beneficial than long draughts at great intervals. Thirst is sometimes caused by dryness of the mouth, and not by any demand of the tissues for water. This form of thirst may be relieved very often, without swallowing any liquid, by simply washing out the mouth with water. In walking and climbing hills try to breathe through the nose, keeping the mouth shut, and regulate the pace so that this can be done without discomfort. Breathing through the mouth induces dryness and thirst. (6) Avoid garments which constrict the neck, chest, and abdomen, and wear clothes which allow free play to all the muscles of the body. (7) Allow plenty of time for sleep—seven hours to nine hours, according to the needs of the individual. Recuperation of the body is most largely carried on during the hours of sleep.

CHAPTER X

CLOTHING

Use of clothing—Amount and character of clothing—Underclothing and chills—Outdoor clothes—Wet feet, damp beds, and "draughts"—Constricting garments: Hats, belts, stays, garters, and boots—Clothing in childhood and in old age—Cleanliness of clothing.

In so changeable a climate as that of England, the subject of clothing must always be one of great hygienic importance.

The chief use of clothing, hygienically considered, is to maintain the temperature of the body at its normal level. Whilst it is necessary, therefore, to have garments to protect the body and limbs from the effects of heat, cold, and moisture, these must be so arranged as to allow the greatest possible freedom to all muscular movements. Any constriction or compression of a limb or of the body retards muscular action, interferes with the circulation of the blood, and in the case of abdominal compression is liable to displace or injure underlying organs.

The amount and character of the clothing that should be worn must depend chiefly upon the weather and the season of the year, upon whether the body is to remain passive or engaged in active exercise, and upon other considerations of a similar character. It is not, therefore, possible to lay down any precise rules of general utility, except perhaps as regards the underclothing—that which is worn next the skin—upon which subject there is a fairly general consensus of opinion amongst medical men.

As a general rule some form of woollen garment should be worn next the skin, because woven wool is a very bad conductor of heat, and whilst it is a good absorbent of moisture, it gives the moisture off very slowly. The first quality—the bad conduction of heat—is due partly to the wool fibres themselves; but perhaps in a greater degree to the fact that a quantity of air—the worst conductor of heat known—is entangled in the meshes of the woollen garment. A woollen garment, therefore, tends to keep up the temperature of the body by preventing the radiation of heat from the surface of the skin. It also prevents chills when the surface of the body is moist from perspiration, as the wool absorbs and holds the moisture, and only evaporates it slowly.

Chills, as is well known, are especially apt to be taken when the body is subjected to cold when perspiring, either from the effects of exercise, or from staying in an overheated atmosphere and then passing out into the cold outer air. The evaporation of the water on the skin absorbs much heat from the body, and if this evaporation is suddenly checked a chill is produced—a nervous phenomenon, subsequently manifesting itself usually in some inflammatory affection. An undergarment of thin calico (cotton) or linen becomes soaked and clammy from perspiration, which is rapidly evaporated, causing a chill to the surface of the body—just the reverse, therefore, of what happens with a woollen fabric. If linen or cotton are worn next the skin owing to flannel causing irritation, the material should be loosely woven so as to intercept as much air as possible in its meshes, in order to render it a bad conductor of heat. The "cellular" cotton underclothing appears to fulfil this condition.

Silk comes next to wool as a material for underclothing, and is superior to cotton and linen, having better hygroscopic (*i. e.* moisture absorbing) qualities than either of the latter. It is, however, too expensive for very general wear.

After severe exercise, it is not wise to trust entirely to the chill-resisting qualities of a flannel shirt. Extra clothing should always be assumed, more especially if the exercise is succeeded by complete rest. Even athletes in the most perfect training are very susceptible to chill when at rest after active exertion.

In cold weather out-door clothes should be thick, dark, and composed largely of cloth, *i. e.* some form of woven wool. The coldest and most trying weather is that experienced when a cold, dry, north-east wind prevails. The wind causes the cold air to penetrate through clothing which is not of the thickest and closest material, and the heated air around the body is swept away to be replaced by cold air. The relative dryness of the air also causes rapid evaporation of moisture from the body. These two causes acting together cause sudden losses of heat, which result in chills, unless the clothing affords proper protection.

Furs, and thick shaggy woollen materials, such as Scotch tweeds and Irish friezes, afford the best protection against cold winds. Waterproofs are also valuable, being impermeable to both wind and rain, but should not be worn during active exercise, as they favour the accumulation of perspiration, owing to their want of porosity, and the body when soaked with perspiration is very apt to be suddenly chilled. Simply as a protection from rain, waterproofs are far superior to heavy, shaggy, woollen overcoats, as the latter become soaked with water, and in that state are not only very heavy, but also difficult to dry.

In hot weather the garments may be light, white in colour, and thin. White clothes are the least absorbent of the heat of the sun's rays. Although it is not desirable to have the body warmly clad in hot weather, chills should be provided against, as a sudden check to perspiration is no less to be dreaded in hot than in cold weather. In some hot countries a cloak is carried, to be thrown around the wearer when he passes from sunlight into shadow, and at the approach of sunset. In India the abdomen is usually swathed in flannel, to avoid the chills, which in tropical countries seem especially liable to set up diarrhœa and dysentery.

Of all forms of indiscretion, the practice of "sitting with wet feet" is perhaps that which most easily conduces to "catching cold." Although the surface of the body which in this case is chilled is comparatively trivial as compared with that of the trunk, yet there can be no doubt a very profound nervous depression results in very many people. So long as exercise is maintained, clothes wet from rain or perspiration, and boots sodden with water, do no harm; but the failure, or inability, to change into dry garments, when the body is at rest, is for the majority of people to incur very grave risk of future ill. A very dangerous form of "chilled feet" is that produced by walking in defective boots through snow which has been converted into slush by means of salt—a most indefensible practice still largely pursued in London and other cities. The salt and snow create a freezing mixture, many degrees below freezing-point, and this liquid—colder than ice—chills the feet of passengers, especially of the badly-shod, to an extent which is undoubtedly highly injurious to health.

Sleeping in damp beds is another frequent source of mischief. During the hours of sleep the vital powers are diminished, and the tendency to chill, arising from the abstraction of the bodily heat to evaporate the moisture in damp sheets, is very much enhanced. No one should ever sleep between damp sheets. It is a safe rule to discard the sheets, and, enveloped in a dressing gown or the day clothes, to seek repose between the blankets.

Colds are frequently caught from "sitting in draughts." Draughts should, wherever possible, be avoided; but if unavoidable, as may be the case in railway travelling, it is always well to remember that less harm is likely to result if a draught is faced, than if the back is turned towards it. The back is decidedly sensitive to cold, perhaps more so than the chest; yet the chest-protectors so commonly worn by a certain class, who suffer from colds and chest affections, are nearly always protectors of the chest, and not of the back. It is seldom wise to clothe the body unequally in this manner. Certainly the woollen comforter so usually worn around the neck is more likely to induce throat delicacy and liability to chill, than to have any useful effect.

The importance of not compressing the limbs or body by constricting garments has been already alluded to. The common sites of constriction are—(1) around the scalp by a heavy, hard, and tight-fitting hat; (2) around the neck by too tight a collar; (3) around the waist by a tight belt in males, and by tightly-laced stays in females; (4) around the knees, either above or below the knee-joints, by garters; (5) compression of the toes by the use of ill-fitting boots.

The compression of the scalp by a hard hat interferes with the circulation of the blood through the blood-vessels, and may cause neuralgia or baldness, the nutrition of the hair-follicles being affected by the disordered circulation. The constriction of the neck by a tight collar may cause venous congestion (lividity) of the face and head, especially during exertion.

The compression of the waist by a belt interferes with the action of the diaphragm—the most important muscle of respiration—and tends to favour the production of hernia. Tight lacing is well known as a cause of dyspepsia in women, from its undoubted effect, when carried to an extreme, in producing displacement of the stomach and other abdominal organs. In moderation there is no doubt something to be said in favour of the use of stays, which give support to the figure, and afford attachment to the more weighty articles of clothing; but for girls and very young women, their use is to be deprecated as causing interference with the proper development of the chest organs.

The use of garters tends to obstruct the venous circulation in the legs, and to favour the production of varicose veins.

Ill-fitting boots, when continuously worn, cause permanent disfigurement of the feet, not to mention such sources of discomfort as corns and bunions.

The natural shape of the foot is that of an open fan, the toes representing the expanded part of the fan. The boot, therefore, should be fan-shaped, the inner side of the fan being more prolonged than the outer side, and the inner line of the sole from the extremity of the big toe to the instep being straight and pointed inwards, and not curved out from the ball of the big toe as is the case with all boots and shoes having pointed toes. In some cases of extreme deformity, from the use of narrow-pointed boots, the toes are made to overlap, and locomotion becomes difficult and painful.

It is very important that the delicate feet of children should not be compressed in ill-fitting, badly-designed boots. Deformities of the feet, which cause so much trouble in adult life, are usually acquired in childhood. The boots should be easy, so as to allow of free movements of the toes, without which proper muscular development of foot and leg cannot take place; and the soles should be pliable, not stiff, so as to allow of the natural bending of the foot across the line of joints forming the ball of the foot, without which locomotion is never easy, free, and graceful. High heels are a mistake. They tend to throw the weight of the body too far forwards, placing an undue strain upon certain groups of muscles in order to maintain the balance, whilst other important groups are not sufficiently exercised. A firm, even tread cannot be expected when high heels are worn.

Garments which fit very tight not only hamper muscular movement, but are generally less warm and comfortable, from the fact that there is not a sufficient layer of non-conducting air around the skin to maintain an equable body temperature, and to facilitate the steady transpiration of skin moisture. Tight garments, which cling to the skin, impede the ventilation of the skin surface, upon which comfort so largely depends, and become more rapidly soaked with perspiration than does loose clothing.

This is no doubt the reason why hats, which do not rest upon the head except at the brim, and afford an air space over the greater part of the scalp, are so popular with the male sex.

At the two extremes of life—in early childhood and in old age—warmth of clothing is most essential. Little children are more susceptible to cold than adults,—firstly, because the circulation of blood is more rapid, and in consequence, more blood being passed through the superficial skin vessels in a given time, more heat is radiated from the surface; and secondly, because the surface of a child's body is considerably larger in proportion to its bulk or contents than is that of the adult. The larger the surface of a warm body in proportion to its bulk, the greater is the rapidity with which heat is lost from it. From such considerations as these it will be understood how senseless and injurious is the fashion of allowing little children to run about with bare arms and legs.

At the other extreme of life, if the body becomes chilled its restoration to a normal temperature is often slow, and the activity of the vital organs becomes dangerously depressed. The feeble and languid circulation and heat-producing powers of old age are manifested by habitually cold extremities, and by a tendency to lividity of the face during exposure to cold.

Articles of underclothing are not very commonly at the present time coloured with dyes containing arsenical or other poisonous pigments. It is worth noting that sores and ulcers on the feet have been traced to the use of stockings containing arsenical colours.

The cleanliness of clothing is not a matter upon which it is necessary to dilate at any length. The garments next the skin absorb perspiration at all times, but especially in hot weather, and likewise become the receptacles for much of the epidermic *débris*, or scurf, which is continually being shed from the skin's surface. These matters are nitrogenous and liable to decompose—a truth which is at once apparent from the odour given off by an undergarment which has been worn too long.

A garment exhaling foul odours is not only unpleasant to the senses of the wearer, but is disgusting to his neighbours, and renders more unsupportable the misery of the close crowding together of human beings.

Cotton and linen articles can be readily washed and purified, but in the case of woollen garments, which are the most absorbent of foul matters, washing with soap in hot water, and wringing out, deteriorates the fabric. The hardening, shrinkage, and loss of elasticity of woollen goods washed by the ordinary methods is well known. The flannel shirt that goes to the laundry a size too large for the wearer, very frequently returns three sizes too small. Woollen goods should be washed in soft, tepid water, with mild soap, and without soda, and should not be wrung. Much of the impurity in wool may be got rid of by long exposure to air and sunlight; but some soap is required to remove effectually the dirty grease which is lodged in them by absorption of the sebaceous secretion from the glands at the roots of the hair-follicles.

CHAPTER XI

THE CARE OF THE SKIN, TEETH, AND BOWELS

The skin as an excretory organ—Soaps and ablution—Hot and cold bathing—Attention to the teeth—Importance of regular action of the bowels.

THE skin is an excretory organ, containing in its substance innumerable sweat glands, the ducts of which open upon the surface. Sweat or perspiration is a slightly acid fluid, holding in solution nearly 2 per cent. of solid substances, chiefly common salt, and various fatty acids and fats. Besides the sweat glands, the skin contains sebaceous glands, which secrete sebum, a fatty substance, whose function is to keep the skin and hair smooth, moist, and supple. The skin is therefore constantly exuding sweat and sebaceous matter, which mixed with shed epidermic scales or scurf, accumulate on the surface, and must be periodically removed if the surface of the body is to be kept in a clean and wholesome condition.

A dirty skin, like dirty clothes, is not only disagreeable to the senses, but is also distinctly injurious, foul and decaying matters on the surface of the body being liable to absorption into the vessels and lymphatics of the skin, thereby producing or tending to foster various skin disorders. It is also the fact that uncleanly people are more liable to chill than those whose skins are clean. The salt in the dry sweat adhering to the skin tends to absorb moisture from the air, and the damp skin acting as a good conductor of heat, leads to surface chilling and the production of cold.

Inasmuch as the dirt to be removed from the surface of the body is largely fatty in its constitution, the application of water merely is insufficient to remove it. As everyone knows, hot water and soap, and plenty of friction with the hands or a flannel, are necessary to secure perfect cleanliness. The reason of this universal custom is, however, perhaps less well understood.

Hot water is required to dissolve the fats in the skin secretion, and soap is necessary to enable them to be washed away. Soap is essentially a compound of an alkali with a fatty acid. The alkali of the soap, when rubbed into the skin, combines with the greasy matters, and enables them to be easily washed off with water; whilst the use of the fatty acid is to prevent the excessive removal of the sebaceous secretion, by which the skin would be rendered over-dry, cracked, and chapped.

Coarse soaps containing an excess of alkali are injurious to the skin, especially in cold weather, the too great removal of sebaceous matter rendering the skin liable to crack and "chap." For young children with delicate, sensitive skins, superfatted soaps, containing no free alkali whatever, are often useful.

In very cold and also in very hot countries, the native custom of anointing the body with oils or greasy ointments is physiologically a sound one. Exposure to the burning rays of the sun, as well as to intense cold, is liable to cause injury to the skin, which the application of oils has considerable effect in preventing.

After washing, the skin should be rubbed quite dry with a rough towel. During this process the loosened epidermic scales are removed, the circulation of blood through the superficial capillary blood-vessels is increased, and the skin is materially improved in texture and appearance.

Whilst the chief use of the hot bath is for purposes of cleanliness, it also has a sedative effect upon the nervous system, tending to allay restlessness and excitability, and to promote rest and sleep. Hot baths are best taken before retiring to bed, as the body is readily chilled if exposed to cold when the cutaneous blood-vessels have been relaxed by heat.

Cold baths are less cleansing than hot, but more stimulating and invigorating. The best period of the day for a cold bath is undoubtedly at rising in the early morning. The immediate effect is the withdrawal of heat from the body and the lowering of its temperature; but this is followed very shortly by reaction—a feeling of warmth and glow—due to dilatation of the cutaneous vessels, accompanied by a sense of exhilaration and increased energy. After leaving the bath the skin should be rapidly rubbed dry with a rough towel, and warm clothes quickly assumed.

A cold bath which is not followed by reaction is likely to do more harm than good. The absence of reaction may be due to the water being too cold, the bath being too prolonged, or the bather being in a low condition of health.

The temperature of the water should be regulated to the age and strength of the bather, and as soon as reaction is established the bath should cease. Young and vigorous people can of course endure longer exposure to cold than those of greater age in less robust conditions of health; but it is a wise rule, especially in outdoor river or sea bathing, to come out of the water as soon as the glow of reaction has commenced. To remain in the water until a sensation of cold is experienced is to render bathing not only devoid of benefit, but actually detrimental to health. Outdoor bathing should not be indulged in until at least two hours have elapsed since the last meal; and except for the robust it is wisest not to bathe on an empty stomach, that is to say, before breakfast.

The daily morning "cold tub" renders the bather little liable to take cold. The nerves of the skin are braced to withstand the shock of cold from draughts or exposure, which to the more sensitive skin induce chills and their consequences.

Cold baths are not well borne by young children, and it is doubtful if it is wise to continue the daily cold morning bath after middle age is reached.

Even if the whole body is not washed daily, the feet should never be neglected. In the coldest weather a very large quantity of perspiration is poured out by the sweat-glands on the soles of the feet, and this requires to be daily removed, along with the dead scales which collect in the spaces between the toes. The feet become more offensive, if not frequently washed, than any other part of the body.

Cleanliness of the hair is also another matter requiring strict attention, especially in children, in whom neglect of cleanliness very frequently leads to the invasion of the head by parasites (lice).

It is curious how frequently the cleansing of the nasal cavities is neglected, even by very cleanly people. A great deal of the soot and dust in the atmosphere of large towns is prevented from reaching the lungs by becoming lodged in the nasal cavities just within the orifices of the nostrils. The nose, therefore, performs to some extent the very useful functions of a filter, but, like other kinds of filters, it requires to be periodically cleaned. This can be best done with a handkerchief and tepid water, without soap, and it is wonderful how refreshing this simple ablution is.

The importance of keeping the teeth in a good state of preservation is now so widely recognised, that it is perhaps unnecessary to remind the reader on this subject, that bad teeth and toothless gums mean deficient mastication of food, and in consequence impaired digestion; and that it is hardly possible to attain a healthy old age unless the power of vigorous mastication is preserved.

The care of the teeth is largely a question of cleanliness, although it must not be supposed that cleanliness alone will render the dentist's aid and advice unnecessary. Under the existing conditions of civilisation, tending as they do to imperfections of development and function, it may be said that every child would be the better for skilled supervision by a dentist from the time of commencement of the second dentition (six years of age) until growth is completed.

No doubt one of the causes of decay or caries of the teeth is the retention of fragments of food between and around the teeth. These matters quickly putrefy in the warmth and moisture of the mouth, and the products of decomposition attack the enamel of the teeth, leading to decay of the dentine beneath the enamel. It is impossible to keep the teeth in a cleanly condition if they are over-crowded in the mouth or overlapping, hence the importance of seeking the aid of the dentist; but in normal mouths the daily use of the tooth-brush, applied to the inside of the teeth as well as to the outside and grinding edges, with some prepared tooth powder, is sufficient to maintain the teeth clean and wholesome. To remove fragments of food which have lodged between adjacent teeth, there is much to be said in favour of a quill toothpick, but any hard metal implement should be avoided, as liable to injure the enamel of the teeth. Even better than a toothpick is the use of antiseptic, waxed, dental floss silk, which, when drawn between the teeth, effectually dislodges retained particles of food.

It is hardly necessary to insist upon the importance of regular action of the bowels. The retention of decomposable and decomposing substances in the lower intestine is prejudicial to health; and there is no habit which tends so much to comfort and well-being as that which ensures a regular daily evacuation of the bowels.

A large and possibly increasing number of people, owing to the manners and customs of nineteenth century civilisation, are very much the subjects of chronic constipation. This is perhaps, on the whole, a matter on which it is best to seek medical advice, depending as it does upon a variety of considerations of physiological and medical import, which have in some cases been alluded to in the chapters on food and exercise (pp. 199, 201, 214), but which cannot very well be further discussed with advantage in this little treatise.

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