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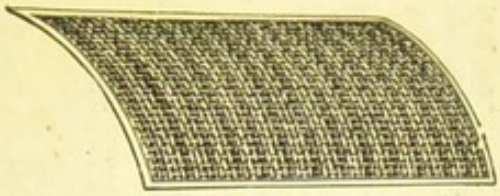
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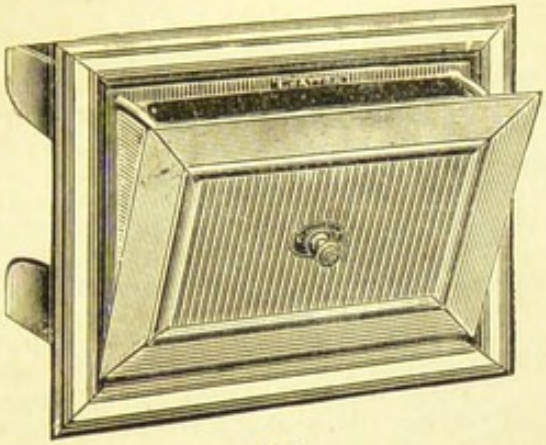
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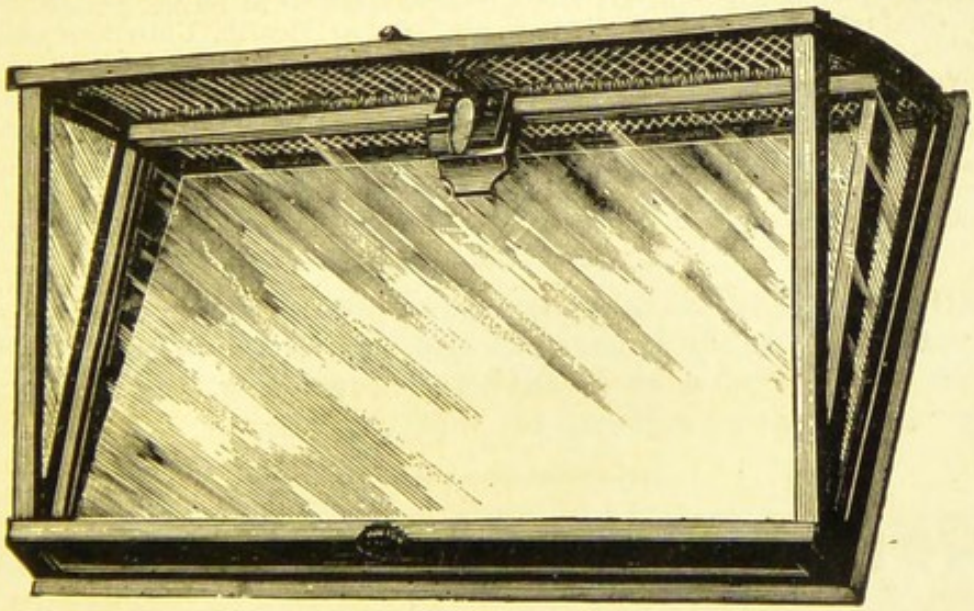
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A MANUAL OF HYGIENE

FOR STUDENTS AND NURSES

ILLUSTRATED BY SEVENTY DRAWINGS

BY

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PREFACE.

SANITARY science, not only in its name but also in its development in this country, belongs peculiarly to the Victorian Era. Sixty years ago sanitation, as we now understand it, was conspicuous by its absence. The health of the peoples of populous centres and of rural communities alike was seriously affected by insanitary environments, by limited house spaces, by imperfect means of sewage disposal, by insufficient and polluted water supplies, and, not less, by general ignorance of the causes which make for disease.

Then, the nation was passively careless of the housing and surroundings of the poorer classes; epidemics claimed their victims by thousands, and their prime causes were so imperfectly understood that they were deemed to be visitations of God, which might only be stayed by prayers and fastings.

bulk more largely in the policy of the future than it has in the past—the science of Preventive Medicine.

The writer tenders his thanks to Messrs. Macmillan & Co., Messrs. Baird & Tatlock, and others for their kind permission to use certain of the blocks which serve to illustrate the text.

Glasgow, 1897.

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HYGIENE FOR NURSES.

CHAPTER I.

HYGIENE AND ITS BEARINGS—THE HOUSE WE LIVE IN, IN RELATION TO HEALTH, CONSIDERED GENERALLY.

HYGIENE is that science which teaches of the preservation of the health of man and of the conservation and prolongation of life. The word is derived from "Hygeia," who was in the pagan mythology designated the goddess of health. She was the daughter of Æsculapius. Hygiene has a collective as well as an individual application; its precepts are alike valuable to man in the mass, as to man in the unit. In its collective application, since it deals with the lives of the inhabitants of a State—which are its most valuable assets—it is denominated State medicine. In respect also that it instructs in the principles of prevention of disease, it is often designated preventive medicine.

But, by whatever name it may be called, the object of hygiene is to enable us to live as healthily and as long as possible by forewarning us against those causes which make for disease, and thus to avoid them. It therefore deals with everything within, without, and around us which will prejudicially affect the natural tear and wear of the body. Thus, the house we live in, the food we

eat, the coverings of our bodies, the air we breathe, and the water we drink, all come under our purview. Our relations to our neighbour, the schemes of drainage and water supply common to large communities, will also demand attention. Likewise, the effects of occupation, rest and relaxation, and sleep in relation to health, the nature of infective matter, the infective diseases, disinfection, and isolation hospitals, will receive some attention.

In the succeeding chapters it is proposed to treat the subject both systematically and succinctly, and in this connection probably the most important subject to be first discussed is "the house we live in, in its relation to health".

The importance of this is at once apparent when it is recollected that the average person spends at least half of his life-time indoors; consequently the home forms a very important factor in our lives. Its condition, from a sanitary point of view, exercises considerable influence on the health of the inmates. It may only be in the direction of impairing vitality, or it may be in the production of actual disease. Most people cannot command everything they would desire in their houses; economic considerations frequently forbid. The exigencies, too, of city life compel many persons to live near their work, amid surroundings alike uncongenial as they are unhealthy. Hence the site of the house, its surroundings, its relation to climatic conditions, to wind, and sunlight, are beyond their control. It will be, at least, certain that the more open the space is around a house, the more bountiful will be the supply of air and sunlight. A house in a hollow is likely to prove a more

unhealthy house than one on a hill ; here the subsoil conditions—the soil upon which the foundations are laid—become of importance. The former house is more likely to be damp than the more elevated one, for reasons which will be pointed out later. Again, the drainage of the latter house will be better than that of the former, since water runs from heights into hollows.

Again, the kind of house in relation to the neighbour is of some importance. The one-tenant, or self-contained, house is more independent of the careless neighbour than the house in a flat, or apartments in a tenement occupied by different holders. The careless neighbour in such circumstances as the latter would likely prove a grave menace to the others, for instance, in the spread of the infectious diseases of children. The housing of people has an influence *per se* on the health of a community. The denser the population in a given area the higher will be the death-rate, under ordinary conditions. This is abundantly proved from the experience of large cities. If this dense population be composed largely of the vicious class, the death-rate will still be higher than if a population of equal density were made up chiefly of the industrious working-classes. The average density of any given population is arrived at by dividing the total number of the inhabitants by the area covered by their habitations. Thus we speak of so many persons per acre, or square mile, or whatever the unit of space may be. The actual density is obtained by ascertaining the precise number of inhabitants living within a certain defined and measured area. The average density, therefore, will be no true guide, since the most densely and most sparsely populated districts

are "lumped" together, as are also the most open with the most crowded spaces. So, too, has the number of rooms in a house an effect on the health of its inmates. Generally speaking, the smallest houses—that is, those of the smallest number of apartments—are occupied by those whose struggle for existence is the hardest. With such people it is all work and no play, and little time, and perhaps less care, are exercised in observing ordinary cleanliness. There is but the scantiest heed for infant life, and hence follows a high death-rate in children. The law of the survival of the fittest is in full operation here, for life at the extremes of age—childhood and old age—is held cheap. As the house increases in size these conditions gradually disappear until a point is reached when disease-producing factors have least chance to operate, because of the observance of the principles of personal hygiene, and of the attention given to the sanitation of the home. It is not to be wondered at, therefore, that from all classes of disease, and at all periods of life, the mortality rates increase as the scale of accommodation is descended.

If we view houses from the point of view of nursing, we can also see why it is that such things should be. Nursing, worthy of the name, is absolutely impossible in houses of the poorer classes, and any kind of medical treatment is well-nigh valueless. Recoveries are to be attributed more to the native strength of the patient—otherwise called the *vis medicatrix naturæ*, *i.e.*, the healing power of nature—than to anything the physician or the nurse may do. In the larger houses, on the other hand, both medical and nursing treatment are afforded room to work, and the patients having been brought up

in healthier conditions are better able to resist the operations of disease; hence more recoveries follow. From these causes, as well as from other physical and moral causes, there are higher death-rates in the poorer class than in the better class houses. Probably the most important factor in the health-conditions of any home, be it small or large, is the "elbow-room," that is, the superficial floor space and cubic space at the command of the occupants. It has been assumed, hitherto, that the average-sized family occupied the classes of houses described, but it is obvious that in houses even of four or five apartments, the elbow-room may be not greater, indeed may be less, than in houses of smaller dimensions. This involves the question of the house-space in relation to the number of occupants. There is a minimum amount of space, both superficial and cubic, which each adult person must have in order that health may be fairly maintained. Economy prohibits the maximum. The Legislature has taken this subject into consideration in connection with the sanitary supervision of the smaller houses of certain populous places. The reasons for this largely depend on ventilation. The following tables illustrate the amount of space given to children in the schools of different countries, and to adults in the poorer classes of houses:—

TABLE I.—SHOWING SCHOOL SPACES IN DIFFERENT COUNTRIES.

Country.	Superficial Floor Space in Square Feet.	Cubic Space in Feet.
Great Britain (Government Code) ...	10	100 to 140
London School Board	—	130
Dundee School Board	—	152
Canada	—	240
Belgium	10½	160
„ Educational League	17½	338
Holland (average)	—	131
„ Haarlem (average)	—	160
Bavaria (children of eight years) ...	—	137
„ (children of twelve years) ...	—	197
Dresden	7	152
Frankfort (Med. Society)	15½	300 to 325
Basle (Switzerland)	15½	148 to 165
Sweden (Primary schools)	16	188 to 266
„ (Higher schools)	17 to 23	271 to 352
America (New York City)	—	88 to 105
Columbia (Commission)	15	210
Massachusetts (State)	Demands that each pupil receive 1800 cubic feet of warmed fresh air per hour.	

Taken from a paper by the Author on "The Hygiene of Schools" in the *Sanitary Journal*, January, 1895.

TABLE II.—SHOWING CUBIC SPACE ALLOWED BY LAW.

Cubic Space allowed by Law or Local Regulations.	Cubic Space per Head.	Authority.
Board Schools under Education Act	80	Education Act.
Board Schools (minimum under New Code)	100	Education Department.
General School-rooms	130	London School Bd.
Graded Schools	117	,, ,, ,,
Dundee Board Schools—newest ...	152	Dundee School Bd.
Canadian Schools	240	Canadian Govmt.
Ordinary Dwelling-houses in Glasgow and Edinburgh, in one- and two-roomed houses—for adult	400	Glasgow Police Authority.
Two children under 10 ...	400	Glasgow Police Authority.
Common Lodging-houses	240 to 300	
Poor Law for healthy persons	300	
Poor Law for sick persons ...	850 to 1200	
Barracks	600	Army Regulations.
Army Hospital Wards	1200	,, ,,
,, Huts (free ventilation) ...	400	,, ,,
,, Hospital	600	,, ,,

CHAPTER II.

THE HOUSE WE LIVE IN.

THE SICK-ROOM.

In the preceding chapter the subject of "elbow-room" was partly discussed. A few words still remain to be said, however, on this subject. If two rooms contained 3000 cubic feet, and were occupied by a family composed of father, mother, and six children, the amount of cubic space available for each—even counting two of the youngest children as one adult—would be less than a room of 1000 cubic feet occupied by two adults. The amount of ventilation necessary to supply the two apartments with an adequate supply of fresh air must necessarily be much greater than that for the one apartment. This will be clearer when the subject of ventilation comes to be discussed, as will also the point whether it would be possible to safely ventilate these apartments in consonance with the health requirements of the inmates. Hence the relation of the amount of cubic space per individual to the possibility of ventilation becomes a question of great importance. It may be taken as an axiom that the smaller the apartment the greater is the difficulty of sufficient and safe ventilation; in like manner the smaller the amount of cubic space allotted per individual the more difficulty is ex-

perienced in solving the problem of supplying the necessary amount of air to maintain health. The cubic space of a room in reference to ventilation has always an important bearing on the health of the occupants at any period of the time of occupancy, and this bearing is a thoroughly practical one. It is quite true that in considering the theoretic amount of air required per person, the question of cubic space loses some of its importance at the end of the first hour of occupancy, but it is always of importance in reference to the practicability of supplying the necessary amount of air.

When illness of any kind enters a house, if the patient must needs be confined to bed, it becomes of prime importance that the room best suited for his treatment should be devoted to that end. Where there is comparatively little spare space in the house, it is often advisable to convert one of the sitting-rooms into a bedroom, particularly if it be more suitable in certain respects than the other rooms. If, however, the house be of more than one flat, usually a bedroom on the upper storey is preferable to one on the lower. The patient is less likely to be disturbed by household operations, the sick-room slops can be more easily disposed of in the adjacent bath-room, and the atmospheric conditions of the sick-room are liable to less disturbance, being further away from the doors opening to the outer air. The conditions which should be looked for in the required room are these, *viz.*, it ought to be well lighted by a window which is capable of being opened under certain precautions to admit of the entrance of fresh air; it should contain a good fireplace, which will exhaust the lower strata of air of the room when the fire

is in operation; and it ought to be convenient to the bath-room, for disposal of sick-room slops. Should there be anything in the nature of the ailment calling for special treatment the room should be chosen accordingly. If, for instance, the patient be a nervous one, or one suffering from insomnia, the situation of the room must be such as will procure the greatest amount of quiet. Here the question of light becomes of less importance, although that of ventilation remains. These general conditions will suffice for the ordinary run of illnesses. When, however, infectious disease makes its appearance in a house, not only is the same attention to be paid to the patient's comfort, but a new element enters into the problem, *viz.*, the comfort and safety of the other occupants of the house. Equally of importance with the care of the patient is the prevention of the extension of the disease to others, both inside and outside the house. Under these circumstances, the position of the room occupied by such a patient becomes of the chiefest importance. It must be removed as far as possible from the living rooms of the other occupants, and it must also be in proximity to the bath-rooms, so that sick-room utensils may be amply disinfected, sick-room clothing be steeped in germicide liquid, the patient be adequately supplied with water for cleansing purposes, and the nurse for disinfecting herself preparatory to taking exercise out of doors. Contagium is a particulate substance, and cannot pass through doors or walls. That is true. Wherefore, then, the necessity for all these precautions? Because this particulate matter is so light that it is easily airborne, and may be thrown into the common air supply

of the other rooms on opening and shutting the sick-room door; besides it adheres to everything that proceeds from the sick-room. Hence the above necessary precautions.

The duties of the nurse in the sick-room, in addition to those necessary for the personal comfort of the patient and to those laid down by the physician, include the proper ventilation of the room, and the maintenance of a suitable temperature, during her term of duty. The ventilation of the ordinary sick-room is by no means a simple matter; indeed, it is rather a difficult duty to perform. "Not at all," says some one; "it only means the opening of the window." If that were all, too much fuss has been made regarding ventilation. Opening of windows without special precautions, spells draughts; draughts mean danger to patient, if not, indeed, actual mischief. Suppose that the temperature of the room has been maintained at 65 degs. Fahr., and that the temperature of the outside air be about 30 degs. Fahr., the air—being so many degrees colder—will rush in by the opened window as does a torrent of cold water, with a quickened velocity, because of the difference of the two temperatures. This will become more apparent to the reader later. There are, however, ways by which safe ventilation may be obtained by means of the window, which will be discussed in due course.

So likewise is the maintenance of a proper temperature in a sick-room of great importance. A routine temperature, say 60-65 degs. Fahr., is not suitable for all classes of diseases. A room temperature suitable for a convalescent who cannot part safely with much

body heat would not be grateful to one suffering from high fever. In like manner a comparatively dry atmosphere would be less suitable to a "croupy" patient than a humid one.

These general considerations are set down to indicate how much less simple than is usually thought such points are.

THE NURSERY.

There was a time when any odd room in the house was thought good enough for the daily life of the little ones. Such a time is now, fortunately for the children, nearly over. The nursery ought, indeed, to be one of the best, one of the largest, one of the brightest rooms in the whole house, situated, perhaps preferably, in the top of the house, because very often there the light is best and most sunlight is to be obtained. After appropriate feeding, probably the next most important thing which is conducive to healthy child-life is abundance of light and sunlight. Like the plant deprived of sunlight which does not develop the chlorophyll—the green colouring matter—in its leaves, so the child grows up pale and sickly-looking; and not only sickly-looking, but actually in depreciated health. The Italian proverb, "Where the sunlight does not go, the doctor does," is very true; and the light seems as necessary for the proper development of the red colouring matter of the blood of the child as for the green colouring matter of the leaf of the plant.

In addition to the best light, let there be free elbow-room. The animal life of the young is considerable. Romping is as natural and as necessary as eating and

drinking, and, while confinement is irksome to all, it is much more so to the child.

Of equal importance to the two foregoing is the temperature of the nursery. Children are like sensitive thermometers ; their bodies register a falling temperature nearly as quickly as do these instruments. Parting with their body heat rapidly, they are extremely susceptible to outside frigifactive influences. Much harm has been produced from ignorance on this point, and many children have received fatal illnesses from mistaken notions on the part of parents and nurses in regard to the means necessary to make them hardy.

Well lighted, large spaced, appropriately heated, let the nursery be, and the children will thrive into vigorous health.

CHAPTER III.

THE HOUSE—SANITARY CONVENIENCES—LIGHTING AND HEATING—VENTILATION.

In every house which forms a connection with a public system of sewerage there must be conveniences for carrying off the "soil" and waste water. Where a public disposal system does not exist, facilities must equally be provided, but these, to some extent, may differ in character from the former. The waste water occasioned by washing, personal and domestic, and by culinary operations, together with the rain water which falls from the house tops (when it is not preserved), must be carried off by suitable pipes. The pipes which come from every fitting of this class ought to be united in a main waste-water pipe, which should reach from a point above the eaves of the house to a point close to the level of the ground. It is extended above the eaves to enable a current of air to pass through it, and so effect ventilation, and it opens below over a grated "gully," which is connected with the house drain, and is trapped. The pipes which form the waste-water system come from baths, lavatories, and kitchen sinks.

There must also be provision for carrying off the excretory products, or "soil" as it is termed, of the inmates. All of the pipes coming from fittings of this class ought to unite in a separate main pipe or "soil-pipe," which should also extend from above the eaves to a point below the ground level, where it enters the house drain through a "trap"; and the house drain, in its

turn, opens into the street sewer. These main pipes are attached to the outside of the outer walls of the house.

If the "fittings" of a house consisted simply of an unbroken continuity of pipes, foul smelling gases, etc., would find their way back into the house and produce ill-health and disease. To prevent such a contingency, "traps," as they are called, are placed at each "fitting," whether it be water-closet, bath, kitchen sink, lavatory, or house drain. A trap in its simplest form consists of a bend in a pipe in which water will constantly lie. The water acts as a "seal" or "trap" against the passage backwards of foul products. An essential feature of an efficient trap is a ventilating branch, which keeps the water of the trap "sweet," and prevents it being emptied by "siphoning". These points will be discussed in detail, later. The object of all traps is to completely cut off the atmosphere of the house drain and sewer from the house interior. The following diagram exhibits the points mentioned:—

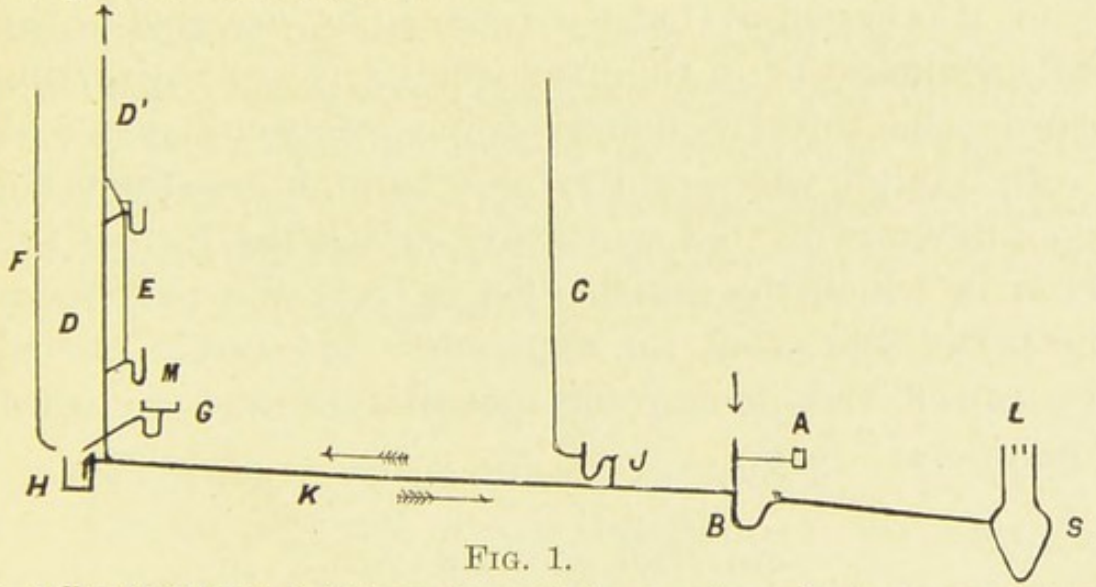


FIG. 1.

A, gully yard trap; B, trap on house drain; C, rain-conductor, trapped at J; D, soil-pipe; D', upper part of soil-stack, as ventilator; E, ventilating pipe of traps of closets M, and one above; F, rain-conductor; G, kitchen sink, opening into H; H, gully trap; K, house drain; L, ventilating grating over sewer; S, sewer. The arrows, on top of B and D, indicate direction of air current, and between K and B, of sewage current from house to sewer.

THE BATH-ROOM.

This apartment ought to be roomy, as not infrequently it lodges, in addition to the bath and wash-hand basin, a water-closet. It should be well lighted, and its window, or windows, must open freely to admit abundant air-flushing in all kinds of weather. All the pipes from each fitting should be uncovered. By no means ought they to be boarded up, as they only become receptacles of dirt. Open pipes, too, more quickly betray defects. In fitting up the bath-room we are at the mercy of the plumber, hence the necessity of employing a craftsman who knows his business, and who does it. The time is coming when no purchaser will buy, and no tenant will occupy, a house, unless and until a written guarantee over the signature of a sanitary official is provided, which will indicate that the property is in perfect sanitary condition.

Where cases of infective fevers are to be nursed at home, it is essential that the room to be occupied by the patient should be in the near vicinity of the bath-room, in order that infective materials may safely be disposed of.

In lying-in cases, on the other hand, unless the bath-room be known to be sanitarily perfect, the further the room in which the patient lies is from the bath-room the better and safer, for experience has amply proved the causal relationship of insanitation and so-called "puerperal" fever.

LIGHTING AND HEATING.

In cities, particularly in winter, it is almost impossible to obtain sufficient light in living rooms. This is one

of the penalties of civilisation, and is caused by imperfect combustion of coal in household fires. This produces a smoke-laden atmosphere, with resulting fogs. Inadequacy of light, too, is often due to too close building of houses and streets. Economic reasons are chiefly, in more recent days, to blame for this. No remedy of a reasonable kind can overtake these contingencies. Abundance of light is essential to health, therefore the more lightly windows are curtained and blinded during the hours of daylight the better for the occupants. While it is probably true that sunlight may destroy the colours of a carpet, it is of greater importance to know that it is probably the best provision of nature for the destruction of microbes.

Apartments are usually warmed either by (1) fires in open grates, now of various forms; (2) closed stoves; (3) gas fires; or (4) steam or hot-water pipes. They are all intended to protect the inmates against variable outside temperatures, and to preserve the walls of apartments against damp. The season of the year has only a general determining influence upon the amount of heat to be artificially supplied in our rooms. The need for artificial heat should always depend upon the difference of temperature at any given time, the determining factor being our sensations.

VENTILATION.

Ventilation is of the utmost importance. To ventilate a room properly means something more than the mere opening of a window. Scientific ventilation aims to achieve two objects, *viz.*: (1) to introduce a current of fresh air to replace the foul air at such a rate of move-

ment as will not operate prejudicially upon the occupants of a confined space, and (2) to introduce it in such an amount as will satisfy the physiological requirements of the occupants. The unchanged air of a room, or of a badly ventilated room, in other words, becomes odorous. We use the words "close," "stuffy," or "foul," to denote this characteristic odour, which is due to gaseous and other products given off from the lungs and skin of the occupants. Ventilation becomes increasingly difficult the more confined the space is; hence a small apartment is not so capable of safe ventilation as a large one. In an ordinary room where no special provision exists for ventilation the doors and windows act as inlets of fresh air, and the chimney, where a live fire is burning in the grate, as the outlet. Of this, however, we will treat more fully in another chapter.

CHAPTER IV.

AIR IN RELATION TO HEALTH—ITS COMPOSITION AND COMMON IMPURITIES—CUBIC AND SUPERFICIAL SPACE.

AIR is one of the prime necessities of life. Without it, animal and vegetable life could not exist, and combustion could not go on either in its chemical or physical aspects. All animals, whether they live in the ocean of air which surrounds the planet, or in the ocean of water which encompasses the land of which it is composed, demand air in one form or another for their existence. All animals may be divided into two main classes, *viz.*, those which inhale air *directly* from the atmosphere, and those which inhale air *indirectly*. To the latter class belong the myriads of animals which live in water. They obtain their supply from the air which is dissolved in the water, consequently their lives depend upon the efficient aeration of that fluid. A simple experiment with fish in a jar will demonstrate this.

We live at the bottom of an ocean of air. If in imagination we picture ourselves living at the bottom of the sea, where all around is water, we will be better able to estimate our position on the earth, where all around is air. Air, like water, is a fluid, and in several respects obeys the same laws. It possesses weight and elasticity, and is capable of contraction and expansion

by cold and heat. By our senses we can easily perceive the weight of water, not so with air. But the latter,

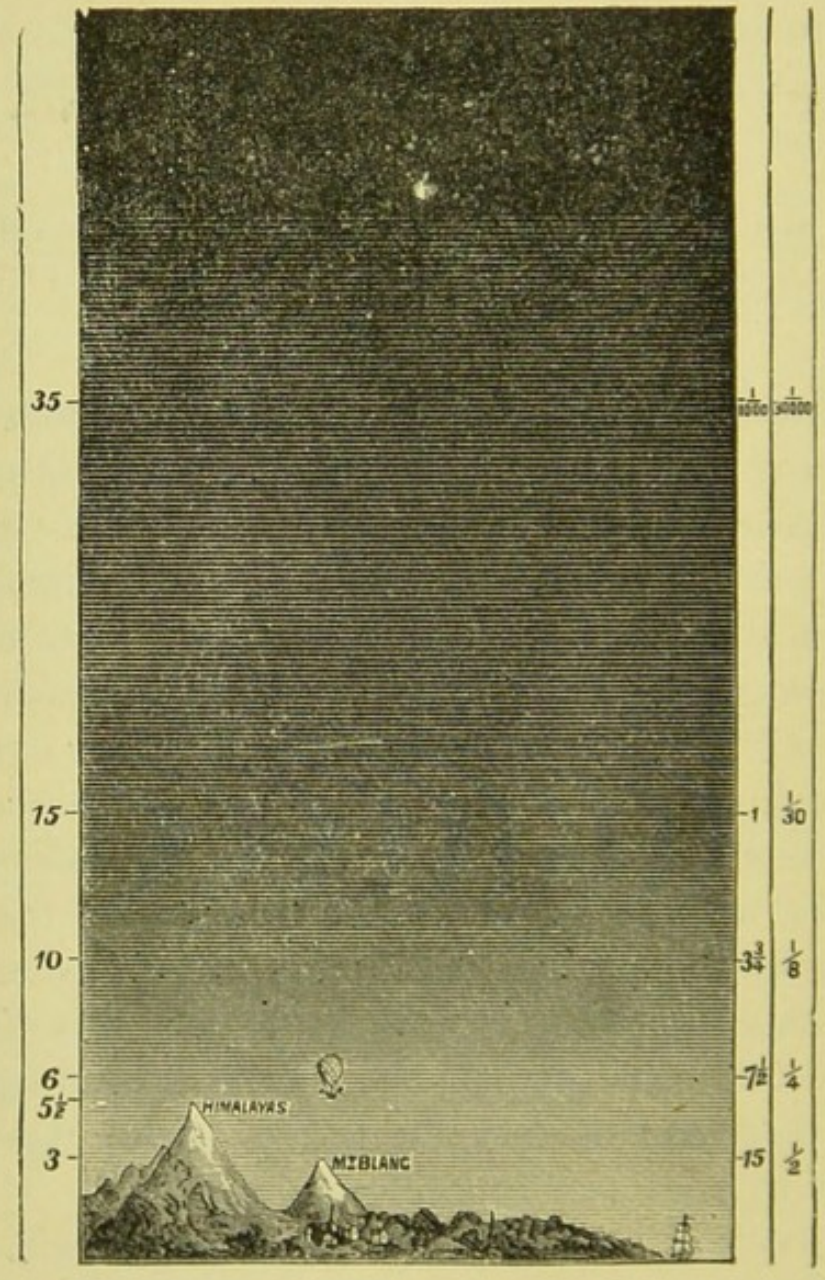


FIG. 2.

The figures on the right of the diagram represent the readings of the barometer in inches, those on the left the height in miles.

like the former, may be weighed in a balance. A cubic foot of dry air at 32 deg. Fahr., and at 30 in. of baro-

metric pressure, weighs 566·85 grains; a similar bulk of water, 61¼ lbs. If it is desired to measure the weight of the atmosphere on a large scale, that is effected by means of the barometer (Gr. *baros*—weight, and *metron*—a measure), or the weight-measure applied to air. When, for instance, the mercury in the barometer at the sea-level stands at 30 in. on the scale, a certain atmospheric weight or pressure is sustained, but if a hill about 2000 ft. in height is ascended, the mercury will now be found to stand at about 28 in.; and the higher the ascent the greater the fall of the mercury becomes. The reason for this is simple. As we ascend, the weight of the atmosphere becomes less, and, in consequence, presses with less force on the mercurial column. Hence it is, that if we could ascend three miles above sea-level, the barometric reading would be found to be but little more than one half of that at sea-level; or, to a height of five miles—about the height of the highest Himalayan peaks—to a little more than one-quarter of the sea-level reading. Fig. 2 illustrates this.

Atmospheric pressure—which varies from day to day and often from hour to hour—has a determinate influence on the health of the people. It has a direct influence on the "fiery" condition of coal mines; explosions occur more frequently when the pressure is great than when it is light. It is directly associated, also, with weather changes.

Air also possesses elasticity. If a thin glass globe be filled with air at 40 deg. Fahr., and sealed, and the temperature then raised to 100 deg. Fahr., the globe would be shivered into pieces. This is due to expansion of the contained air. Conversely, air may be compressed

into smaller bulk ; indeed, it has been recently liquefied so that it could be poured from one vessel to another. The usefulness of the aneroid barometer depends upon this phenomenon of expansion and contraction of air.

COMPOSITION OF AIR.

Pure air consists of a mechanical mixture of certain gases. It is not a chemical mixture. The difference between the two is very distinct. In a mechanical mixture the component parts retain their individual identity, and do not form new compounds. In a chemical mixture the constituent parts lose their identity, and become transformed into new compounds. However intimately we grind together salt and sugar, they will remain for all time as a mechanical mixture of salt and sugar; and the same would happen if they were dissolved in water. If, on the other hand, we put some clear lime-water into a bottle, and breathe into it, the water will now become milky, owing to a new substance having been formed by the union of the carbonic acid of the breath and the lime-water. This would be a chemical mixture.

The gases of which air, in its purest form, is composed, are oxygen, ozone, nitrogen, carbonic acid, and watery vapour in a gaseous form. In 1000 volumes of such air oxygen = 209·6 + nitrogen = 790·0 + carbonic acid gas ·4 = 1000. The amounts of watery vapour and ozone are very variable. Volumes may be called pounds, ounces, gallons, or any other measure or weight, since these proportions are relative in any amount in any measure or weight. By shifting the decimal point one place to the left, percentages are obtained. Oxygen

is the vital constituent of air. By it combustion in any form is sustained, and it is the source by which the blood in the lungs is purified. The act of breathing consists essentially of inspiration, *i.e.*, the taking-in of air, and of expiration, *i.e.*, the out-putting of air. In the former we inhale fresh air, in the latter we exhale foul air. The composition of expired air is therefore very different from that of fresh air. In 1000 volumes of it, oxygen = 169·2 + nitrogen = 790·4 + carbonic acid gas = 40·4; together with watery vapour and organic matter. The nitrogen serves the useful purpose of diluting the oxygen for the needs of the body. It is an important agent, also, in plant nourishment, being, in thunderstorms, converted into such a form as to enable plants to assimilate it. Carbonic acid gas may be deemed, so far as man is concerned, a normal adulterant or impurity of air, but it also serves a useful purpose as plant-food, as during sunlight the green-colouring matter of plants splits it up, absorbs the carbon, and liberates the oxygen. Probably, therefore, for plants it is an essential atmospheric constituent.

IMPURITIES OF AIR.

These may be divided into two main classes, *viz.*, (1) those that are particulate, and (2) those that are gaseous. The cause which chiefly determines the amount of both is the congregation of persons in a limited area. In populous places, the former class mainly consists of unconsumed particles of coal-soot, débris from the tear and wear of the bodies of men and animals, of the streets, and from industrial operations, of both inorganic and organic composition; and micro-

organisms. The second class is composed chiefly of the gaseous products of combustion and of chemical works —these being mainly compounds of ammonia and sulphur of different chemical compositions. Hundreds of thousands of tons of these gases are computed to be given off annually into the atmospheres of large cities. Carbonic acid gas is also largely increased in these circumstances. In foggy weather, in Manchester, London, or Glasgow, this gas may be increased from four to seven parts per 10,000 of air. The air of a populous place is, therefore, notably more impure than that of the open country or the sea. In like manner the air of an occupied room becomes impure by increase of carbonic acid gas, watery vapour, and organic matter. In schools, for example, this gas may be found present from five to ten times more plentifully than in pure air, and organic matter twenty times more.

SPACE IN REFERENCE TO AIR SUPPLY.

By superficial space is meant space multiplied into two dimensions, *viz.*, the length by the breadth; by cubic space, into three dimensions, *viz.*, length by breadth by height, or thickness. Feet multiplied by feet equals square feet, and feet × feet × feet equals cubic feet. Both measurements are of great importance in reference to air supply, the one as much as the other. Superficial space in reference to a room is often called floor-space or floorage. The cubic space of a room is obtained by multiplying the length by the breadth, and the product by the height. In considering the dimensions of any room in reference to ventilation, regard must be had to each dimension. This is true of

rooms whether occupied by the healthy or sick. In the latter case, however, each dimension of space must be increased, and particularly so in infectious hospitals, where the minimum amount of superficial space per patient ought to be 144 square feet, and of cubic space, 2000 feet.

CHAPTER V.

VENTILATION—ITS PRINCIPLES—DETECTION OF AIR IMPURITIES.

We frequently speak of an empty room, but, in relation to ventilation, a room is never empty, since all its available space is filled with air. Whether its total capacity is filled with air or not will depend upon whether or not part of its air space is occupied by solid substances, such as solid articles of furniture; and since no two portions of matter can occupy the same space at the same time the solid article takes up its own bulk of air space. It is important that this simple fact should not be forgotten. Ventilation begins to have importance when a given column or body of air, bounded on four sides by walls, the openings in which bear but small proportions to the total superficies so bounded, requires to be more or less frequently changed in a given period of time. In the open, ventilation goes on unimpeded. It is only when artificial obstacles to the free interchange of currents of air are imposed that means must be devised to overcome the difficulty. It is of importance that the chimney of a room should "draw" well, else the up-draught will not be sufficient to carry off the fire-smoke; hence it will cause a smoky room. How much more important, then, is the question when the processes of combustion within the

body require attention. To sustain life we must breathe. An average adult male person inspires 30·5 cubic inches of air at each breath, and he inspires about seventeen times per minute. A simple calculation will, therefore, enable us to arrive at the total amount of air used in twenty-four hours, *viz.*, 30·5 × 17 × 60 × 24 = 746,640 cubic inches of air, or 432 cubic feet. Women and children inspire less than the adult male. Hence, however insignificant in percentage amount any given impurity in the air may appear, in the light of the total daily requirement, it assumes considerable importance.

In an inhabited room the chief causes of impurification of its atmosphere are (1) its human occupants, and (2) artificial lights. Both need oxygen for their sustenance. The impurities from the human being proceed from the lungs and skin, and from artificial lights, from the combustion of the lighting medium, gas or oil. As has been shown, the amount of carbonic acid gas given off from the lungs is 101 times greater than that found in the same volume of pure air, and, in addition, expired air contains organic débris from the lungs in a state of incipient putrefaction. Both are hurtful to health, the latter more so than the former, but riddance of both is at the same time desirable and necessary for health. The odour imparted to an impure atmosphere is solely due to this organic matter, and not to the carbonic acid gas, but the amount of the latter in any atmosphere is approximately a measure of that of the former.

A very simple experiment will demonstrate the need for a supply of fresh air to support combustion. Place a lighted candle on a soup plate, partly filled

with water, and cover the candle with a thin glass bell-jar. The candle will burn only as long as there is air present in the jar, and will go out in a few seconds. In imagination, substitute for the candle a mouse or a man, and for the bell-jar a sealed glass case or an air-tight room, and the result will be extinction of the light of life. The Black Hole of Calcutta and the steamer "Londonderry" afford the requisite proof. Between the condition of no ventilation and one where it is free and faultless we must place our living rooms and public buildings. Bearing in mind that the problem of ventilation consists of supplying in a given space to a given number of persons in a given time an adequate supply of fresh air, without draught, the difficulty of solution begins here. Physiological requirements indicate 3000 cubic feet of pure air per hour as the supply to be aimed at, and the rate of movement of the supplied air must not exceed, for delicate persons, 1½ to 2 feet, and for average persons 2½ to 3 feet per second, unless the air be warmed, in which case the velocity may be raised from 5 to 8 feet per second. This is the crux of the problem, and hence it is that the cubic space per person assumes great importance. Suppose two rooms, each of 1000 cubic feet capacity, be occupied by one and by four adults respectively, a little calculation upon the foregoing data would show that, means of ventilation being provided, the necessary amount of air could be for the one person supplied at a velocity of less than one foot (·8) per second, but that for the four persons the needed supply of air would require to have a velocity of 3⅓ feet per second; in the former case, therefore, the air would enter without

draught, but in the latter it would be perceived as a draught, and would be, therefore, harmful.

The average adult gives off, in ordinary circumstances, at least ·6 of a cubic foot of carbonic acid gas (CO_2) per hour, or 14·4 cubic feet per twenty-four hours. It is an odourless gas. As has been shown, in pure air CO_2 amounts to ·04 per cent., or four parts per 10,000 of air. This is called original or "initial" impurity, because this percentage is found in the purest air. The disagreeable odour imparted to an imperfectly ventilated room is due to the organic matter from the lungs of the occupants. The proportion of CO_2 in a room given off by respiration is called the "respiratory" impurity, and is that amount in excess of ·04 per cent. (When artificial lights are burning, as at night, they also contribute their share of this gas.) The total impurity in the air of a room is therefore made up of the CO_2 from the lungs of the occupants, and the CO_2 found in the air normally; or, in other words, the "initial" plus the "respiratory" impurity equal the total impurity. When the proportion of CO_2 from the lungs is less than ·02 per cent. no disagreeable odour is perceived, above that proportion odours become perceptible; thus ·04 per cent. gives a "stuffy" odour, ·06 per cent. an offensive odour, and ·08 per cent. a foul, sickening odour. Beyond this the sense of smell fails to distinguish. In the presence of the latter proportions flushings, faintness, headache, or even sickness affect the occupants. We, therefore, aim to have in our rooms not more than ·06 per cent. of this gas (CO_2), of which ·04 per cent. is "initial," and ·02 per cent. "respiratory" CO_2.

DETECTION OF IMPURITIES IN AIR.

The best ordinary test for these is the sense of smell, exercised on entering the room from the open air. In so far, then, as the odour of a room is in some measure an approximate test of the amount of CO_2 present the test is valuable. To estimate the amount by chemically accurate methods is beyond our present object. But there are two comparatively easy and approximately correct modes of doing so, called the methods of Angus Smith and of Lunge-Zeckendorff. The former consists of a series of stoppered bottles, measuring respectively 20, 10½, 8, and 6½ ounces. The chemical substance to be used is a tablespoonful (½ ounce) of clear lime-water. The test is used as follows: into the 10½ ounce bottle put ½ ounce of lime-water, stopper, and shake contents vigorously for a minute. Should the clear liquid have become turbid, the sample of air contains more than ·06 per cent. of CO_2; if no turbidity results, it does not contain more than this proportion. The following figures will guide to the use of the other bottles:—

Size of bottle in ounces.	No precipitate. CO_2 per cent.
20½	·03
10½	·06
8	·08
6½	·10

The Lunge-Zeckendorff method requires a certain chemical knowledge, but is, in practice, owing to a table of instructions which is provided by the makers with the apparatus, almost mechanical. The apparatus consists (1) of a bottle of certain cubic capacity, stop-

pered by an india-rubber cork perforated in two holes through which pass two glass tubes, one of which is connected with a rubber-ball of definite capacity by means of rubber-tubing; and (2) a "standard" solution of carbonate of soda, coloured pink, with an "indicator" called "phenolphthalein". To use the apparatus, a definite quantity of the prepared solution is put into the bottle, its attachments are fixed, and the rubber-ball is compressed and released alternately so as to slowly force the air through the solution in the bottle, shaking the contents after each ballful, until the pink colour practically disappears. Reference to a given table shows from the number of ballfuls used the percentage amount of CO_2 in the air examined. Our experience of the apparatus warrants us in saying that it is a fairly reliable approximate guide to the atmospheric CO_2 present. This apparatus, composed of the foregoing constituent parts, may be purchased, along with the necessary chemical solutions, and with it a table of instructions is given.

CHAPTER VI.

METHODS OF VENTILATION APPLIED TO ROOMS, LARGE BUILDINGS, AND HOSPITAL WARDS.

ALL schemes of ventilation that have yet been, or may yet be, advanced are separable into two main divisions, depending on the motive power which originates them. The one division has its motive power in the ordinary forces of nature, the other depends on some form of artificial mechanical aid. The former is known as *natural* ventilation, the latter as *artificial* or mechanical ventilation. Natural ventilation is effected (1) by the law of the diffusion of gases, and (2) by the motion which is set up between two columns or bodies of air of different temperatures and pressure. By the former law we find that gases of different densities (or weight) will eventually mix uniformly, even against the law of gravity; hence the uniformity of composition of the atmosphere; and practical evidence of the latter is afforded by the motion of the atmosphere which we call wind, or by the ascension of smoke in the chimney. Gases expand by heat and contract by cold, and the amount of expansion of a gas for every degree of increase of temperature is at once definite and determinable. For every increase of temperature of 1 deg. Cent., a gas expands $\frac{1}{273}$ part of its volume, and for 1 deg. Fahr. above 32 deg., $\frac{1}{491}$ part; or, expressed in decimal fractions,

for every degree Cent. the volume of a gas will become 1 + ·00366, and for every degree Fahr. 1 + ·002. As a gas expands, its increase of bulk demands more space and it causes the air which surrounds it to move. Varying degrees of pressure, too, cause air movements. When the wind blows across a chimney-top it causes a partial vacuum in the chimney shaft, and a consequent upward movement in the air of the lower part of the shaft. This action is well illustrated in the ordinary spray apparatus. The steam which issues from the horizontal tube creates a partial vacuum in the perpendicular tube, and causes the medicated fluid to rise and become mixed with the steam.

MECHANICAL VENTILATION.

All schemes of this class are divisible into two subdivisions, *viz.*, (1) those where the fresh or pure air is forced into a building under pressure—hence called the propulsion or *plenum* method, and (2) those where the foul air is drawn out—known as the extraction or *vacuum* method.

Fig. 3 exemplifies natural ventilation, and air motion induced by unequal temperatures. As the plenum and vacuum methods will be discussed later, the problem of ventilation of a sick-room may now be considered.

In the average ordinary room the only available means of ventilation are (1) the door, (2) window, and (3) fireplace. With a fire in the room, the two former act as inlets, the last as outlet, extracting the foul air, as in the above figure. Through a small grate, from three to five cubic feet of air per second will

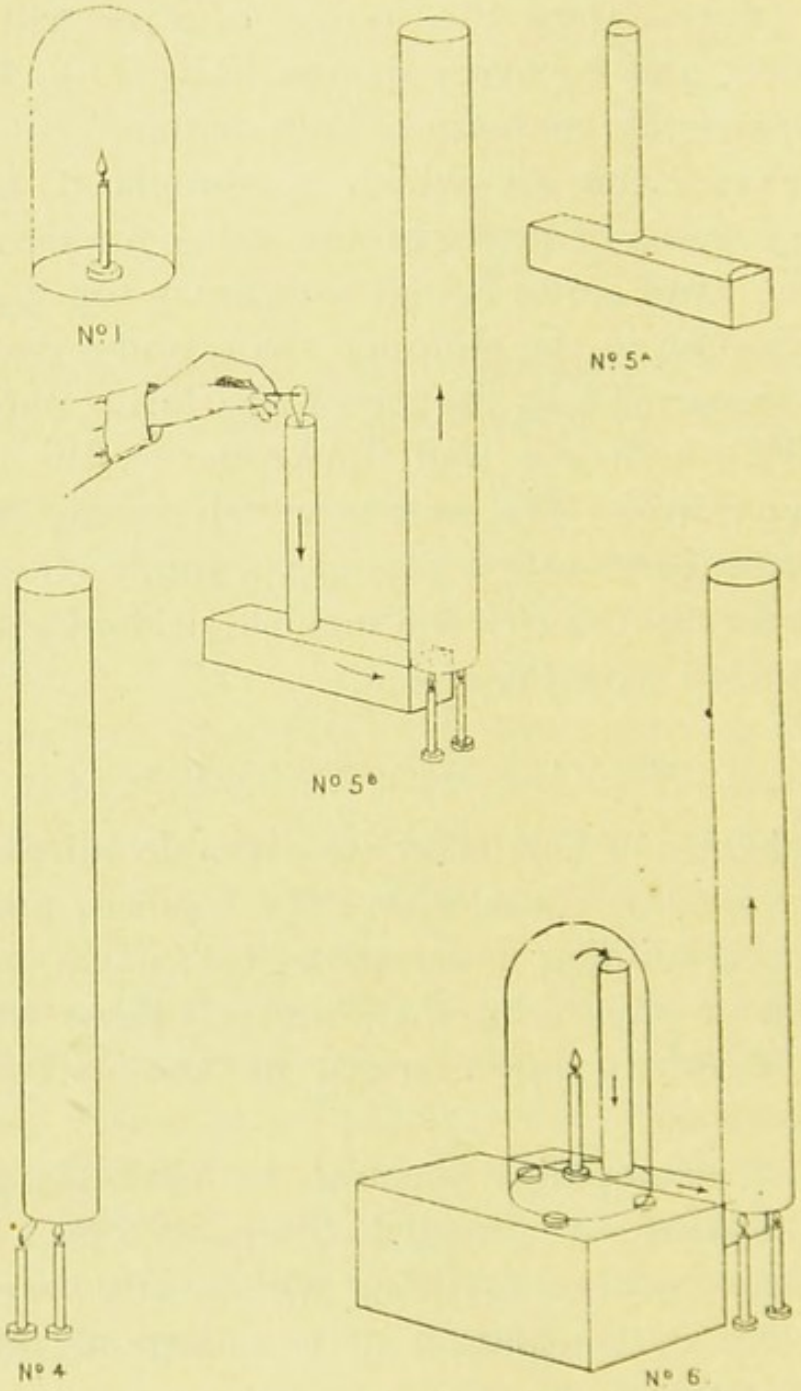


FIG. 3.—Represents simple apparatus by which the student may experiment to prove the principles of ventilation by extraction or vacuum at very small cost.

The whole apparatus consists of a bell-jar, cardboard funnels varnished, and an air-tight cardboard box into which is fitted a small funnel as at No. 5 A, and out of the top of one end of which a crescent opening is cut. *First Experiment.* To prove that combustion or respiration ceases when fresh-air supply is cut off. Under a bell-jar (No. 1), placed in a shallow vessel containing a little water, place a lighted candle. The candle goes out as soon as the oxygen of the contained air is used up. *Second Experiment.* Place the bell-jar on a flat surface and raise it by placing three pennies under it, at

pass, while through the ordinary grate, from five to eight cubic feet; that is to say, in the former from 10,800 to 18,000 cubic feet per hour, and in the latter from 18,000 to 28,800 cubic feet in the same time. To meet this, air rushes in from crevices around windows and doors and through flooring-joints. The atmosphere of a room is practically divisible into two different layers, the lower reaching from the floor to the level of the artificial lights, and the upper from the lights to the ceiling. By reason of the door and window currents the coldest parts of a room are in lines drawn, between these points and the fire-place, in straight paths. The lower stratum is, therefore, some degrees colder than the upper, and is often too well ventilated—draughty—while the upper is practically unventilated unless by the diffusion of gases. In a room without a fire the body-heat of the occupants determines the same currents, but at a less rate of motion, and upon

equidistant points. The re-lighted candle again quickly goes out, for the reason that no current of air is established. *Third Experiment.* Make a cardboard funnel about two feet long as at No. 4. Varnish it to make it air-tight. Place one candle, lighted, under the funnel; the heated air rises, and a current of air is set up round the bottom of the tube, which may be demonstrated by placing a second lighted candle just outside the edge of the funnel, when the flame will be drawn into the lumen of the tube without burning the funnel. *Fourth Experiment.* Place No. 4 and No. 5 A together, as at No. 5 B, the long funnel just covering the crescentic opening in the box. Place the candles as in No. 4. A current of air will immediately be set up from the small funnel through the box and up the large funnel. This current may be visibly demonstrated by holding a lighted taper or smoking brown paper over the mouth of the small funnel. *Fifth Experiment.* Place the bell-jar and other parts of the apparatus together as in No. 6. Light one or more candles under bell-jar, when they will be found to burn as long as they will last, showing that the products of combustion are carried away by the current set up in the direction of the arrows, the motive power being the heated air in the long funnel. This roughly demonstrates the mode of ventilation of the House of Commons, if for the members of Parliament you substitute candles, for the House itself, the bell-jar, for the foul air shaft, the cardboard box and small funnel, and for the clock tower and furnace, the long funnel and the lighted candles at its base.

occasion, in summer, in basement flats, the chimney may act as an inlet of air. The general principle always to be kept in mind is, that a colder body of air always moves in the direction of a warmer, and with a degree of velocity corresponding to the relative difference of temperature; the greater the difference in temperature the higher the velocity. Ventilation of the sick-room is one of the most important duties of the nurse, and she ought to be able to exercise some ingenuity to effect this object. The first point to consider is the position of the bed of the patient relative to the window, door, and fire-place. If the plan of the room permit, the bed ought not to be placed in a direct line between door, or window, and fire-place. It ought to be in the leeway of both, outside of direct air-currents. If this, however, cannot be avoided, direct draughts must be prevented by the interposition of a screen or curtain. The ventilation of the room may be effected either fitfully, *i.e.*, for brief periods every hour, or steadily and continuously throughout the day and night. Under the former plan probably the simplest and safest way is to half open the door, pull down the upper window-sash for a distance the extent of which must be regulated by outside weather conditions, and cover this by the blind, a few inches below the level of the opened sash, in order to break any direct draught. Protect the bed by a screen. Leave the sash open for about five minutes at a time, and repeat from two to four times per hour. Any plan, however, which would enable ventilation to go on continuously is obviously better. To this end various expedients have been suggested, which are usable in

ordinary sash windows. The plan of Hinckes-Bird is very simple and easily applied. It consists in placing



FIG. 4.

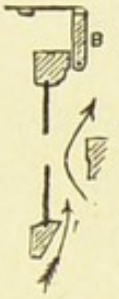


FIG. 5.

A is block of wood at bottom of window; C is the upper part of lower sash; the long arrow shows the direction of air current, and the small arrow passes through a conical hole in lower part of upper sash—an addition sometimes made, but not suitable for town houses where air contains "blacks". By varying the size of block A, the size of interspace is regulated.

Fig 5 shows another method of producing a like result. B is a metal plate affixed to upper part of window frame, which enables upper sash to be pulled down without top draught, and creates interspaces as in Fig. 4.

a block of wood, varying in thickness, on which the lower sash will rest, at the bottom of the window. This has the effect of separating the sashes at their junction, and enables air to pass inwards between the sashes. Fig. 4 illustrates the effect produced.

Very little expense and trouble might upon emergency simplify window ventilation. If, for example,



FIG. 6.

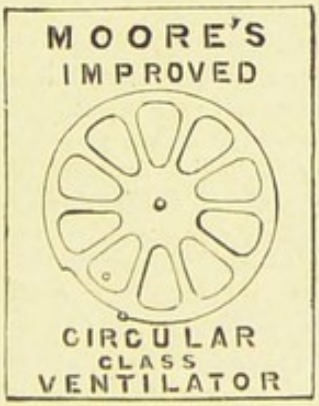


FIG. 7.

Moore's louvre, or circular glass ventilator were fitted into a window frame, draughtless ventilation may be

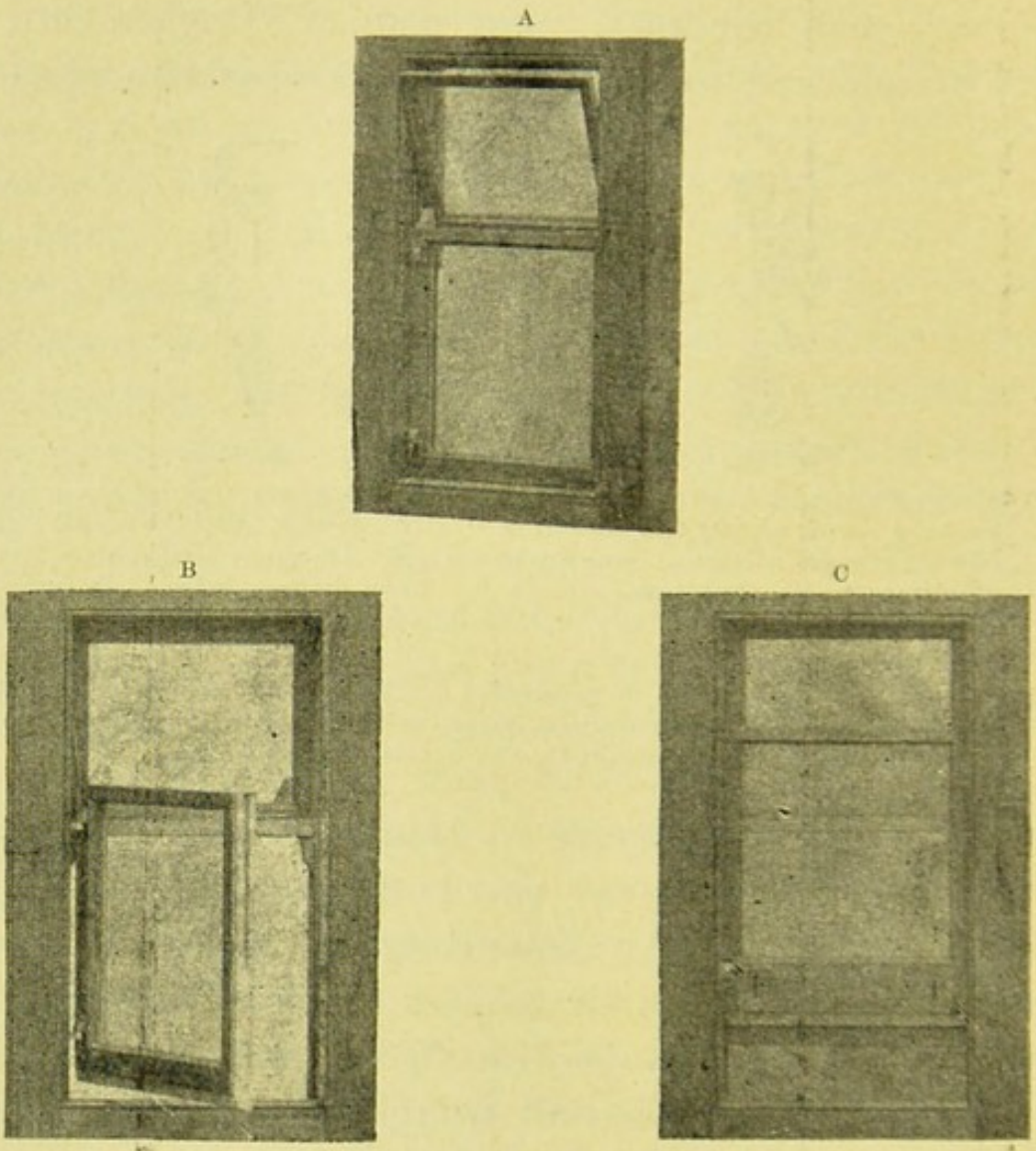


FIG. 8.—To show new methods of window ventilation suggested by the author.

The above are photos of four feet long working models for teaching purposes. Fig. A may be made to act as an ordinary sash-window, with up-and-down movement; or the upper sash to act as a hopper, as shown in A; or the lower sash to act as a hinged window, as in B. This is effected by means of sunk movable hinges in side of window frame, the sockets of which are screwed into side of sash. By means of these two movements, therefore, differing degrees of room ventilation, according to weather, may be obtained, and besides the whole window may be cleaned by a servant from the interior of the apartment. C shows the author's modification of the Hinckes-Bird arrangement. In the latter system a series of blocks of different thickness is required to regulate the amount of inter-sash ventilation on account of weather. In the author's plan one block, which is always at hand, serves for all weathers. This is effected by counter-sinking into the lower frame of the lower sash a movable teak block, which may be lengthened or shortened by means of two screws working in brass slots. When this block is pushed "home" it is "flush" with the level of frame.

effected. (Figs. 6 and 7.) The louvre ventilator may be opened according to necessity, and in like manner the circular, which in Fig. 7 is shown closed.

Another excellent plan is to substitute for the upper half of the window Hatton's hopper window ventilator, which not only prevents direct draught, but at the same time screens the air of particles—a desideratum in smoky cities. (Fig. 9.)

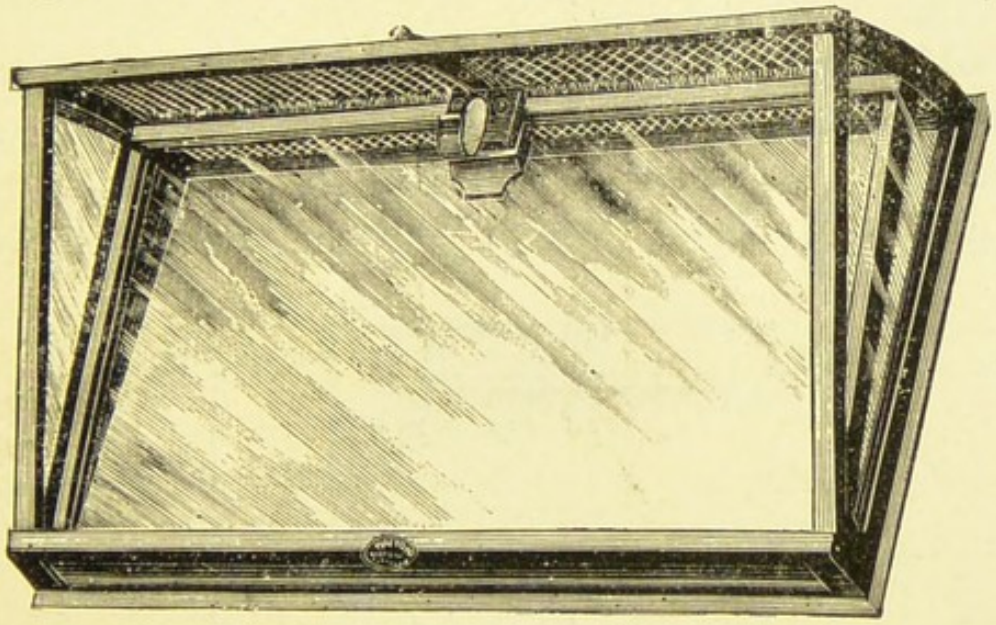


FIG. 9.—Hatton's Hopper Window Ventilator.

By means of the hinge, shown in upper part of diagram, the hopper may be pulled room-wards at will, thus regulating the amount of air that will pass inwards. The incoming air is screened of sooty particles, by the fine, meshed copper gauze, which by the action of a brush along the whole upper length of the hopper, as the hopper is moved, are brushed off. In this way the smoky air of a town is freed of "smuts".

Various other modes have been suggested, such as double windows, perforated panes, and double-glazed panes, where the outer pane has a bottom gap and the inner an upper gap; but in smoky places they are decidedly objectionable, because of the "smuts" accumulating in the interspaces, which cannot easily be cleaned.

CHAPTER VII.

VENTILATION—MODES APPLICABLE TO LIVING ROOMS, LARGE BUILDINGS, AND HOSPITALS.

In addition to means of ventilation applicable to ordinary window fittings, we ought to be acquainted with special modes, so that we may intelligently know how to use them, when present. Of the special forms of

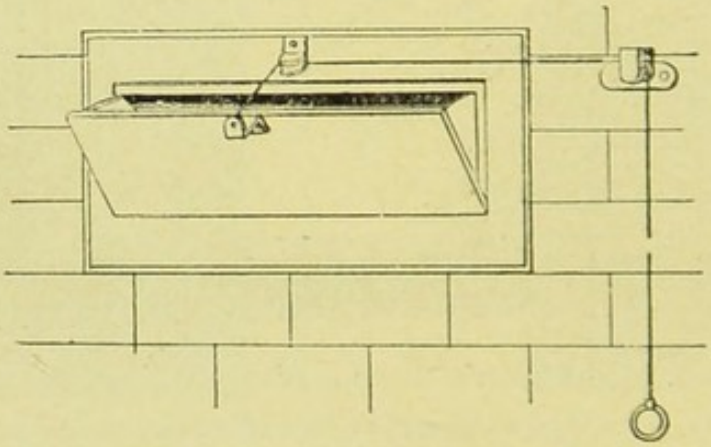


Fig. 10.—Sheringham Valve in position in wall.

ventilators, Sheringham's valve, Hatton's screen valve, and Tobin's tube deserve some notice.

They are inserted into the outer wall of a room, so that one end communicates with the outer air and the other with the apartment. In the two former, the admission of air may be regulated by closing or opening the valvular opening, and in the latter, by a screen in the throat of the tube. Ventilation is also effected into the chimney by valve openings which open into it close

to the ceiling of the room. Arnott's, Boyle's and Buchan's valves are some of these. The valves, made of mica, or silk, are so laid that they only permit of the air passing from room to chimney. These act as outlets of foul air, the former as inlets of pure air.

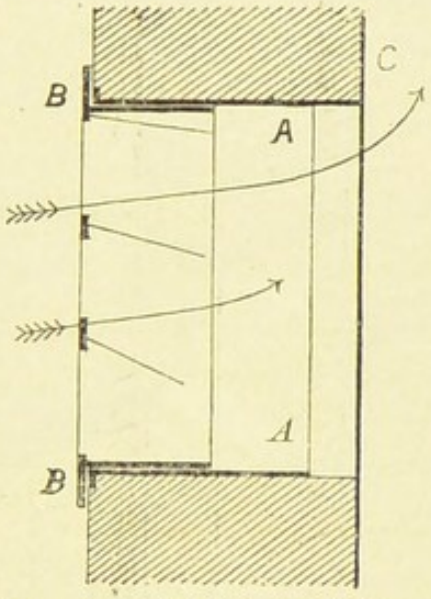


FIG. 11.—Chimney Valve, by which foul air from upper level of room is passed into chimney.

B B, inner surface of room-wall. A A, valve box; C, chimney. Arrows indicate direction of air current.

LARGE BUILDINGS AND HOSPITALS.

Until recent years most of the large buildings and the older hospitals of this and other countries were singularly defective in means of ventilation. Nowadays ventilation is rightly put in the forefront of the constructor's design. It may be said of any large scheme of ventilation that none is in the least likely to be successful which does not unite the problems of heating and ventilation. This combination enables larger quantities of air to be sent into a building in the same time, and with greater safety, since the air is warmed.

In towns and cities it is essential that such air be screened of its sooty particles. Hence, to effect this, it is necessary to employ mechanical aids to ventilation —so-called artificial ventilation—whether it be by revolving fans, jets of water, or the expanding force of compressed air suddenly liberated.

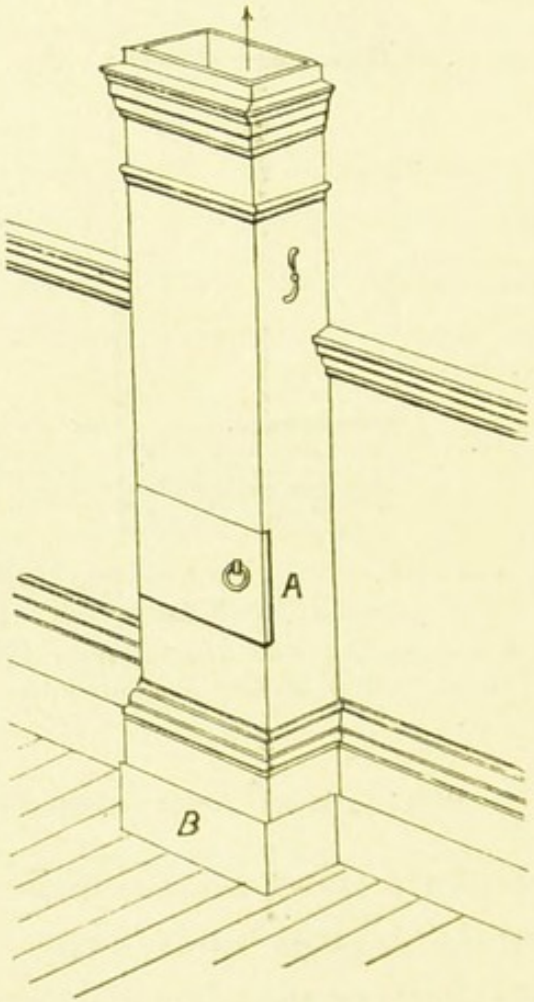


FIG. 12.—Tobin's Tube in position.
A represents a sliding door to permit air to enter at that level if wanted; *f*, handle for regulating amount of incoming air.

Mechanically-aided ventilation schemes are (1) those where fresh air, washed and warmed, or warmed without washing, is propelled into buildings and the foul air driven out by special channels; or (2) those in which

the foul air is extracted, the fresh air entering to fill its place. In the former the motive power acts at the beginning of the air circuit, and in the latter at the end; and in the former that motive power must be some form of mechanical force, whereas in the latter it may be mechanical force—as a fan—or the extracting power of a fire or furnace. The following diagrammatic figure will assist the student:—

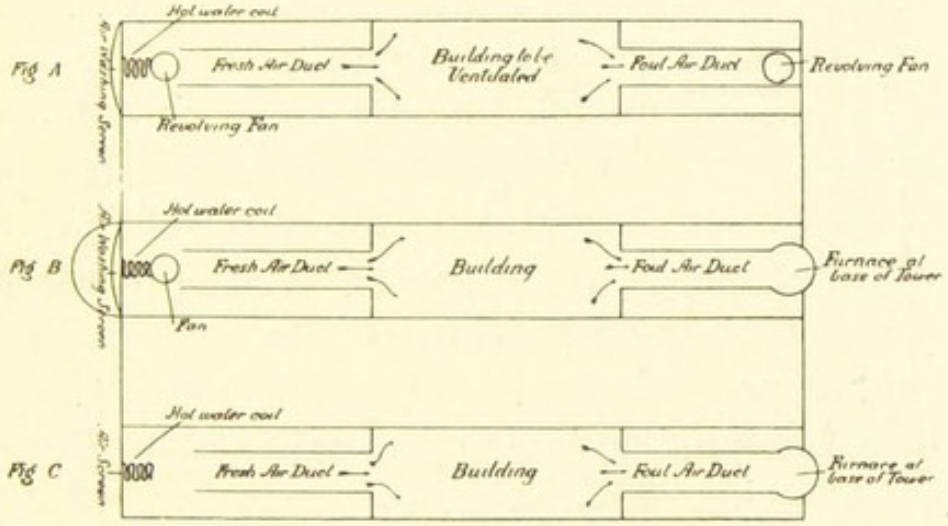


FIG. 13.

A, the air-propelling and extracting forces are fans, acting in direction of arrows; B, the air-propelling force is a fan, the extracting force a furnace at base of tower; C, the air-extracting force is a furnace, by which air is drawn through whole circuit, or it may be replaced by a revolving fan.

Regarding the respective merits of the propulsion and extraction methods, much difference of opinion exists. Each has merit, and each its probable defect. Of the two, efficiency would appear to be on the side of the propulsion method, because of the steadiness of its action. In Key's propulsion system, *vide* Fig. 65, the air is washed and screened by being passed through a screen composed of fibre, which is constantly kept damp by an automatic dripper; it is then warmed and propelled forward, free of "smuts," into the building. Our

observations of this system, as carried out in the Victoria Infirmary, Glasgow, enable us to say that it provides (1) clean air, (2) evenly warmed air, and (3) a steady supply. The air is warmed in passing over and through steam coils of sufficient radiating surface to give all the heat required, and which may be regulated according to necessity. The same system can provide cooled air in hot weather. Closed windows—double if necessary—and double, or, if single, tight-fitting, doors are requisite in this system, so that the circuit of air may be subjected to the minimum disturbance in its course. Indeed it may be said of both systems, in order that they should work efficiently, that the nearer the building to be ventilated conforms to the parallel of a tight-fitting box with suitable openings, the more thorough is the ventilation. Open windows and doors destroy, in great measure, the continuity of air-current, and are the prime causes of failure and inefficiency.

The source of air-supply in populous places is always a matter of importance where the air is not washed and screened. Air is always more foul the nearer to the surface of the ground. For this reason the supply is sometimes obtained by high towers, as in the French House of Deputies and the Madison Theatre, Melbourne. The British House of Commons obtains its air-supply from, practically, the ground level. The advantage of washing the air is best seen in foggy weather. In the Victoria Infirmary the atmosphere is perfectly clear, although a dense fog may prevail outside.

The following diagram shows the plan of a school in which the foul air (the fresh being warmed but not screened, at its entrance to the building) is extracted

from the various school-rooms by means of ducts which lead to the main outlet shaft in the roof, the extracting

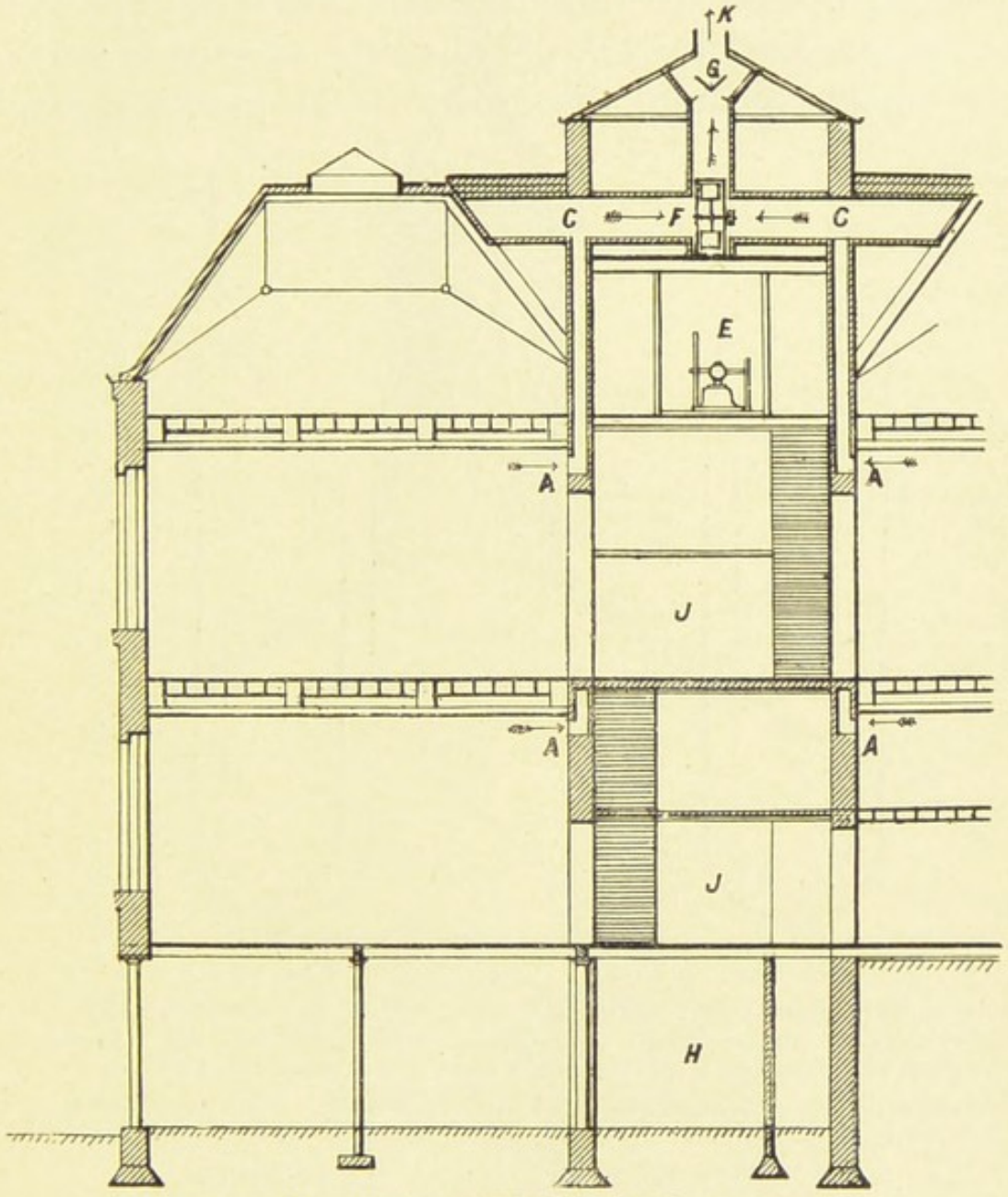


FIG. 14.—Ventilation of Hillhead School, Glasgow.

A, A, A, A, outlet ducts for foul air; C, C, passages to the fan; F, fan-propeller; G, K, main outlet shaft from fan; J, J, staircase; H, air-warming chamber in basement, from which shafts communicate with each room opening at floor level.

force being a fan, worked by a gas-engine. This is an example of the *extraction* or *vacuum* principle of ventilation.

Attempts have been made to adopt the plan of washing and warming the air in the ventilation of clubs and dwelling-houses. It cannot be said that they have been, as yet, successful. The plan usually adopted is to take the outside air from the ground level, pass it through

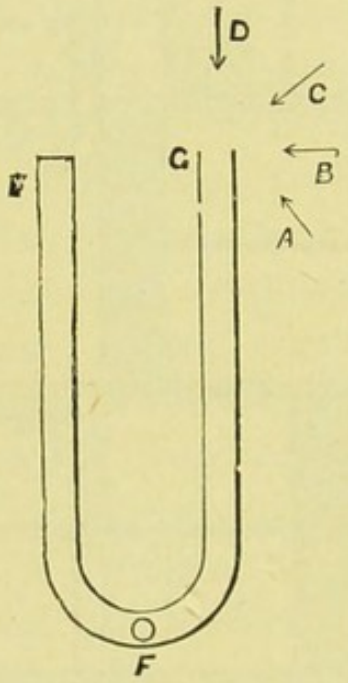


FIG. 15 A.

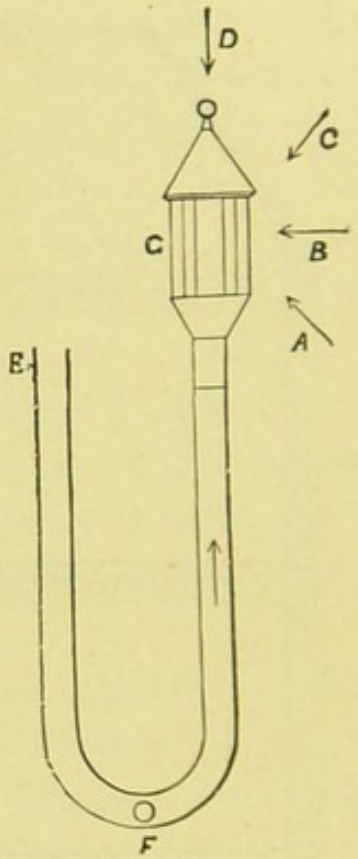


FIG. 15 B.

A is a bent glass tube containing a small ball of fine cotton-wool, F. If a current of air be blown over G from A or B, the ball will traverse the glass tube between F and G; but if from C or D, then from F to E.

B represents experimental tube fitted with fixed cowl. If air be blown from A, B, or C, the ball of cotton, F, will rise in direction of arrow to G, the cowl.

revolving water-spirts situated in the walls of the building, then through and over hot-water coils, until it reaches the apartment through a grated opening at the top of an artificial dado. Such a plan is exposed to the attendant risks of frost.

Means have also been devised to supply living rooms

with warmed air by utilising the spent heat of the fire or stove. By means of a special duct either surround-

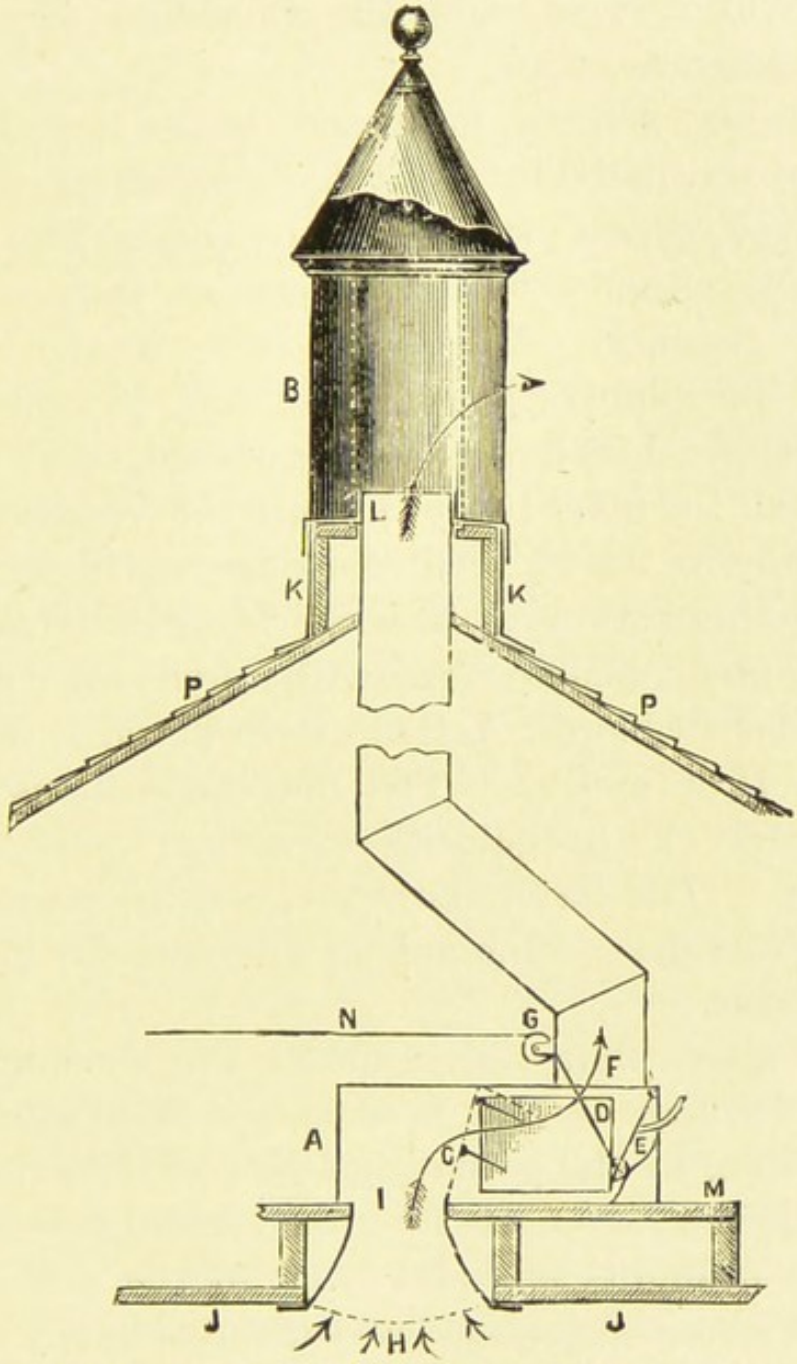


FIG. 16.—Buchan's Induced Current Fixed Ventilator.

A, valve box by which air may ascend, but cannot descend; B, fixed ventilator; C, silk valve; L, shaft; H, grated opening in ceiling. J, J, ceiling.

ing or in close proximity to the source of heat, the entering fresh air is warmed, and is passed into the

room either at the ceiling level or close to the fireplace. Of these, Galton's stove, George's caligoren, Bond's thermohydric stove, and the Canadian school stove may be taken as types.

Churches, schools, halls, and similar large buildings are often ventilated by roof-ridge ventilators, which are either fixed, or are movable by the wind. The movable ventilators either act in weather-cock fashion or in a rotatory manner. Much has been written for and against this plan of ventilation, but, in our opinion, where failure has had to be registered, that must be attributed to inadequacy in size of ventilators and accompanying ducts. All roof-ridge ventilators act by the perflating action of atmospheric air currents, which, in our climate, seldom move with a less velocity than 15 to 20 miles an hour. Action by perflation is illustrated by Fig. 15 A and B. The main objections to this system are (1) irregularity of action, and (2) back-draughts. The latter, however, may be prevented by suitable valvular arrangements and periodic inspection of apparatus.

The above figure also shows the mechanism by means of which foul air is extracted from the interior of a building by the perflating action of the wind. The apparatus is so arranged that foul air can pass outward, but back-draughts are prevented by the action of the valve, made usually of silk, which immediately shuts on a backward current setting in. This apparatus requires periodic inspection to ensure efficiency of action. The best-known makers of roof ventilators are Boyle, Buchan, Howorth, Banner, and others (Fig. 16).

CHAPTER VIII.

HEAT IN RELATION TO HEALTH—MODES OF HEAT PROPAGATION.

HUMBOLDT, the famous naturalist, in summing up the characteristics which differentiate man from the lower animals, declared that man was the only animal that cooked his food. If he had broadened the statement by saying also that man was the only animal that generated artificial heat for the purpose of warming his body, he would have made it even more forcible. On our planet the distribution of heat and cold is very unequal. The warmth of the Equator meets the converse of frigidity at the Poles. Obviously, therefore, the incidence of man's position on the globe will affect the necessity which arises for the generation of artificial heat for the purpose of maintaining the body warmth. The conservation of the heat of the body by artificial means at the Equator is less urgent than it is at the Poles; and between these two points—the extremes—the necessity of artificial heat becomes the more acute as is the distance from the warmer point, and as is the season of the year.

Apart from his food, man conserves the heat of his body in three ways, *viz.:* (1) By the erection of a shelter wherein to protect himself from the rudeness of the elements; (2) by some form of bodily covering; and

(3) by the artificial generation of fire. These apply to man at any point of the earth's surface. The condition and character of the two former are determined by the local clemency or inclemency of weather, and he utilises the fire which cooks his food to warm his body.

The sum total of energy in the universe is always the same, varying nothing, never more, never less. Heat is not matter, but a form of energy. It therefore cannot be weighed. A vessel containing water at 60° Fahr. will weigh precisely the same when the temperature is raised to 180°. Heat is generated simply

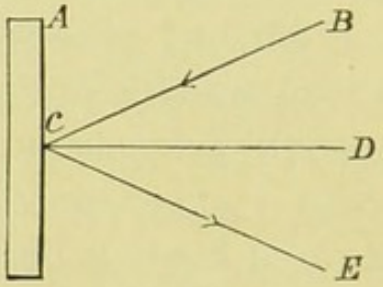


FIG. 17.—Illustrates reflection of radiant heat.
A, body on which ray D strikes; C is point of absorption; B and E are angles of reflection.

by the commotion of the intimate particles of matter, which commotion may be set up in various ways—by rubbing a metal button on one's sleeve, or two pieces of dried wood together, or in water in a vessel over a flame, or in a vessel of water exposed to the direct rays of the sun. The human body is a machine in which heat is generated by the combustion of the food swallowed, and by the different chemical processes which go on within it, much in the same way as in a steam-engine heat is generated in the water in its boiler by the combustion of coal. The temperature of the body in health is 98·6° Fahr., and of the

blood 100° Fahr. These temperatures vary but within the slightest limits, whether at the Equator or the Poles. Man is, therefore, called a warm-blooded animal, since he retains his normal heat in the most varying environment. Other animals—as fishes and reptiles—are called cold-blooded, because their bodily temperatures accommodate themselves to the temperature of their environment, although, even for them, there are limits of heat and cold which are incompatible with life. In temperatures below the normal body heat, the human body parts with its heat, and it becomes essential, there-

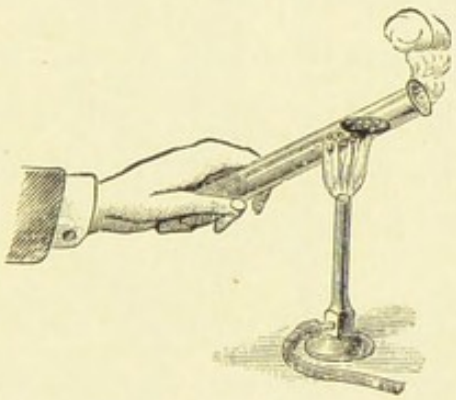


Fig. 18.

fore, that artificial means must be adopted to prevent undue loss. The terms *amount* and *intensity* of heat are often used, but they do not mean the same thing. In a cupful and a kettle of water, each at 212° Fahr., the intensity of heat will be identical, but the amount of heat in the latter will be proportionately larger, as is the relatively larger quantity of water present in it. Temperature is the condition in which a body is in respect of hotness at any given time. The term temperature implies certain fixed points of heat and cold—some standard of heat measurement; for, after

all, bodily sensations are but delusive guides. There are two fixed points of cold and heat with which all are acquainted, *viz.*, when water freezes and when water boils. From these points an instrument has been made whereby we gauge heat amounts or temperatures, called a thermometer or heat-measurer. Of this instrument something will be said in another chapter.

MODES OF HEAT PROPAGATION.

Whatever the source of heat, the heat so liberated flows towards the colder body, which it warms. If we could imagine a certain fixed amount of heat set free in an air-tight room, the effect would be that the colder bodies in the room would be warmed until each attained the same uniform temperature. This is what happens in nature.

But we distinguish as to the mode by which heat is propagated through different bodies or media. There are three such modes, *viz.*, *radiation, convection*, and *conduction*. Radiation is most common in aerial or gaseous bodies, convection in liquids, and conduction in solids. Radiation occurs in a vacuum as well as in air, and if air contained no particles the heat would pass through without warming it. The presence of particulate matter, however, causes a slight rise of temperature. Radiant heat rays are like light rays. They are propagated in all directions equally, and in right lines, and like light rays may be intercepted by a screen. (Fig. 17.) Radiant heat is usually associated with luminosity. A lady shades her face from the sun by a parasol, or her furniture from the effects of heat by

a screen. The intensity of radiant heat is in direct proportion to the temperature of its source, and inversely as the square of the distance from the source—that is, a body two feet distant from the source will only receive one-fourth, and one four feet distant one-sixteenth, the heat of one a foot from the source. When radiant heat falls upon an object, part is absorbed, part reflected, the respective amounts of each

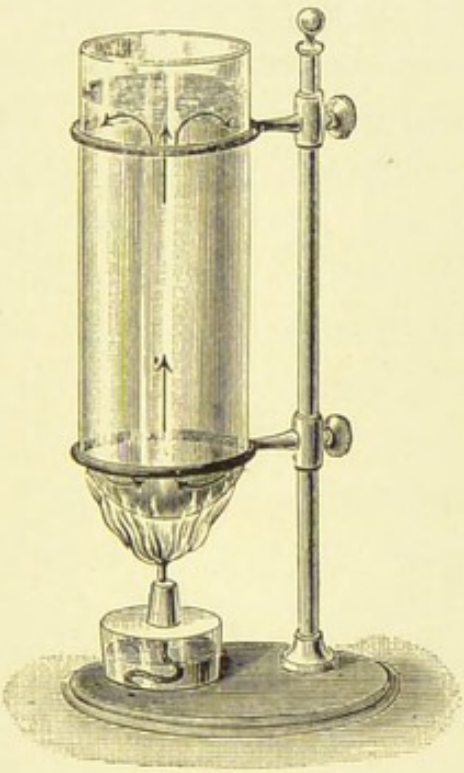


FIG. 19.

depending on (1) the material composing the body, (2) its surface-character, and (3) its colour.

Rough bodies absorb more heat than smooth, dark-coloured more than shining bodies. For this reason, outsides of kettles are rough and black, and engine fittings which require to be handled are kept clean and shining. Black clothes absorb more heat than they reflect; white clothes the reverse.

Convection is peculiar to liquids. A kettle boils best when placed on the fire, not when the fire is placed on the kettle. Fig. 18 illustrates this point. The water in a test-tube may be made to boil in its upper part, while its lower part will remain quite cold. In a kettle placed on the fire what happens is this: The layer of water next the fire first becomes heated; it therefore becomes lighter than the superposed layers, and rises to the top of the vessel; the layer which takes its place next becomes warmed and rises; and so on, till the whole column of water becomes of uniform temperature, *i.e.*, till it boils, as in Fig. 19.

CHAPTER IX.

HEAT IN RELATION TO HEALTH (*continued*).

COMPARATIVE VALUES OF HEAT-GIVING SOURCES.

CONDUCTION is the mode by which heat is propagated in solid bodies. If one end of a long knitting needle be held in a flame, sooner or later the heat will travel along the wire to the fingers. Here the heat is transmitted from one metallic particle to the other, until the whole length is traversed. Bodies differ as to their capacity of conducting heat. This is called *conductivity*. Some are good, some bad, conductors. A good conductor is one which robs a body warmer than itself quickly of its heat; a bad conductor, slowly; the former parts with its heat readily, the latter, grudgingly. The sensations, as has been said, are but poor guides to temperature. For example, if the hands be put, in succession, on the fire-irons, the stone hearth, the wooden floor, and a carpet, we are apt to conclude that they vary in coolness in the order named. But a thermometer registers the same temperature for each. Whence, then, the fallacy of the senses? The conductivity of the substances named varies in the order named, the first being the best, and the last the worst, heat conductor. The sensation of cold when the hand is on the iron, is due to the rapid absorption of the

heat of the hand by the metal. And what the hand loses, the metal receives; and a thermometer will now register a higher temperature in the iron than before the experiment. It is for this reason that door handles are made of wood, or porcelain, in preference to metal, and that hot-water pipes or engine fittings are sometimes covered by felt, or the teapot is wrapped in a "cosy," or, in our ice-making apparatus, the outer vessel is of wood, and the inner of metal.

SOURCES OF HEAT IN HOUSES.

These are (1) open coal or wood fires; (2) closed stoves (coal or oil); (3) gas fires; (4) hot-water pipes (at ordinary pressure); (5) hot-water pipes (at high pressure); and (6) steam pipes. The open coal fire still holds, as it is likely to maintain, the premier position as the source of heat in our rooms. It sends out radiant heat which is stimulating and exhilarating. To some extent, doubtless, sentiment prejudices mankind in favour of the open fire. But, apart from this, there is much to be said in its favour. It least of all directly warms the room atmosphere; its radiant heat warms the objects which it strikes—the bodies of the occupants, the furniture, the walls—and the whole room is thereby warmed. The chief objection to our present mode of utilising the heat is needless waste. In an ordinary fireplace, from five-eighths to three-fourths of the total heat generated is of no value to the apartment. It is usually considered lost, but this is not so, as it heats the walls of the house—thereby keeping them dry—and it raises the temperature of those rooms nearest the flue, in the upper flats.

This so-called waste of heat is produced in two ways, *viz.:* by (1) faulty construction of fireplace and grate, and (2) the mode of consumption of fuel. The air-supply of the fire comes from the outside by doors and windows or ventilators. In ordinary combustion, probably one-third of the coal passes off in smoke, therefore producing no heat, to contaminate the outside atmosphere. This may be called "active" or "quick" combustion, in contradistinction to another mode of fuel consumption called "slow" combustion. In active combustion, the air-supply passes through and from beneath the fire-seat; in slow, it only passes through the fire, and not from below the fire. By reason of the reduced air-supply, in the latter mode, the combustion of fuel is slower, and the chimney-ward movement of air is less rapid; hence, for a smaller amount of fuel, a larger amount of heat is conserved for the uses of the apartment, the fuel lasts a longer time, and the total cost of firing is less. From a long series of practical experiments made by us with different forms of grates, the slow combustion grate has proved the most economical; and the simpler the grate, the better the results. The following form, which has never been patented, has been evolved from these experiments, as it gives the best results. It consists of a plain metal frame, which is "flush" with the wall. The floor is composed of one large thick fire-brick, as are also its sides and back. The outer lining of the fireplace, behind these side and back bricks, is composed of ordinary fire-clay bricks built in cement. The "throat" of the chimney is contracted, and is rounded by cement. In such a grate it is difficult to start the fire. To over-

come this a "blower," which consists of a sheet of iron, and which may be pulled down from a sliding socket in the upper part of the grate frame, acts efficiently. When the fire is well started it is pushed back into its rest. Such a fire requires to be replenished but twice daily to thoroughly warm a room of about 6000 cubic feet capacity. Another advantage of the slow combustion grate is that it does not produce the objectionable draughts between doors and windows

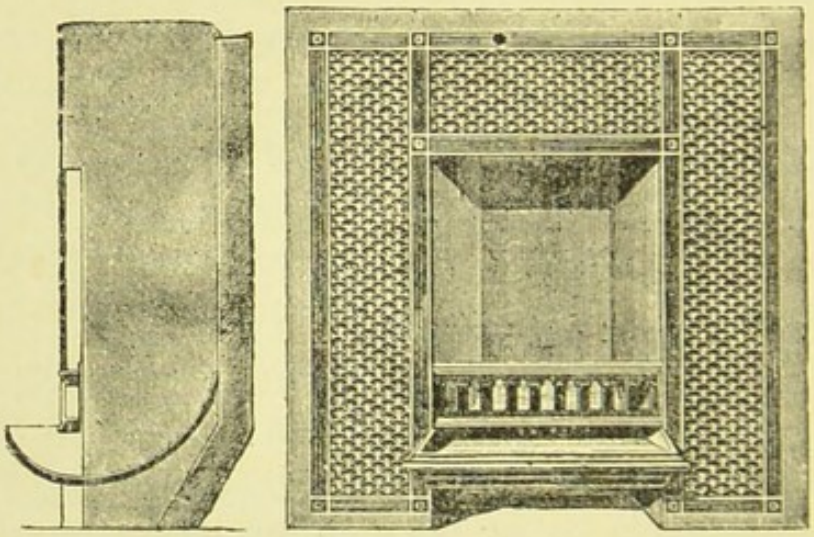


FIG. 20.—Brown and Green's Grate for smoke prevention.

and fireplace present with an ordinary grate. Next to petroleum, coal gives off more heat than any other form of fuel. It gives more than twice that of wood, and when properly burned the carbon unites with the oxygen of air to form carbonic acid gas, thus $C + O_2 = CO_2$.

Improper combustion causes smoke, and a smoky atmosphere is the cause of fogs. Domestic fires are the chief cause of the smoky atmosphere of populous cities, and such atmospheres are prejudicial to the public

health. The remedy is to be looked for in smoke-consuming grates.

Fig. 20 represents Brown and Green's smoke-prevention grate. The coal is put into the fire by a specially constructed shovel below the incandescent coal on the curved ledge shown in the section.

CLOSED STOVES.

These are very commonly used in countries which experience rigorous winters. They economise fuel. They do not, however, warm the room objects so much as the air of the room, neither do they form such efficient outlets for foul air as open fires. They are chiefly made of iron, either solely or with an exterior covering of porcelain slabs or tiles. Cast-iron stoves are by no means impervious to the gases of combustion, as alternate heating and cooling cause expansion and contraction of the metal, and thus the seams or joints are loosened. The chief objection to closed stoves consists in the fact that they "dry" the air of the room; that is, they produce the sensation of dried air upon the occupants. This is by no means imaginary, and is produced in this way. Watery vapour, in gaseous form, is always an atmospheric constituent. As is the temperature of the air at any given time, so is the total possible amount of watery vapour which it can sustain. This is called the maximum amount, *or amount of saturation*. Most usually, however, the air only holds some proportion of this total amount. Most comfort is experienced when the air holds 70 to 80 per cent. of the possible total amount it can hold at that temperature.

Suppose, then, when a stove is lighted, that the temperature of the air of the room is 40° Fahr., and it holds 75 per cent. of the total possible watery vapour, or humidity, as it is often termed. When the room temperature has risen to 65° Fahr., the percentage of humidity *for that temperature* will be less than 75 per cent. of its possible total amount; consequently the air feels dry to the occupants. What happens, then, is this. The air robs everything and everybody in the room of moisture to satisfy its requirements, hence the skin begins to feel dry, the hair becomes crisp, and a general sense of uneasiness ensues. To avoid this it is advisable to place shallow vessels containing water near the stove to supply the needed humidity. But saturation of the air is quickly produced, and when the room air cools down this excess of humidity becomes condensed upon the walls, and is apt to show itself as tiny streamlets. This is most likely to happen when the number of persons in a room is relatively larger than it ought to be.

CHAPTER X.

HEAT IN RELATION TO HEALTH: GAS STOVES, OIL STOVES, HOT-WATER PIPES, STEAM PIPES.

GAS STOVES.

THESE are the outcome of a public demand for a form of heating which is at once handy, cleanly, and comparatively cheap. We have tried practically every form, but have discarded them all. All the objections urged against coal stoves have greater force against gas stoves, not only from the point of view of efficiency, but mainly from that of health. That they are handy, cleanly, and relatively cost less than other heat sources, and that they have a limited field of usefulness, cannot be gainsaid. When, for instance, they are fitted into grate-places, which are filled with asbestos or fire-clay lumps, they constitute the least objectionable form, since they combine, to some extent, to give the radiant heat of the coal fire with the handiness and cleanliness of the gas fire. The same, however, cannot be said of those gas heaters which are only provided with a flue-pipe of a half to one inch diameter. Such are worse than useless, for they give to those who use them a false sense of security; and, by them, ventilation is practically non-existent. Flueless gas or oil stoves are absolutely harmful, unless adequate provision be

made to neutralise by absorption the resultant gases of combustion. The former, which purport to do this, are still on their trial; but until some special provision be made for the absorption of carbon monoxide gas (CO), which is exceedingly poisonous and, at the same time, odourless, they cannot be deemed healthy. Acetylene, a very pungent and penetrating gas, is liable to be given off from gas fires when the Bunsen flames chance to become choked with soot, thereby preventing the necessary admixture of air and coal gas. It is very irritating to the throat and lungs. Cleaning of the burners will put matters right at once. It appears to us that the special field of usefulness of the gas fire is that for cooking purposes. Where expedition, at any time, is necessary, and in summer especially, when kitchen fires are likely to be low, a gas fire, or grill, which can be lighted in a moment, is not only handy, but exceedingly useful.

Oil stoves share the general condemnation. There is no practical difference between burning several wicks under cover of coloured glass and burning several single lamps equivalent to the same number of wicks. They equally consume the air of the room, and for equal quantities of heat, consume more oxygen than coal-gas. Besides, the products of combustion pass off into the general room atmosphere, and are harmful. Another objection to their use is the disagreeable odour which an imperfectly cleaned oil stove is apt to create.

Whereas, then, the open grate, whether with quick or slow combustion, acts not only to warm the room and its occupants—and the walls equally with any other part—by radiant heat, but also acts as an ex-

cellent "outlet" ventilator; the same cannot be said of the ordinary close stove, gas fire, or oil stove, which directly warms the air of the room, and the objects of the room unequally, and which does not act as an efficient ventilator. Besides, imperfect combustion of coal-gas or oil is liable to cause the production of certain malodorous gases, which are as harmful as they are disagreeable.

HOT-WATER PIPES.

Heating by pipes containing hot water at ordinary pressure is much more common in large public buildings, such as halls, churches, schools, hospitals, barracks, and the like, than in private dwellings. It is, however, now becoming more general in the latter. The hot pipes, which are made of cast iron, warm the air of the apartment by conduction, or rather, by convection, as applied to gases. Little objection can be offered to their use (except the absence of the stimulating rays of radiant heat) provided special means are adopted for the ventilation of the apartment. When this mode of heating obtains, great care must be exercised during severe frost to prevent the colder water in the return pipes from freezing. This is by no means unknown; and where no other provision for heating is made much discomfort results. In view, also, of possible disturbances of the water-supply, it is always advisable to have a reservoir upon which to fall back when the public supply is likely to be cut off for a period of time.

The high-pressure system of heating by water in pipes—under a pressure of three or four atmospheres,

i.e., 45 to 60 lbs. per square inch of surface—is also used in large buildings. The pipes which compose the system, and which form a continuous whole, are made of wrought iron. They are much smaller in calibre than those of the ordinary system, because of the greater amount of heat which is given off from a smaller area, and, consequently, they occupy less space. The water is heated by one end of the pipe-system being placed in the furnace fire, and at the highest point of the system an expansion branch is formed to prevent explosions. The heat is distributed throughout the building by placing "coils" at different points. Fig. 21 shows such a coil.

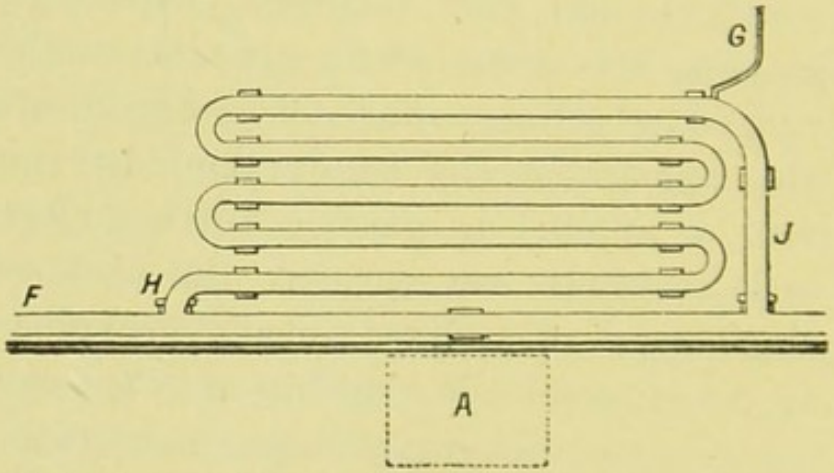


FIG. 21.—High-pressure Hot-water Coil for heating incoming cold air of a room.

A, entrance of cold air ducts; F, main pipe; H, J, branch pipe; G, expansion pipe.

STEAM PIPES are rarely used, even in large buildings, for heating purposes. Spent steam may be used for heating conservatories which are situated close to steam-generating apparatus. Probably the only large experiment of heating the houses of a community by this method is that which was carried out in the town of

Lockport in America. The steam can be turned on or off at will in each house in the circuit, and may be used for heating or cooking, or as a motive power. The prime cost of the system, however, is high.

Any system of heating by hot water or steam conveyed by pipes demands skilled attention, and this is more true of the high-pressure water and steam systems than of the low-pressure system. When they are installed into a building, arrangements of a valvular kind, which can be operated upon by a screw or wheel, usually exist, whereby the amount of heat required may be regulated.

CHAPTER XI.

MODES OF HEAT MEASUREMENT—THERMOMETERS —TEMPERATURE SCALES.

As many diseases which come under the care of a nurse exhibit febrile disturbance, and as it is necessary for the information of the physician that the daily periodic temperatures should be recorded, it is of the utmost importance that the nurse should be familiar with the instrument by which such temperatures are registered. There are two ways of estimating the temperature of a patient, one of which is entirely wrong and fallacious and the other scientific and correct. Before the thermometer came to be so much used, the habit was to judge of the patient's condition by the apparent relative difference of temperature of the hand of the observer and the body of the patient. This was but a rough-and-ready method, and has fallen, very properly, into desuetude. The modern method is by the thermometer, Fig. 22, which is the heat-measurer. The clinical thermometer is probably the principal tool of the nurse. She ought, therefore, to know not only how to use it, but its merits also, and how it is made. What is a thermometer? It consists of a glass tube of uniform capillary bore terminating at one end in a bulb. Part of the tube, and the whole of the bulb, contain mercury; the other end of the tube being sealed. The space

between the upper level of mercury and the sealed end is a partial vacuum. A scale, divided into equal parts, called degrees, and into sub-divisions of a degree, either engraved on the glass of the tube, or on paper enclosed within an outer glass tube, or the wooden framework of the instrument, is an essential part of the thermometer. Clinical thermometers usually have the scale engraved on the glass, thermometers for chemical purposes on paper, and ordinary thermometers for varied use on a wood or metal frame. The temperature range of the instrument varies, depending upon the purpose for which it is to be used. For example, the range of a clinical thermometer is usually from 92° to 112° Fahr., these extremes being beyond the temperatures, either below or above, which are compatible with life; the chemical thermometer may either range between 0° and 100° Cent., or 0° and 360° Cent., or even higher, depending upon its destined use.

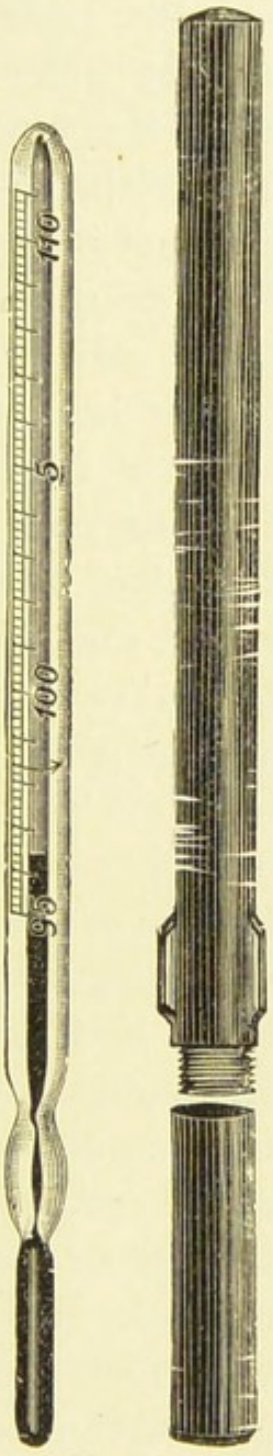


FIG. 22.

The glass portion of the thermometer having been made, it becomes necessary to "calibrate" the instrument as a heat-measurer. *Calibration* means the graduation of the instrument with reference to the uniformity of its bore. Mercury, which it contains, like other liquid substances, expands definitely in pro-

portion to definite amounts of heat, and it is chiefly used for the clinical thermometer because it enables a compact instrument to be made. Alcohol, coloured, is used by preference, however, for thermometers which are used in some other fields of observation. *Graduation* of the thermometer is a very important matter. In making an ordinary instrument the workman has two fixed points from which to operate, *viz.*, the freezing-point, and the boiling-point, of water. To get the former he places the bulb of the ungraduated instrument in melting ice, and when the mercury remains stationary he marks that level on the glass. To obtain the latter he suspends the bulb in the steam of boiling water, and when the mercury rises to its highest point he makes a second mark. If the glass tube of the instrument be of equal bore between these two points, he may "graduate" the stem by putting equidistant marks upon it. The number of degrees or "grades" (Latin, *gradus*, a step) on a scale may be of any number, according to the choice of the user, so long as they have equal and known value. In effect, however, the instruments now in use in the world are graded according to one or other of three different scales, and are called respectively the thermometers of Fahrenheit, Celsius or Centigrade, and Réaumur. The first is in common use in our own country; the second in most Continental countries, and for all scientific work; and the last mainly in Russia. Fahrenheit—a native of Dantzig—was the first, in 1720, to use mercury in thermometers; before that time alcohol was the registering fluid. He took as the limit of coldness the temperature of Dantzig in the winter of 1709, which was the same

as that produced when the mercury was plunged into a mixture of snow and ammonium chloride, and he called that point zero, or freezing-point. But in so doing he made a considerable mistake, whereby much confusion in the student mind has since resulted, for the point which he called zero was 32° below the actual freezing-

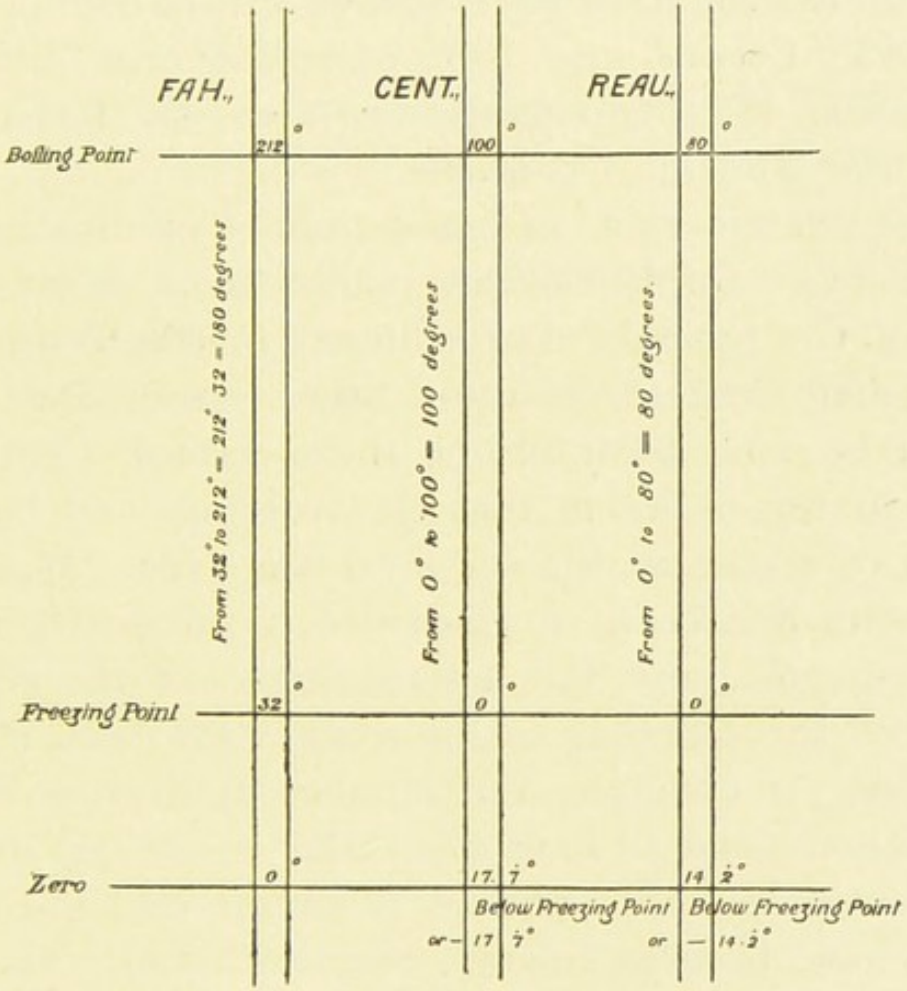


FIG. 23.

point of water; therefore, freezing-point on his instrument is not synonymous with the zero of the other scales, but is 32° above it.

Celsius—a Swede—twenty-one years after, rectified this mistake by graduating his instrument from the melting-point of ice, which he called zero, and which

has been the standard to this day. Between zero and boiling-point he made 100°, therefore his instrument and scale have come to be called Centigrade (Latin, *centum*, one hundred; *gradus*, a step or grade).

Réaumur—a Frenchman—based the zero of his instrument in the same way as Celsius. Fahrenheit divided his scale from his supposed zero to boiling-point into 212°, Celsius into 100°, and Reaumur into 80°, or grades. The foregoing diagrammatic figure will assist the student. (Fig. 23.)

The relative value of one degree of one instrument to one degree of the others ought to be known. In view of the possible establishment in this country of the metric system, and for other reasons, a nurse should be able to interpret these values. The first point to remember is that the freezing- and boiling-points of water at the sea-level are fixed. If all instruments had been so graduated, no difficulty would have emerged, and the determination of the relative ratios of the different scales would have been simple. Suppose, for example, the number of degrees in the Fahrenheit scale to have been 212° − 32° = 180°, in the Centigrade 100°, and in Réaumur 80°, the ratios would have been as follows, *viz.*, 180 : 100 : 80, or ÷ 20 = 9 : 5 : 4; in other words, 9° Fahr. would equal 5° Cent. and 4° Réau., and conversely. But the freezing-point of each scale is, unfortunately, not the same; in Fahr. it is 32°, in Cent. 0°, and in Réaumur 0°. Since we work with the entire scale of each instrument, however, the factor of difference between the zero and freezing-point of the Fahr. scale must always be reckoned with.

The following table shows how to transpose correctly the scale of one instrument to that of the others :—

1. To convert degrees Fahr. into degrees Cent.—subtract 32°, then multiply by 5 and divide by 9.
2. Fahr.° into Réau.°—subtract 32, multiply by 4, and divide by 9.
3. Cent.° into Réau.°—multiply by 4 and divide by 5.
4. Cent.° into Fahr.°—multiply by 9, divide by 5, add 32.
5. Réau.° into Fahr.°—multiply by 9, divide by 4, add 32.
6. Réau.° into Cent.°—multiply by 5 and divide by 4.

CHAPTER XII.

SICK-ROOM TEMPERATURES—REGULATION OF HEAT OF SICK-ROOMS—BATH TEMPERATURES.

The temperature scale of the clinical thermometer usually ranges from 92° to 112° Fahr. The extreme points are obtained by placing the instrument in liquids, in which a standard instrument records these temperatures. It is then graduated between these points in the manner already indicated. It must not be assumed that every instrument which may be bought is accurate. Most of them, indeed, have errors of calibration, or graduation, or both. It is important to have an accurate instrument, although an instrument which is not precisely accurate will register variations of temperature in a relatively accurate manner. If, however, its initial accuracy be at fault, any given single temperature will either be too high, or too low. To secure an accurate thermometer, it ought to be corrected against standard instruments, as is done at Kew Observatory. The modern instrument is self-registering; that is to say, when the mercury has attained the highest point of the reading, the index column remains in this position, while the rest of the mercurial column recedes into the bulb. This is accomplished by intervening a minute bubble of air between the main and the index column. Before another read-

ing can be taken, the index column must be shaken below the level of the normal temperature reading, this being done by holding the non-bulbous end of the instrument in the hand, and giving it one or more shakes in the air. This design of instrument enables the observer to remove it from the body of the patient before the reading is taken; whereas, with the non-registering form, the reading has to be taken with the instrument in position. Quick temperature-registration instruments are made by having the bulb thinned and elongated so as to present a larger mercurial surface to the heat-giving source. Spirally-coiled instruments, for taking mouth-temperatures, are sometimes used, but they have no merit over the elongated form.

The normal temperature of the human body in health, taken in the armpit, is 98·6° Fahr., or 37° Cent., or 29·6° Réau.; taken in the rectum or mouth it is 99·2° Fahr., or 37·3° Cent., or 29·9° Réau. A temperature registered above these points is called a hypernormal temperature (Greek, *hyper* = above); and one below, a subnormal temperature (Latin, *sub* = below).

TABLE OF TEMPERATURES.

Temperature of collapse	= 95° to 97° Fahr.
Subnormal temperature	= 97·6° Fahr.
Normal temperature	= 98·6° Fahr.
Subfebrile or slightly hyper-normal temperature	= 99° to 101° Fahr.
Febrile temperature	= 101·5° to 103° Fahr.
Highly febrile temperature	= 103·5° to 104·5° Fahr.
Hyperpyrexial temperature	= 105° to 106·5° Fahr. and upwards.

TEMPERATURE OF SICK-ROOM.

The temperature of the sick-room ought entirely to be regulated by the comfort of the patient. A routine temperature which fulfils this condition for convalescents, elderly persons, and young children is one from 60-65° Fahr. Patients who suffer from fever generally, or from one of the specific fevers particularly, experience more comfort when the room is about 55° Fahr. than when it is higher. In addition to temperature, comfort is materially added to certain patients if the humidity of the air receive special attention. This is true of pulmonary diseases generally, but especially of "throat" and "croupy" cases. It is practically impossible to reduce the amount of watery vapour in any atmosphere, but it is possible, and often advantageous, to increase it. This is the reason for the croup kettle and other steam-generating apparatus for the sick-room. The thermometer, therefore, ought to have a prominent place in every sick-room and to receive the careful periodic attention of the nurse. (Fig. 24.)

Fig. 25 is the wet and dry bulb thermometer, by means of which, on reference to a table of instructions, the amount of moisture in the atmosphere may be determined, in addition to the temperature. The little vessel at the bottom of the thermometer on the right contains water, which, by capillary action, passes up the strands of wick from the vessel to the bulb of the instrument, and so keeps it wet; hence the name wet bulb, which instrument, unless the atmosphere be saturated with watery vapour, always gives a lower reading than the dry bulb instrument, by reason of the evaporation from

the bulb. The other thermometer has no such arrangement, hence the name dry bulb. The temperature of the sick-room requires careful attention, especially about midnight and the early hours after midnight, and four A.M., for at these times the bodily temperature falls lowest.

The regulation of heating of ordinary sick-rooms,



FIG. 24. Thermometer.

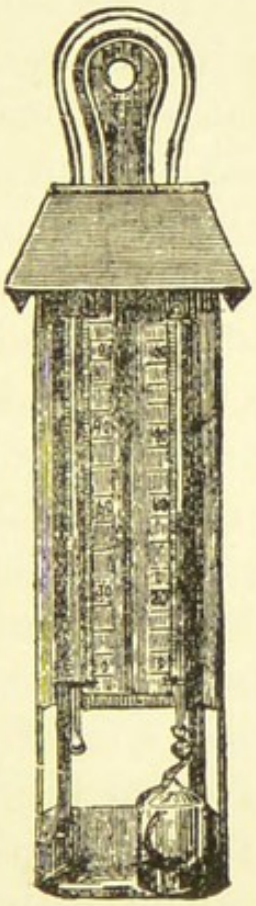


FIG. 25. Wet and dry bulb Thermometer.



FIG. 26. Bath Thermometer.

especially at night, is a somewhat difficult task. To lower the temperature, beyond the ordinary method of opening the window and door, as already described, there is little to suggest. Careful attention to firing, especially when lights are burning, will make the task easier. Direct heat from the fire may be prevented reaching the patient by the simple interposition of a screen.

BATHS AND BATH TEMPERATURES.

Both in hospital and private nursing the bathing and sponging of patients are important items of the nurse's duty. Here, also, the thermometer is all-important. Fig. 26 shows a bath thermometer. It is important, alike for the physician who orders the bath, and for the nurse who is to carry out his instructions, to understand clearly what is meant when a particular bath is called for. We speak, for instance, of a cold, a tepid, a warm, and a hot bath. What is meant by these respective terms? They are all relative terms; for example, a patient with a temperature of 104° Fahr. will feel less cold on being put into a bath at 65° Fahr. than will a person whose temperature is normal; and tepid water will feel warm, and warm water hot to a cold body. It is for this reason that the rule-of-thumb method of testing a bath temperature by passing the hand through the water should, once and for all, be discarded as untrustworthy, for the amount of hotness or coldness which is perceived by the testing hand will depend entirely upon the temperature of the hand at the moment of testing. Again, patients have been scalded by having been put into baths by careless attendants who had not used the thermometer. For these reasons, therefore, the bath thermometer should always be used before the immersion of the patient. To return, however, to bath temperatures. While a cold bath may mean anything between the melting-point of ice and 65° Fahr., it is necessary when a cold bath is ordered, as is now not infrequently done in certain febrile diseases, that the physician should signify the temperature of the

water to be used. If this be omitted, the nurse ought to have some knowledge of ordinary bath temperatures and to be able to apply it.

The following table may serve as a useful guide in this matter:—

Cold Bath	60° to 65° Fahr.
Tepid	86° ,,
Warm	95° ,,
Hot	104° ,,

Routine bath temperature for infants and young children, 85° to 90°.

Bath thermometer always to be used before immersion of patient.

It is always safer for convalescents, elderly people, and persons generally who cannot afford to part with heat freely, to wash in the winter season in tepid or warm water. Much nonsense has been written regarding the innervating effect of cold water and the enervating effect of warm. The former may so act for the vigorous and healthy, but it does not for a large number of persons, particularly those whose heart's action is slow and feeble, or who are below par generally. Sponging of the body at intervals with a damp sponge wrung out of tepid water is very grateful and soothing to the feverish patient, and it will often be the means of inducing sleep, and certainly restfulness in delirium, in feverish patients. As a general principle, the temperature of the water used ought to be regulated by the amount of fever present, *viz.*, the higher the fever the cooler the water. The accompanying comfort will not only be more marked at the time, but will also be more lasting.

CHAPTER XIII.

WATER IN RELATION TO HEALTH—SOURCES OF SUPPLY—MODES OF SUPPLY.

WATER, like air and food, is one of the prime necessities of life, animal or vegetable. It enters into the composition of nearly everything in nature. Everyone knows about the disastrous effects of unsatisfied bodily thirst. The human body is made up of 75 per cent. of water, hence the daily need is not inconsiderable. Water is a potent factor also in personal, domestic, and public hygiene; hence the need for a plentiful supply which can be easily tapped by every consumer to populous places. The physical appearances of water are matters of common knowledge, but with its chemical composition most persons are less familiar. It is a chemical compound which results from the union of two gases, *viz.*, hydrogen and oxygen. When two volumes of the former and one of the latter are mixed, and are exploded by an electric spark, a new liquid substance—water—is the result; therefore the chemical symbols for water are H_2O. Chemically pure water does not exist in nature, although it is found approximately pure. It exhibits interesting physical conditions upon occasion. It freezes from the effect of cold, and it boils from the effect of applied heat. Water may thus exist in one of three forms, *viz.*, as a solid, below 32° Fahr., or 0° Cent.; as a

liquid, between 32° and 212° Fahr., or 0° and 100° Cent.; and as a gas, above 212° Fahr., or 100° Cent. When water in the gaseous form is reduced to the liquid form by cold the process is called condensation. This is a very important, and, for us, an absolutely essential operation of nature. When, again, water is cooled to the solid state of ice, a very interesting phenomenon is to be noted in the process of cooling. When the temperature falls to 39·2° Fahr., or 4° Cent., the process of contraction which the water has undergone between 212° and 39·2° is suddenly changed. From 39·2° it begins to expand, until the freezing-point—32° Fahr. —is reached. Were it not for this fact, intense frost would convert our rivers and lakes into solid masses of ice, instead of a top layer of ice and a lower layer of water, as the foregoing condition demands. When water passes from the liquid to the solid state it expands, that is to say, the volume of ice formed is greater than the volume of water from which it was formed. It is erroneously believed by many that frozen pipes burst when the thaw comes. The fact, however, is that the pipe is burst during freezing by the expansion of the ice, but the fracture is not apparent till water can once more flow in the pipe, then the leak shows the fracture.

The boiling of water is also an interesting phenomenon. Water contains in solution the gases of the atmosphere, much in the same way as in aerated waters. The noisy, bubbling process, known as boiling, is simply the disengagement of these gases by the heat. After they have been driven off a noiseless boiling will ensue, if the heating be continued. The temperature at which

water boils is always the same under the same conditions. The boiling-point of water is always reckoned at a pressure of one atmosphere—that is to say, the pressure which a column of atmosphere, of assumed equal density and five miles in height, exercises on a body at sea level. If this pressure be increased or diminished the boiling-point will rise or fall correspondingly. For example, water boils at the level of the Dead Sea at 214° Fahr., because that is about 1300 feet below the ordinary sea level; on the other hand, at the top of Mont Blanc, it boils at 186° Fahr., because that mountain is about 15,000 feet above sea level. The period of time required for cooking any article of food which demands boiling is reckoned by our experience of the fact at or near the sea level. But potatoes, for instance, will not be more quickly cooked at the top of Mont Blanc than in London or Glasgow. Cooking under increased or diminished pressure is now frequently carried out on the large scale. Papin's digester—an apparatus largely used in Continental hospitals for making beef tea—is worked on the principle of increasing the pressure within the apparatus by placing weights on the air-tight lid, which is provided with a safety-valve. On the other hand, in public works where food stuffs and condiments are made, the cooking takes place in vacuum pans, in which the atmospheric pressure is diminished.

The public health largely depends upon the abundant supply and free use of wholesome water. A water famine is disastrous to the health of a city, as it also is to the public economics. Where the carriage of sewage depends on the water supply, reduced con-

sumption of water means impurity of sewage channels, and the risks to health which are consequent. But however ample a public water supply may be, experience has shown that unless it be easily accessible to every householder, it is not so freely used as it ought to be for cleansing purposes. The effect of this in poorer districts is certain to be harmful sooner or later.

SOURCES OF SUPPLY.

The original source of all the water used by man at any point on the earth's surface is the ocean of water which encircles the land. Whether the proximate source of supply be lake or river, reservoir, rainfall, well, or spring, the original source is the same. Our planet is at once a huge evaporating and condensing apparatus. Just as the sea is the storehouse of summer heat, which it gives back to us in the winter, so is it the source of the watery vapour which is driven from it by the sun into the atmosphere, which is condensed in the form of clouds, and which returns to us as water, either in a liquid or solid form. Fig. 27 is a diagrammatic representation of the process of evaporation and condensation. In the centre is the source of heat; at the bottom, the source of watery vapour; the ascending arrows indicate the ascent of this vapour, as mists, fogs, and on the top of all, as clouds; the descending arrows, the descent of the vapour, as snow, hail, rain, dew, to form springs, rivers, lakes, and wells. Water, in one form or other, having fallen upon the surface of the earth, it depends upon the configuration of the land upon which it falls, and upon its geological structure, whether it will sink mainly into the earth or collect

upon its surface. There is thus formed an underground or subsoil collection of water, and an overground or surface collection; and the level of each at any given time depends upon the antecedent rainfall. A well taps this underground supply, and the depth of the well before water is reached depends upon the distance from the ground surface the level of the underground water is. In some parts it is near, and in others far,

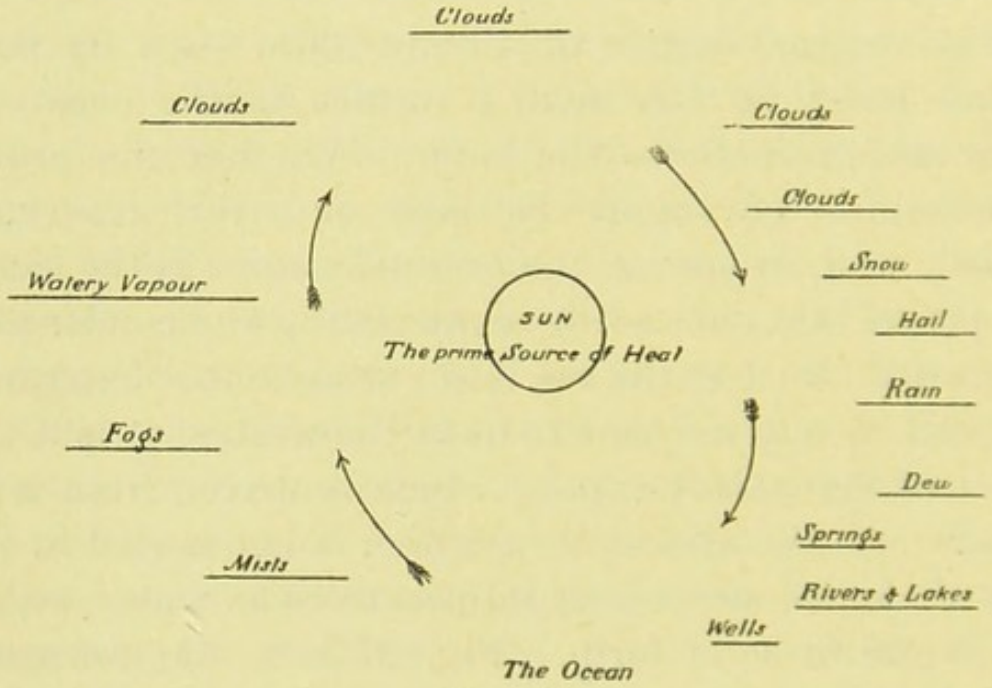


FIG. 27.

from the earth's surface. That part of the rainfall which does not percolate into the soil forms lakes and rivers, the incidence and position of which depend upon the topography of the land and its geological formation. Springs arise from the underground water, which in the course of percolation downwards encounters an impervious rock stratum. This stratum dips out on the land surface, and the water travelling along it thus eventually appears as a spring.

CHAPTER XIV.

WATER SUPPLY (*continued*)—MODES OF SUPPLY—CHARACTERISTICS OF WHOLESOME WATER.

THE present-day water supplies of the world are obtained either from (1) rivers, (2) lakes, (3) springs, (4) wells, or (5) directly from the rainfall. These demand some detailed consideration.

RIVERS.—In its virgin condition a river is but a moving column of rain water, having in solution what the water may have dissolved in its passage through the air on its way to the river, in the various rivulets, or in the river-bed itself. In this state, the water of a river is usually a good water. Hence rivers are tapped as water supplies; less, however, now than formerly. London, to some extent, is still supplied from the Thames and its tributaries. At the same time, by reason of the risks of pollution, rivers are suspicious sources of supply; as a rule, they are positively dangerous. Before the best of them can be used efficient filtration must precede distribution. It were better, indeed if they could be done without, by reason of actual pollution.

LAKES are natural upland collections of water, and constitute the source of our purest supplies. Occurring in sparsely inhabited areas, they are little liable to contamination; formed on rock strata, difficult of

solution, they contain but little mineral matter; and, constituted only of water from the clouds, they are "soft," and, therefore, excellent for washing purposes. The chief objection against them is that they are rich in vegetable organic matter, which sometimes acts as a solvent of the lead of the pipes which contain and convey the water.

RESERVOIRS are but artificial lakes, formed in similar districts and for similar reasons. They form

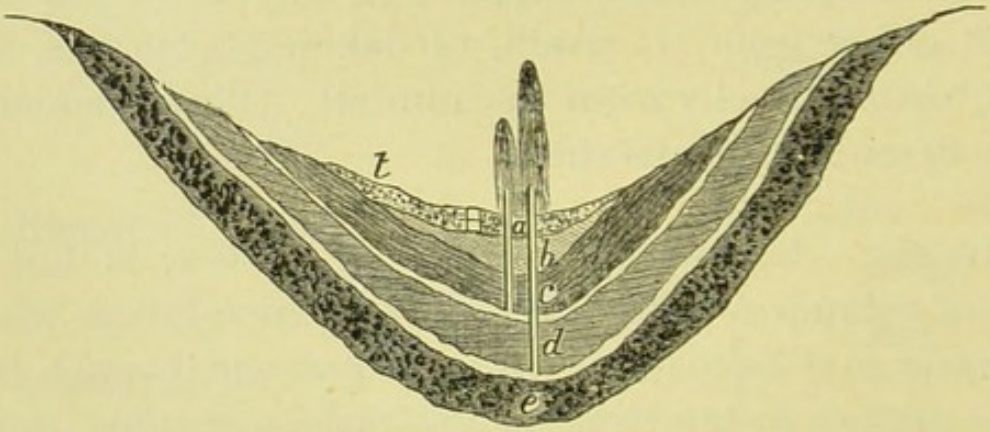


FIG. 28 (from Fessenden's *Physics.*)—Figure represents a vertical section of geological strata of basin.

A, loose sand or gravel layer; B, clay bed; C, stratum of slate; D, stratum of limestone; E, a bed of granite. Upright lines show spouting bore tubes.

the focussing point of the water which falls over a given portion of land, called the *gathering ground.*

SPRINGS usually supply but limited amounts of water, enough, however, in many cases, for small collections of houses.

WELLS constitute the chief source of water supply of rural districts, and of isolated houses, including farms. The purity of the water, in relation to milk supplies, becomes of prime importance. There are three kinds of wells, *viz.*, (1) *shallow or surface*, (2) *deep*,

and (3) *artesian;* and their designation does not so much depend upon their actual depth as upon their relation to the earth strata through which they are driven. A shallow or surface well is one which, sunk into pervious soil, taps the underground water which has percolated from the surface of the ground within the immediate vicinity of the well-shaft. A deep well is one which, sunk through the pervious surface-layer of soil and an underlying impervious stratum of rock, taps the underground water which has percolated from the land surface at some distance from the well-shaft. An artesian well (so called from Artois, a province in France, where they were first used on a large scale) is one in which the shaft is sunk through (1) a pervious layer, (2) an impervious layer, and which taps a collection of water lying on the top of (3) an impervious layer, the two latter of which "outcrop" on the surface of the land, it may be, several miles away. The water which is tapped, falling on the area of land between the two outcropping layers, sinks into this basin-like formation, and lies there under considerable pressure. When the bore tube, in the process of sinking, reaches this collection of water, the pressure on the mass of water lying between the two impervious layers forces the water up the tube, and into the air occasionally. Fig. 28 illustrates the conditions requisite for this kind of well.

Artesian wells are usually of considerable depth; that of Grenelle, in Paris, is 1800 feet; of Passy, 1900 feet; and of Rochefort, 2765 feet. Their waters are high in temperature, depending on the depth; that of Grenelle is 82° Fahr., and that of Rochefort 106° Fahr.

They provide large quantities of water; that of Grenelle, for example, 500,000 gallons per 24 hours. The water from the well of Grenelle drains a district 100 miles from Paris. They supply waters free from organic pollution, but frequently containing much mineral matter in solution.

In respect of purity, waters from springs and deep wells are the best, while surface water and stored rain water are suspicious sources, and rivers and shallow wells are dangerous sources.

Rain water is sometimes collected for potable uses, but only rarely; whereas for washing purposes it is eagerly stored in districts where the other supplies are "hard," because of its "softness". We have computed the total amount of rainfall in the British Islands in an average year to be 232,000,000,000 tons of water, or 52,000,000,000,000 gallons, but a very large proportion of this finds its way back to the sea by the rivers, and to the atmosphere by surface evaporation.

HARDNESS AND SOFTNESS.

These are terms employed to express the difficulty or ease with which water unites with soap to form a lather; or, the soap-destroying power of a water. Economically, this is a matter of importance in a manufacturing community, and for domestic purposes. As a hard water requires much more soap than a soft one, the increased expenditure in soap alone forms a formidable money bill in London, or in any other community supplied with a hard water. Waters differ much as to hardness or softness; for example, the

water of Glasgow has about 1° of hardness, those of London from 12° to 21°, and that of Sunderland 30°. This difference depends on the source of supply. Rain water is the softest, and from the following sources in progressive order they become harder, *viz.:* Lakes, rivers, deep wells, artesian wells. Hardness is due to the presence of salts of lime and magnesia dissolved in the water from strata containing these substances, through the agency of CO_2 which the rain takes up from the atmosphere in falling. The other principal factor of hardness is iron, which is dissolved in the water in the same way. Lime and magnesia, as carbonates or sulphates, or both, and iron are, therefore, the chief causes of hardness in any water. Any one can determine between a hard and soft water by the simple act of personal ablution, but the rationale of it is not so well understood. The following facts will explain: Hard soap is a compound of a fatty substance and soda. The fatty substance is composed of fatty acids and glycerine—in union. These fatty acids unite with the alkali—soda—to form hard soap—chiefly the oleate and stearate of soda, which are soluble in water. When soap is dissolved in a water which contains lime or magnesia, or both, the lime splits up the soap and unites with the oleic and stearic acids to form these salts of lime, which are insoluble in water. Hence, so long as lime is present ununited with these fatty acids, no lather will form. For this reason, therefore, a hard water uses up more soap than a soft one. We distinguish between kinds of hardness, based solely upon the chemical nature of the lime and magnesian salts present in the water. There are "*total*," "*temporary*," and

"*permanent*" hardness. Total hardness means the natural soap-destroying powers of a water; permanent, the hardness which remains after the water has been boiled; and temporary, that which disappears on boiling. Temporary hardness is due to the carbonates of lime, magnesia, and iron; permanent, to the sulphates of these metals. Hard waters usually contain both. The carbonates are kept in solution by excess of CO_2 in the water. By boiling, this gas is driven off, and these salts, no longer able to exist in solution, fall as a white powder, which adheres to the sides of the vessel, and accumulates to form a crust. This crust prevents a kettle or a boiler from being easily heated, therefore more coal has to be used to make the water boil or to generate steam, hence increased expenditure of money. Besides, the crust acts chemically on the boiler plates, gradually makes them thinner, and, therefore, less able to withstand the internal pressure, and this, together with the extra firing necessary to keep up steam, forms a not infrequent cause of boiler explosions; hence a danger to life. In "limy" districts the knowing housewife prevents the encrusting of her kettle by placing in it a large playing marble, around which the crust forms. Thus, after boiling, water containing lime, etc., as carbonates, is rendered softer. This is temporary or removable hardness. Lime and magnesian sulphates are unaffected by boiling, hence the hardness remains persistent, and is therefore called permanent hardness. Total hardness is the sum of both. To remove the hardness due to sulphates the washerwoman adds carbonate of soda, which, reacting on the lime and magnesian salts, forms sulphate of soda

and carbonate of lime, which latter becomes precipitated in boiling.

So much discomfort and increased expense arise from hardness in water, that methods have been invented to overcome it, and with some degree of success. But for necessity, therefore, no populous place would choose a hard water if a wholesome soft water could be obtained.

CHAPTER XV.

WATER SUPPLY (*continued*)—CHARACTERISTICS OF POTABLE WATERS—EFFECTS OF IMPURE WATER ON HEALTH.

A PURE and wholesome water ought to be (1) colourless; (2) tasteless; (3) odourless; (4) bright, sparkling, and clear; (5) to have little mineral substance in solution; and (6) to be without organic contamination.

Except the purest rain water, an absolutely colourless water does not exist in nature. Potable waters all have a certain degree of colour when viewed *en masse*. The tints of colour usually vary from bluish to yellowish; the former in chalky waters, the latter in peaty waters from upland lakes. Upon rare occasions a greenish hue is observed in water taken from rivers, reservoirs, or lakes infested with pond-weed, which is due to the dissolved green-colouring matter of the plants. Water of a reddish tint betokens iron. Good water is palatable, does not possess any distinct taste. But palatability may be found in an impure water. This characteristic depends upon the presence of the atmospheric gases in the water; when water is boiled, and these gases are driven off, the water becomes insipid to the average palate. Actual taste in a water can only be imparted either (1) by contamination, or (2) by an unusual amount of mineral substances—as in mineral

waters. We have examined a water which tasted of petroleum, due to accidental contamination of the reservoir. The substance which, in smallest amount, imparts taste to a water, is iron, the amount being one-fifth grain per gallon. Lime salts do not taste a water till they exist in amounts from 10 to 25 grains per gallon. Before common salt can be tasted, it must be present to the extent of 75 grains per gallon. Certain water plants impart a bitter taste.

Good water has no smell. Certain mineral waters have a disagreeable odour owing to free sulphur gases. Water, however, may be accidentally contaminated by fæcal matters, or by coal gas, which are revealed by the odour. We once examined a water which smelled of coal gas. The best way to detect an odour is to heat the water. No water is usable which has a perceptible odour.

A water which has no colour, taste, or smell, is usually also bright, sparkling, and clear. But this last feature is often found in contaminated waters, hence not much reliance must be placed on this single characteristic, as gases of decomposition may simulate the appearance of atmospheric gases. The presence of lime and magnesia may be predicated by the hardness or softness. The "usability" of a water does not so much depend upon the amount of the mineral substances present—although to some extent it is a determining factor—as upon their nature. Certain of them are considered as indicative of animal contamination; and the amounts found which are sufficient to condemn a water are, comparatively speaking, infinitesimal. They act as the danger signal. Such are the

chlorides, the nitrates, and the salts of ammonia. They are not hurtful *per se*, but they often point to organic impurity, to sewage contamination, and to likely accompanying hurtful elements. All waters which contain organic matter are suspicious until it be determined whether the source of it be animal or vegetable; the latter, except when considerable, being comparatively innocuous. Animal organic impurity is dangerous.

All the foregoing considerations point to the need for continuous and careful examination of water supplies, both chemical and biological; and also, for prudent deliberation in the introduction of a new supply, both in respect of (1) purity, and (2) adequacy and continuity of supply.

EFFECTS OF IMPURE WATER ON HEALTH.

Impurities in water apt to affect health are divisible into two classes, *viz.*, (1) those which have their source in filth or sewage contamination, and (2) those due to the nature and amount of mineral constituents. The second class is of lesser vital importance than the first. From the former may arise dysentery, cholera, enteric fever, and diarrhœal diseases. Not many years ago about 20,000 inhabitants of Hull were more or less affected by reason of ditch water finding its way into the supply reservoir, and about 1000 cases of enteric fever occurred in Kidderminster from the accidental leakage of a sewer into the public water supply. From a newly manured field, the surface drainage entering a water supply, 400 cases of the same disease resulted;

and a like outbreak, attributed to Glasgow manure, although not so extensive, occurred near Irvine, in the West of Scotland. Water contaminated with the specific microbe of enteric fever and mixed with milk has been the provocative cause of several epidemics of this disease in Glasgow and elsewhere. In fact, the farmyard well has done more to propagate this disease in cities than any other single cause, if not indeed than all causes put together. Hitherto too little attention has been paid to the sanitation of farmyards, either in respect of milk storage or milk pollution. Cisterns for fresh water are apt, through careless or ignorant plumbing, to become contaminated. We have seen cases to which illness from this cause was clearly traceable, and at Caius College, Cambridge, where an outbreak of enteric fever among the students occurred, the same cause obtained. From the foregoing, therefore, it will be observed that a water supply is apt to become polluted either (1) at the source of supply; (2) during conveyance; or (3) at the point of distribution. To avoid contamination it is necessary to select a "gathering ground" for the water supply removed as far as possible from the haunts of men, and to safeguard it against sources of pollution.

Cholera is most usually a water-borne disease. The recent outbreaks at Hamburg and elsewhere demonstrate the relation between this disease and a water contaminated by the specific microbe. A pure water supply, therefore, is the first and best line of defence against cholera.

Certain parasitic diseases which affect man are also traceable to water which contains the ova of certain

parasites. Intestinal worms have, not infrequently, this origin, and are found both in man and in the lower animals. During the tunnelling of Mount Gothard many of the workmen were seized with intestinal hæmorrhages, which, after investigation, were found to have been caused by microscopic leechlike parasites in the drinking water.

The mineral constituents of water, when abundant, are apt to create, not only discomfort, but actual disease. It is sometimes difficult to believe that alterations in diet, or physical surroundings, affect health, and it is equally so to think that the mere change of water supply may be the cause of actual illness. Persons who, for nine or ten months of the year, use for drinking purposes, and in the preparation of food, soft water, are very liable at first to gastro-intestinal disturbance when they remove for a summer holiday to a district where the water is hard. This is a common experience. Constipation, alternating with diarrhœa, or continuous diarrhœa, are common effects, until acclimatisation is effected. Certain diseases have been for ages attributed to the constant use of hard water. "Derbyshire neck," or gôitre, is one of these, and cretinism—chiefly found in Switzerland—is another; they are not infrequently found associated. By some observers they are said to be due to the sulphates of lime and magnesia, and by others to certain metallic sulphides, notably that of iron. In Switzerland, the Himalayas, Cochin China, and the Pyrenees, cretinism, which consists of a certain rickety condition of the bones of the body, associated with mental imbecility, is by no means uncommon. A French Commission appointed to inquire into this sub-

ject obtained some striking evidence on the matter, as, for instance, the following: In 1848, in a town called Bozel, of a population of 1472 persons, 900 had gôitre and 109 were cretins, while the population of a village, St. Bon, situated about 1100 yards higher than Bozel, was absolutely free from both diseases. Each place had a different water supply, that of the former a "hard" water containing magnesium and lime sulphate, that of the latter a "soft" water. A pipe was laid from St. Bon to Bozel conveying this soft supply. Sixteen years after—1864—Bozel only contained 39 gôitrous persons and 58 cretins. While the connection between hard water and gôitre is so close, it has not yet been absolutely determined that lime and magnesium salts are alone the causative agents. But they have this connection, although their physiological operation in the body is still obscure. Vegetable matter—principally from peat—when present in amount may give rise to gastro-intestinal catarrh, but more serious mischief is not likely to follow.

CHAPTER XVI.

DETECTION OF IMPURITIES IN WATER—MODES OF PURIFICATION OF WATER.

THE impurities of a water may consist either of (1) suspended matter, or (2) organic matter, or (3) mineral substances in solution, derived from organic sources, which are removable by adequate filtration, the former entirely, the latter to a varying degree. Let us meanwhile deal with the impurities dissolved in the water. Their detection falls within the domain of the chemist; but without trenching unduly in his field, it may be pardonable if intelligent persons should desire a little knowledge of the subject—sufficient, at least, to enable them to sound a note of alarm. As chemical solutions nowadays can be purchased ready made for testing, the mere operation of testing becomes mechanical; the difficulty emerging at interpretation of the results of the tests. The impurities to be looked for are those which are animal in origin, and may be taken, when found in amount, as evidence of sewage contamination. They are liable to be present in waters from surface wells, owing to soakage of excrementitious fluids. There are three substances which are not difficult to detect, which, too, when found in notable quantity, in waters from certain sources, point indubitably to animal pollution. These are *chlorides*, *ammonia*, and *organic matter*. Urine is their common source. Sodium chloride—common salt—is always abundant in healthy urine. So is urea, which, when

acted upon by a microbe, is decomposed into salts of ammonia. Of themselves they are not harmful, but owing to their common association with more potent factors for ill they may be taken as danger signals.

Chlorides may be detected by adding to a test tube half full of the water to be examined a few drops of a dilute solution of nitrate of silver (lunar caustic) and a like amount of dilute nitric acid. A white haze, or turbidity, or precipitate indicates chlorides, and the denser the haze the larger the amount of chlorides. A marked haze indicates a suspicious amount.

Ammonia is detected by adding in a similar tube a few drops of Nessler's solution. If ammonia be present a yellowish or yellowish-red colour will develop, the colour deepening in intensity with the amount of ammonia present. A marked yellow colour indicates danger. Each of these reactions is best seen by looking down through the column of water in the test tube; in the first against a dark ground, and in the second against a white surface: and by placing alongside a second test tube, filled with water to the same level, but to which the chemicals have not been added, the slightest difference in colour may then be detected.

The presence of organic matter points to contamination from animal sources if the chlorides and ammonia are present in notable quantities. Organic matter is detected by a weak solution of Condy's fluid, made by adding two drops of Condy to half a teacupful of pure water. Of this add four drops to a test tube containing water, with one drop of dilute sulphuric acid, and warm contents of tube. The pink colour disappears if organic matter, either vegetable or animal in origin, be present.

TABLE SHOWING TESTS FOR QUALITATIVE ANALYSIS OF ORDINARY DRINKING WATER.

Physical appearances: 1. Colour, 2. Taste, 3. Odour, 4. Suspended matter, } to be tested against equal quantities of distilled water.

Substances Tested for.	Reagents.	Effects Produced.	Remarks.
Chemical reaction.	Methyl-orange.	Yellow colour, if alkaline; reddish-pink, if acid.	Compare with distilled water.
Lime.	Strong solution, or powdered crystals } of ammonium oxalate, + NH_3.	White haze, turbidity, or ppt.	Five grains per gallon give decided turbidity.
Magnesia.	Add excess of NH_3 and strong solution of sodium phosphate, with NH_4Cl.	Slowly-forming crystalline ppt. of ammon. magnes. phosphate, hastened by stirring.	
Chlorine (as chlorides).	$AgNO_3$ + dilute HNO_3.	White haze, turbidity, or ppt. of AgCl.	One grain per gallon gives decided haze; four grains, marked turbidity.

TABLE SHOWING TESTS FOR QUALITATIVE ANALYSIS OF ORDINARY DRINKING WATER—continued.

TABLE SHOWING TESTS FOR QUALITATIVE ANALYSIS OF ORDINARY DRINKING WATER—*continued.*

Substances Tested for.	Reagents.	Effects Produced.	Remarks.
Sulphuric acid (as sulphates).	$BaCl$ + dilute HCl.	White haze, turbidity, or pp. of $BaSO_4$.	Two grains per gallon give slowly-forming haze; three grains, immediate haze.
Sulphides, or Hydrogen Sulphide.	1. Acetate of lead. 2. Copper sulphate.	Dark discoloration due to PbS, or CuS.	Observable when sulphides or H_2S are markedly present, and in long columns of water.
	3. Na HO + Nitro-prusside of sodium.	Violet coloration.	Traces discovered by this test.
Ammonia (NH_3).	Nessler's solution.	Yellowish, or yellowish-brown coloration.	Detects minute quantities.
Nitrites (in combination).	1. Zinc iodide and starch solution + dilute H_2SO_4.	Blue coloration due to formation of starch-iodide. $ZnI_2 + 2KNO_2 + 2H_2SO_4 = I_2 + ZnSO_4 + K_2SO_4 + 2NO + 2H_2O$.	One part in fifty millions of water may thus be detected.
	2. Weak acid solution of metaphenylamine diamine + dilute H_2SO_4.	Yellowish-brown, or dark-brown colour.	Reaction appears slowly.
	3. Sulphanilic acid (solution in acetic acid) + naphylamine acetate.	Beautiful pink colour.	Reaction appears slowly.

TABLE SHOWING TESTS FOR QUALITATIVE ANALYSIS OF ORDINARY DRINKING WATER—*continued.*

Substances Tested for.	Reagents.	Effects Produced.	Remarks.
Nitric acid (as nitrates).	1. Evaporate to dryness small quantity of sample; add two drops H_2SO_4 and a granule of brucine. 2. Solution of diphenylamine in H_2SO_4 + strong H_2SO_4. 3. Evaporate water to dryness. Add five drops of phenol-sulphonic acid, a little distilled water, and solution of KHO in excess.	Rose colour, which afterwards becomes rainbow like. Blue colour. Yellow colour.	Detects one part in a million of water. The nitric acid is converted into picric acid, which forms with KHO the yellow salt of picrate of potash.
Phosphoric acid (as phosphates).	1. Add a little dilute HNO_3 to sample of water and evaporate to dryness. Heat residue cautiously, then dissolve in dilute HNO_3, and filter. To clear filtrate add twice the volume of warmed, strong solution of molybdic solution. 2. Heisch's Test.—Add to water small quantity of sugar in a clear glass stoppered flask. Place flask in strong light, in a temperature of about 80° F. The phosphatic fungus develops, after some days, as minute bunches of grapes.	Yellow colour of ammonium phosphomolydate.	Phosphoric acid is usually absent, except in sewage-contaminated waters. Coloration appears slowly.
Oxidisable organic matter.	Very weak solution of $KMnO_4$, acidified with H_2SO_4. Add a couple of drops to the water.	Pink colour disappears.	This reaction is due to the reduction of permanganic to manganic acid.

Substances Tested for.	Reagents.	Effects Produced.	Remarks.
Iron. Lead. Copper.	Differential detection— Add to sample NH_4HS = black coloration. Divide sample into two parts. To No. 1 add dilute HCl. Coloration disappears = iron. If coloration remains— To No. 2 add strong solution of potass. cyanide. Coloration disappears = copper. If coloration still remains = lead. Confirmatory tests :— Iron.—Acidify sample of water with HNO_3 and concentrate by boiling ; cool. Add a few drops of solution of potass. sulphocyanide (KCyS) = blood-red colour. Lead.—Concentrate water by evaporation. Add solution of potass. bichromate = yellow turbidity. Copper.—Concentrate as above and add solution of potass. ferrocyanide = mahogany-red colour.		
Zinc.	Add HNO_3 to water sample ; boil ; filter. To clear filtrate add potass. ferrocyanide.	White haze, turbidity, or ppt.	This test discovers the merest trace.
Arsenic.	Add to water large pinch of pure Na_2CO_3. Evaporate to dryness. Dissolve residue in small quantity of distilled water ; then add a few drops of pure HCl and two small pieces of pure copper foil. Boil.	Copper is stained with steel-grey deposit.	

General Remarks :—

(1) When making comparisons between sample of water to which reagents have been added, and one without reagents, use columns of water of equal length in similar test tubes.

(2) When making observations of reactions, where the result is a white haze or turbidity, look down *through* the test tube against a *black* ground ; where the result is a darkened discoloration, or a yellow or blue, or pink colour, against a *white* ground.

PURIFICATION OF WATER.

Those impurities of water due to sewage contamination which are most dangerous to life are rendered innocuous by the simple operation of boiling the water before it is used. To make it palatable for drinking it should, after cooling, be re-aerated as follows: Pour the water forcibly from one vessel to another, in the open air, or by means of the rose of a watering-can, which by dividing the liquid into fine streams causes it more easily to reabsorb atmospheric gases. It should then be kept covered in a cool place, and, in summer, preferably in a porous earthenware jar.

Suspended matters, such as mineral matters, particles of floating substances, or even animate beings such as water insects, or, upon rare occasions, small fishes, may find their way into the main supply pipes unless the water be strained or filtered at its source. The water of Loch Katrine is not filtered before distribution, and curious tenants are sometimes found in the water-pipes. Our neighbour experienced one a few years ago. The supply to the kitchen tap was suddenly and completely cut off, although it was as usual in the other parts of the house. On opening the pipe it was found that the cause of the obstruction was a small trout measuring about four and a half inches in length. It is difficult to say whether this fish made a subterranean voyage of thirty or seven miles, the respective distances of the loch and reservoir.

Where suspended matters are present, filtration must be resorted to by the water companies. Filters are constructed on the grand scale, and the filtering

materials used are sand, small gravel, large gravel, shells, and small boulders, in that order from above downwards, the respective thicknesses of the layers of each varying according to the opinion of the engineer. These filter-beds, in addition to straining suspended matter, remove to a considerable extent both organic matter and microbes. This is purification on the large scale.

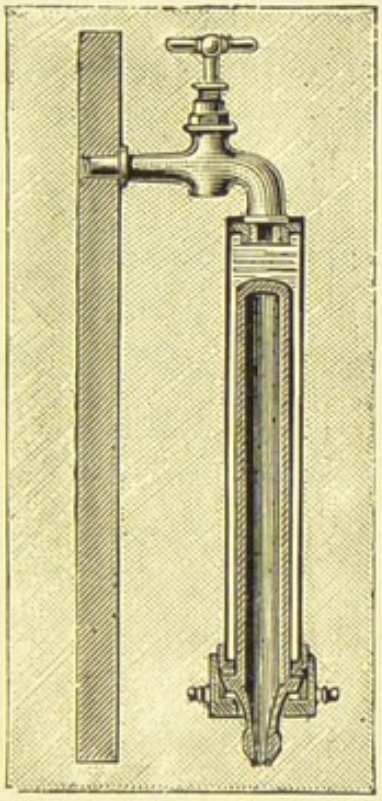


FIG. 29 A.—Chamberland Filter.



FIG. 29 B.—Porous "Bougies".

Household filters are the means adopted to purify on the small scale. Much has been written lately condemnatory of these filters in respect of their failure to achieve what is expected of them. They fail chiefly in not arresting microbes, and in respect that the filtering media are not cleansed often enough they permit of the multiplication of such microbes—in short, become breeding grounds for these organisms. On the other

hand, if the filtering media be repurified at regular short intervals their action is quite safe. The media employed are: (1) Carbon, animal or vegetable, sand in powder or in block, iron, in some form, and asbestos. To purify the first and last named it is only necessary to subject them to the influence of fire, to a red heat, and the others by washing several times with boiling water. The only filters which do not permit the passage of microbes are the Pasteur-Chamberland and Berkefeldt filters, the former of which is made of tubes

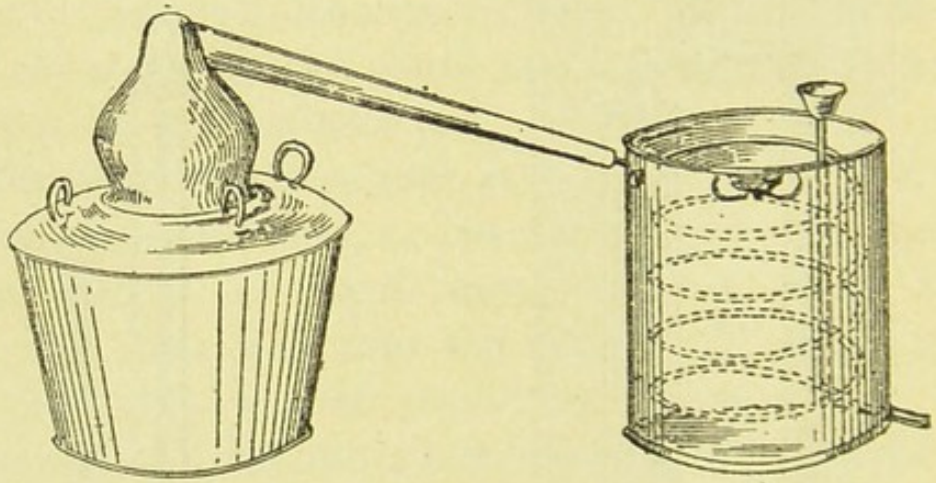


Fig. 30.—The Still and the Worm.

of unglazed porcelain, and the latter of tubes of compressed diatomaceous earth, spoken of as "bougies". Fig. 29 A shows the Chamberland filter fixed in position on the water-tap, and Fig. 29 B shows the porous "bougies" through which the water filters.

Distillation is another mode of purifying water, and is now commonly adopted in ocean-going steamers for the supply of potable water from sea water. This process ensures purity, and, after re-aeration, no better water can be had. It is nature's mode of supplying the earth with water.

Fig. 30 illustrates an apparatus for distilling. On the left of the figure is the vessel containing the heat, on top of which is the retort containing the fluid to be distilled; this opens into the condensing apparatus, a tube or "worm" lying in a vessel containing cold water. The circular dotted parallel lines indicate the "worm," which presents, by its spiral form, a larger condensing surface. The distilled fluid escapes at the bottom of the condenser by the small tube.

To rid water of hardness-producing mineral substances—chiefly lime and magnesia—is of importance where it is necessary that a soft water only should be used, as in certain commercial operations. This may also be deemed a form of purification, inasmuch as materials are got rid of which, for the purpose intended, would be objectionable. But this purification is one of expediency more than necessity.

CHAPTER XVII.

HOW WATER REACHES OUR HOMES—THE PUMP—GRAVITATION—THE SIPHON—THE HYDROMETER.

THE source of a water supply largely determines the mode by which water reaches the homes of the users. In wells, for example, there is a collection of water lying at the bottom of a shaft, more or less deep, which, before it can be used, must be lifted. This is usually accomplished either by a windlass, or a hand-rope and bucket, or by a pump. Of the former not a word more need be said, but of the latter some explanation must be offered.

THE PUMP.

Every one is acquainted with the fact that, if an ordinary glass syringe is dipped into water and the piston pulled out, water will rise in the barrel. This is due to the difference of atmospheric pressure within the barrel at the moment of drawing the piston, and that on the surface of the water in the vessel from which it is drawn. The pressure being greater on the latter than in the former, the water is forced into the barrel, following the piston. In this simple experiment several of the points in the action of a pump are demonstrated. To Galileo and Torricelli we are indebted for our knowledge of pump-action. The ordi-

nary pump is called the lifting pump, or the suction pump. Figs. 31 and 32 will assist in the comprehension of the following explanation of the action of a pump. A pump consists of these essential parts, *viz.* : (1) The piston, which runs in the pump-barrel; (2) the pump-barrel, within which the accurately fitting piston is moved up and down by the pump-handle, and from which the spout opens; (3) the pump-tube, which

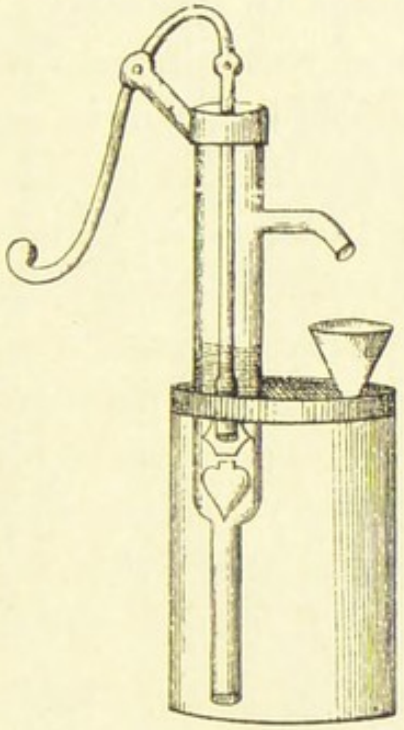


FIG. 31.

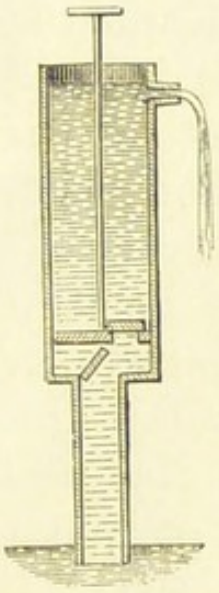


FIG. 32.

The Lifting Pump.

extends from the bottom of the pump-barrel to some depth in the water of the well; (4) the pump-handle, which moves the piston; and (5) certain valves, one in the piston, and one in the pump-tube. When the piston is raised the piston-valve is closed, because of the pressure of water above it, and water is forced out of the spout; at the same time the pump-tube valve is opened and water is forced into the barrel, as in the

syringe, and for the same reason. When the piston has reached the highest point of the up-stroke, it is now made to descend in the barrel, when the piston-tube valve opens and the pump-tube valve closes. By this alternate up and down movement of the piston by the pump-handle, therefore, the water is raised from the well into the pump, and from the pump-spout, vessels may be filled. Indeed, the operation is accomplished in less time than it takes to describe it. But the lifting pump can only raise water from a limited depth, which, in theory, is about 34 feet, but in practice, from 25 to 30 feet. This limit is due to the fact that ordinary atmospheric pressure (14·7 lbs. per square inch) can only support a column of water of that height, or 30 inches of mercury. And since mercury is 13·59 times heavier than water, the same pressure will support a column of water of the same size to a height equal to 30 in. × 13·59, *viz.*, 34 feet. When water has to be raised from greater depths than this different pumping apparatus must be used, which, however, is beyond our purview.

THE SIPHON.

Connected with the flow of water, and based on the same facts, is the instrument known as the siphon, which in its simplest form consists of a tube of glass or other material bent upon itself, one limb of the bend being longer than the other. This is of considerable use in ward work, where fluids consisting of layers of different densities require to be separated, or a fluid from a deposit, or in transferring antiseptic

fluids from reservoirs to the operating table. Besides, it is used in the treatment of certain gastric diseases, and in emptying the contents of the stomach in cases of poisoning. To set the ordinary siphon in

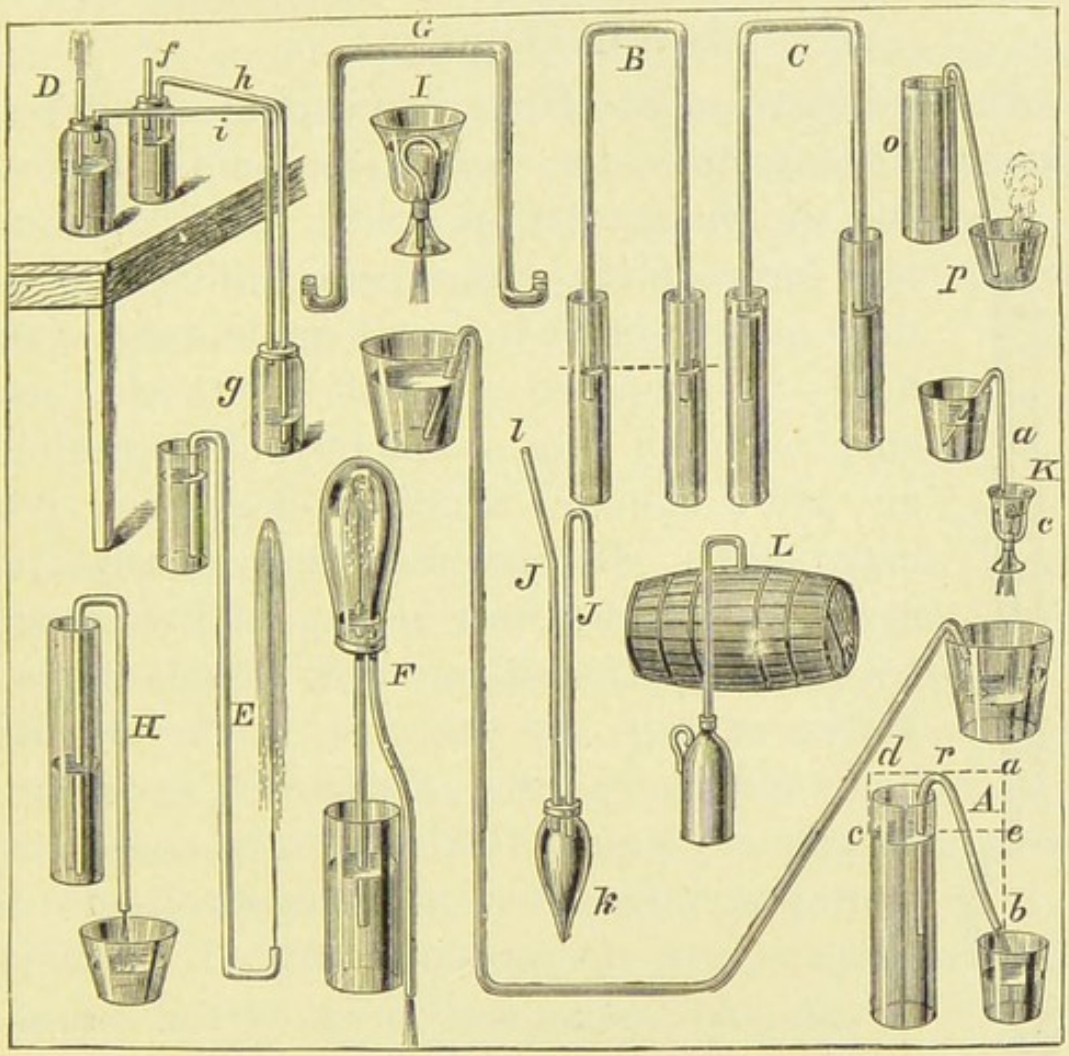


FIG. 33.—Different Forms and Uses of Siphons (from Fessenden's *Physics*).

A demonstrates the physical laws of the siphon; B, C, H, P and K, siphons for ordinary uses; G from its shape is always ready for use; J, for corrosive liquids; I, Tantalus cup; D and E, siphon fountains; L, action of siphon on contents of barrel.

operation all that is necessary, provided the nature of the fluid permits, is to suck, or by the use of a syringe to exhaust, the air out of the long limb of the siphon after placing the shorter limb in the vessel, when the

fluid will run in a continuous stream until the level of the liquid in the vessel reaches the extremity of the tube. Fig. 33 shows the practical application of the instrument in various ways.

THE HYDROMETER.

Another instrument of use in hospital and private nursing is the hydrometer, which is intended to show the specific gravity of fluids. Fig. 34 shows one form of the instrument. The ordinary urinometer—or hydrometer graduated for this fluid—is composed of a bulb containing mercury or small shot, a second bulb containing air, and a stem, in which is enclosed a graduated scale. The specific gravity of any liquid is the weight of a unit volume of it compared with an equal volume of a standard fluid. Water at 4° C., or 39·2° F., is the standard fluid, and its specific gravity is 1, or, as it is usually expressed, 1000; or, as is more common, the instrument is "standardised" for fluids at a temperature of 15·5° C., or 60° F. In using the instrument, a cylindrical vessel is filled two-thirds full of the liquid to be tested, into which the hydrometer is placed. The depth at which it will float depends on the weight or density of the fluid; the point on the stem at which it becomes stationary, and which is at the level of the surface of the fluid, is then noted, and the figure corresponding to that point written down. This registers the specific gravity of the fluid tested. Special instruments are made for special

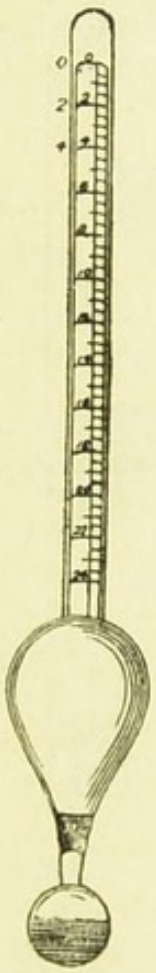


FIG. 34.—Twaddell's Hydrometer.

fluids, *viz.*, the urinometer for urine, the lactometer for milk, the saccharometer for sugary liquids, and the oleometer for oils; and they are graduated within the limits of gravity known to be possessed by these different classes of fluid substances. In addition to being used for testing the specific gravity of urine it is likewise used for fluids from tumours or from the natural cavities of the body. The lactometer, used for taking the specific gravity of milk, is worse than useless as indicative of the purity of the sample, for reasons which space forbids us to enter upon.

SUPPLY BY GRAVITATION.

To return, however, to water supply to the house. When populous places are to be supplied from natural or artificial collections of water, the relative heights of the source and the area of distribution become of importance. Water will run down hill whether in an open channel or in a pipe, owing to the law of gravity; hence such supplies are often designated gravitation supplies. To be of the greatest service the level of the source must be some feet higher, at least, than the highest point of distribution, else the water will not rise to houses on this level. Sometimes, however, this cannot be avoided, and in such cases auxiliary pumping-stations must be erected to supply the higher levels. Fig. 35 illustrates in section a gravitation supply. From the lake, A, the dotted line being the level, the water flows under the river, B, into a reservoir, E, and from thence to the houses, F. Should, for any reason, the level of the water in the lake fall much, the top

flats of the houses, F, would not be supplied because the pressure would be insufficient, since the fall would be equally experienced in the reservoir, E.

From such gravitation supplies the supply to houses within the area of distribution is either continuous or constant, or intermittent, *i.e.*, either on a tap at any time of the night or day, or for periodic intervals only, in the course of the day. Adequacy of supply is the chief determining cause of this. Where water is abundant the constant supply prevails, where barely adequate, the intermittent. In the latter case it is necessary to

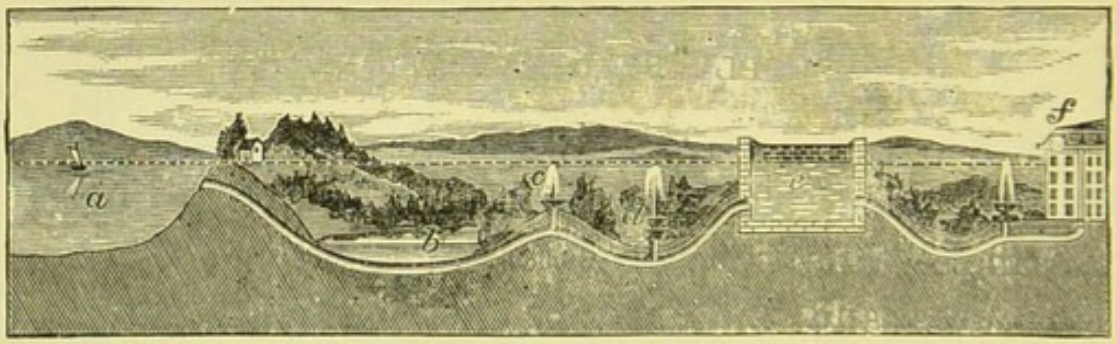


FIG. 35.—A Gravitation Water Supply (from Fessenden's *Physics*).

erect house cisterns wherein to store water against the time when the main supply is cut off. This entails risks of pollution, with attendant harmful results to the consumers. A supply of water ought, therefore, to be continuous in action, plentiful in amount, and it ought to be easy to obtain by every householder, in order to contribute to cleanliness, both public and domestic.

The amount of water to be supplied per head of population per day is necessarily regulated by the abundance of supply. But there is a certain minimum which is necessary. The average adult needs for nutrition from 70 to 100 oz. daily. Each soldier in barracks is

allowed 15 gallons daily. From 12 to 15 gallons per day may, therefore, be considered a fair minimum. The supply per individual may be apportioned as follows, *viz.:* Dietetic: (1) cooking; (2) drink; Sanitary: (3) personal ablution; (4) cleansing of clothing; (5) as a vehicle for sewage.

In towns the amount per head per day ranges from 20 to 300 gallons, many towns in England giving the former, and New York the latter amount. These amounts cover a variety of purposes, *viz.*, personal and domestic cleanliness, including baths and closets, animal nutrition and cleansing, municipal and manufacturing uses. The citizen of London receives, on the average, 28 gallons daily; of Liverpool, 30; of Paris, 31; of Edinburgh, 35; of Glasgow, 50; and of Rome, 100. These are typical city supplies.

CHAPTER XVIII.

PERSONAL HABITS IN RELATION TO HEALTH—HEREDITARY AND ACQUIRED.

It may be said that the personal habits of a people find their reflex in the standard of national health. These habits, if objectionable, may be minimised or intensified, however, by the geographical position which the particular country occupies, and by other factors. This becomes still more true of the inhabitants of certain districts of populous places which are the habitats and resorts of the vicious, the thriftless, the lazy, and the dirty. Such places are deplorable blots on the social landscape, and no scheme of amelioration has as yet solved the problem of successfully overcoming the evils caused by them.

The cardinal point around which personal and public health revolves is cleanliness—of the person, of food, and of the home. Probably the oldest sanitary code in existence is that which was enacted during the Mosaic Dispensation, and which is carried out to this day by all faithful Jews in whatever part of the world they are situated. It would be well for hygiene if the injunctions laid down in that code could be carried out, if not in their entirety, at least in large measure, as part of the religion of all peoples. In the forefront of it stands cleanliness—individual, dietetic, and domestic;

and there is no doubt that the longevity and general excellent standard of health of Jews are to be attributed to the observance of the laws laid down in the Bible and the Talmud. The plentiful use of water, the frequent bathing of the person, the cleansing and disinfection of the home, and many like important rules, are prominent injunctions of the Mosaic code.

Personal cleanliness ought not, at this time of day, to be a doctrine which needs to be inculcated; unfortunately, however, it is still one which requires teaching. The bulk of persons have much to learn regarding the physiology of the skin; when the fact is considered that millions of sweat and oil glands open on the surface of the body, it will be at once apparent that cleanliness is essential to the proper performance of their function. If it be unattended to, a greater share of work than ought to be is thrown upon certain of the internal organs—notably, the kidneys—from which disease is apt to arise. The proverbial saying that "cleanliness is next to godliness" would read better if it were put that "cleanliness is part of godliness". Dust and "dirt" are two things against which every cleanly housewife wages constant warfare. When the former is examined microscopically, it is found to consist of a large variety of particulate substances which are the products of the tear and wear of our bodies, and of objects around us. Dust always contains micro-organisms, and every dark, dusty corner harbours a large number. The prevalent mode of dry dusting is simply a farce, and consists only in dislocating the dust from the place on which it lies, into the atmosphere of the room, again to settle in a new place after the

atmospheric disturbance has subsided. It is time that this method should give place to moist dusting by a damp cloth. It may mean more trouble, but it is worth it. Another old-fashioned method of sweeping a carpet, previously sprinkled over with moist spent tea leaves, is infinitely preferable to the more modern sweeping-made-easy machines of American origin. There is an old Scottish proverb, which must have descended from prehistoric times, which says, "The clartier (*i.e.*, the dirtier) the cosier". The followers of this precept have long since realised its falsity, for the Nemesis of insanitation has overtaken them. Fifty years ago, all over this kingdom, typhus fever raged as a plague. Even then it was pointed out that the plague raged worst in the dirtiest places. Now, owing to the forward march of sanitation, it is a comparatively rare disease.

A dirty person is usually a careless, a thriftless, and very often a vicious person who is regardless of his responsibility to his relatives and to his neighbour. In a population composed of such persons sickness is more prevalent, and death-rates are always high.

Cleanliness in feeding is not only conducive to personal comfort, but it tends to prolong life. Good cooking of the humblest fare will nourish, while imperfect uncleanly cooking of even the best will but provoke mischief. Flesh meat is probably the most common vehicle of parasitic disease. To avoid this, the Mosaic code laid down the strictest injunctions, and in the Talmud no fewer than 86 chapters, divided into 642 paragraphs, are devoted to this subject. So long as the present imperfect system of meat inspection obtains

in this country, all flesh meat should be thoroughly cooked, that is, till the fire has acted on every part of it. Thorough cooking renders parasitic germs innocuous. Cold pies of all sorts, brawn, corned beef, sausages, and "tinned" meats, have, at times, occasioned serious and sometimes fatal illnesses. Pies which are intended to be eaten cold should have two good-sized vent-holes in the crust. This lessens the chances of putrefaction. Putrefactive micro-organisms, which find the "jelly" of the meat an excellent feeding ground, are prevented from thriving, by reason of the plentiful admission of air. Tinned meats only become dangerous when air has been admitted by a pin-hole opening some time prior to the time of using, and for the above reasons also. Care, therefore, should be exercised in the purchase of "canned" goods. A wholesome "can" should have its top and bottom tending inwards towards the centre of the "can," and should not emit a "crackling" sound when pressed by the finger. Any "can" which evidences the opposite of these characteristics ought to be rejected. These are, apparently, trifling facts, but they are very important, nevertheless.

CLEANLINESS OF THE HOME.

The cleanly person has a cleanly home, and the reverse is equally true. In addition, the dirty person and the dirty home menace, to some extent, the health and life of the neighbour. All the sanitary Acts are aimed against the careless and negligent, which terms are often synonymous with the dirty person. This is especially true of the spread of infectious disease from the

home and school. Cleanliness of the home necessarily includes particular attention to the bath-room and water-closet.

VICIOUS HABITS not only operate prejudicially on the health of the individual practisers, but, in the mass, they produce fruits in high mortality of offspring, in shortened lives generally, and in high death-rates. If we were to particularise regarding those habits which are most harmful, we should name (1) abuse of alcohol; (2) of tobacco; (3) of tea; and (4) immorality, as among the chief. Alcohol, in some form, has been manufactured by every nation of the earth, and from aboriginal times.

OCCUPATIONAL HABITS.

It may fairly be said that there is hardly any occupation which is unattended by some objectionable habit on the part of those employed. Such habits may be divided into two classes, *viz.:* (1) those which are postural or attitudinal, owing to the position assumed by the worker, and which, too, are difficult to avoid; and (2) those which are only incidental to the occupation, and which might be avoided. Of the former class, are those where the employment compels the worker to assume a cramped or constrained attitude. Clerks, handloom weavers, authors, glovers, lacemakers, and shoemakers are instances; the stooping posture of the clerk or author at his desk, the pressure on the chest of the weaver or the shoemaker, by the loom and the "last" respectively, sooner or later provoke illness. Of the latter class are enervating

occupations, such as are carried on in chemical or iron works, where heat is intense, or in badly ventilated workshops; these invite the use of alcoholic stimulants and cause habits of intemperance. This is especially true of persons engaged in the manufacture, transport, or sale of alcohol. The mere negligence to clean the hands in such occupations as plumbing, type-setting, glazing, pottery-dipping, etc., accounts for much lead-poisoning.

HEREDITY AND ITS INFLUENCE ON HEALTH.

Each of us is the product of his or her ancestors. Each has had handed down as the legacy of his birth some of the physical, mental, and moral characteristics not only of the parents, but also of the grandparents, and of the ancestral line backwards. Regarding the transmission of the two former characteristics all are agreed. That moral defects are also hereditary, although doubted by some, is also now generally acknowledged. The children of depraved parents, who themselves were of similar stock, are likely to betray tendencies to kindred depravities; hence our dipsomaniacs from a drunken stock, and our moral delinquents from a theftuous ancestry. It is a difficult question, however, to determine in such cases how much of the delinquency is due to example, and how much to transmitted tendency. When we come to the possibility of transmission of disease from parent to child, it will be seen how hereditary conditions may affect the health of a population. In most of the diseases commonly believed to be transmissible, it ought to be remembered that it is not always

the disease itself, but the tendency or vulnerability which is transmitted. All that is transmitted is the predisposition or cell-impression, and this makes the individual more liable to contract the disease when exposed to it under certain conditions. For example, the child of gouty ancestors may avoid the disease by a careful and constant attention to diet and regimen. Intermarriage with kindred blood, with and between weakly persons, or even diseased persons, is the cause of much transmitted tendency to disease. The marriage laws of the Australian aborigines, or of the American Indians, might well be copied by the civilised peoples of to-day, as they entirely prevented such contingencies. The physical aspects of marriage have not received the consideration they deserve, and if but a tithe of the care expended in the breeding of healthy stock were shown in our marriage relations, there would be much less disease resulting. State control can have no part or lot, however, in the attainment of this. Education, only, against the attendant evils of improper marriages may effect a change, but such will be achieved but slowly, since so many other considerations enter into the choice of a life-partner.

CHAPTER XIX.

EXERCISE—REST—RELAXATION—IN RELATION TO MAINTENANCE OF HEALTH.

THE animal body is a machine built and fitted for the generation, storage, and expenditure of energy. Like other machines of a complicated kind, the various parts do not only perform their work in their own special way, but they have a correlation with one another, and with the entire machine. Linking together the mind and the body is the nervous system, by which the will may send from the brain to muscle messages with lightning speed. When, for instance, it is desired to bend the elbow, a message is sent to the biceps muscle by means of the nerves which cause this muscle to contract, and the necessary action is produced. During contraction the muscles become harder and thicker, whereas during relaxation, they become softer. In this simple movement there is expenditure of energy, because work has been done. Regular use of muscles produces an increase in their bulk and strength. For this reason, the arm of the blacksmith becomes "brawny," and his muscles "strong as iron bands". This condition of a muscle—when increased in size proportionally to the general muscular standard of the body—is called hypertrophy (Greek, *hyper*—over, and *trophè*—nutrition). During the process of enlargement

of the muscle the supply of nutriment is greater than the waste, hence there is growth; and when the maximum growth has been attained this supply must be equal to the waste, hence there is maintenance of condition. On the other hand, if the expenditure of energy be continuously greater than the muscle can bear another condition may come on, called atrophy (Greek, *a*—under; *trophè*—nutrition). Here the waste is greater than the supply of nutriment. Complete inaction of a muscle induces the same state, as in a limb which has been "up" in splints for a length of time.

From these facts, then, we may gather two principles for our guidance, *viz.*, first, that over-exercise is harmful, and, second, that under-exercise is equally baneful, and, as a natural corollary, follows the additional fact, that adequate exercise is necessary for the maintenance of bodily health. It is approximately true that in health the excretory products are equal to the waste of the body, due to the expenditure of energy, and to the excess of food taken. If an amount of food be taken which enables a healthy man to sustain hard labour over a period of time, the supply will probably just equal the demand; but if an enforced period of inactivity follow with the same supply of nutriment, the supply will become greater than the demand, the elimination of effete products less complete, and, sooner or later, discomfort or illness will follow. Exercise increases the functional activity of every organ of the body. The number of respirations per minute is increased, consequently the amounts of CO_2, watery vapour, and organic matter from the lungs are also

increased; and, in like manner, the functions of the skin, kidneys, liver and stomach become more active. This usually leads to development of appetite, by the amount of which the food supply required by the body is, or ought to be, regulated.

The practical aspects of exercise and work are of great importance. From the physiological point of view it matters little whether the energy expended be in pleasure or in business. The two main evils of to-day are over-training on the one hand, and insufficient exercise on the other. Successful training ought to consist in the attainment of maximum muscular development compatible with health. This is not the same for all men, but is relative to the individual. We cannot all be Samsons; at the same time, the man of small physique may be stronger muscularly than he of larger bulk. Over-training involves grave risks to health. It involves undue strain on the heart and large blood-vessels; hence athletes of all classes, whether of the field, of the ring, or of the river, are most liable to break down from diseases of these organs. But under-exercise is probably the more prevailing evil. Temptations are all in this direction. The railway-train, the omnibus, the tram-car, and penny steamer have all been invented to save time, which, to-day, in the race for wealth, has a money value. It is difficult to convince the eager business man that walking to business will pay him better in the end than any of the aforementioned modes of progression. The leisurely business man in the end accomplishes more than his colleague who rushes through his business day at high pressure. The increasing nervous diseases, the

flow of insanity, the sudden deaths from heart diseases, and many crippled lives from other causes are the costs of this unceasing restlessness.

Exercise for the young is all-important. Out-of-door games of all kinds, suitable to the physique and temperament, ought to be encouraged. Usually children adapt themselves to the kind of exercise most suited for them. Sex is not now the barrier it formerly was in the prevention of girls and women taking part in athletic exercises. Tennis, cricket, croquet, golf, fishing, cycling, and even shooting, now form the pastime of both sexes. Walking is the only general form of exercise which threatens to become a lost art in our city populations; and yet there is no more healthful form of exercise. A walking tour, to a person in training, amid picturesque scenery, is one of the most invigorating of holidays. A day on the river, rod in hand, is a stimulant of the most bracing character; and the like is true of the round of golf on the upland links, or the game on the bowling green. Persons who work in confined positions, those of sedentary occupation, can maintain good health by walking, by moderate gymnastic exercises, or by any of the aforementioned modes. All work and no play makes Jack not only a dull, but also an unhealthy boy. The healthy mind in the healthy body can only be attained and maintained by consideration being paid to the needs of both brain and muscle respectively, and in ratio to the relative calls upon each.

REST.

After labour comes rest. Exertion brings with it the sense of fatigue, which is nature's signal for rest, and

for the need of nutrition. Every machine has a natural term of life, and this is as true of a locomotive as of a man. The tear and wear, which eventually cannot be repaired, renders the machine useless. In a man, expenditure of energy of brain, or body, or both, calls for rest. The close inter-association of brain and body means that fatigue of the one involves, to a certain extent, fatigue of the other. In unskilled labour there is greater expenditure of muscular than mental energy; in skilled, there is expenditure of both. For the mental worker the energy expended is principally nervous, and little or none of it muscular.

Rest, therefore, for these classes of workers, is but a relative term. The manual worker needs bodily rest; the mental, brain rest. In the former, moderate mental action, as in reading, would be beneficial, and in the latter, moderate muscular action is required. Change of mental labour is a form of rest, for there is a certain sense of relief experienced in changing the field of study. But this is only temporary; for, after all, while the current of thought is changed, it is but switching the current into a new channel, and the thought-generating machine is working all the while. Rest of any organ depends largely upon its function, both as to amount and kind. In walking we do not hop upon both legs at once, as does the kangaroo, and in the alternate use of the limbs, nutrition and alternation of energy-expenditure take place. Even the heart, though constantly in action, has its periods of rest in the momentary pauses between each beat; and special provision has been made for rest of the brain in sleep.

Rest is the animal expression of relief from the

sense of fatigue. The tired animal, like the tired man, lies down to rest its weary limbs.

Relaxation, however, is only possible to the thinking animal, man. During relaxation there is a certain amount of expenditure of mental or bodily energy, or both, but it partakes of a form which is only calculated to divert the mind or titillate the senses. We look at pictures, we converse, listen to lectures or music, or attend the theatre, from the sense of pleasure these things produce. Rest and relaxation, therefore, are inseparably linked together when one dissociates himself from the business of his life, but they may not be present in equal degree at the same time. The object of both, however, is *re-creation.* The fitful daily periods of rest and relaxation from daily toil doubtless serve a useful purpose, but they are unsuited entirely to sustain the body healthfully over long periods of continuous work. Holidays ought to form part of the scheme of life of every man, and they ought to be for him holy-days, set apart as religiously for the duty of physical recreation as his Sabbaths are for spiritual recreation. Especially is this true for the denizens of populous places, but equally necessary for all. A holiday conduces to better health and longer life, and if it be devoted to the regeneration of the mind and body in the contemplation of nature or art, the works of God or those of man, accompanied the while with agreeable physical exercise, it will achieve this purpose. "Hobbies" and "fads," of whatever kind, are most healthful and helpful. They exercise a beneficial reactive influence in taking the individual out of the rut of routine, and they make the wheels of life go more smoothly. Whatever

its form, be it carpentering, model making, photography, book or stamp collecting, autograph hunting, chemistry, or any other kindred science, such as botany or geology, let the hobby be pursued leisurely, profitably, and consecutively, and let it contrast as much as possible with the serious business of life. For the mental worker, let it be an occupation of the hands, which will cultivate skill, and which can best be carried out in the open air. His object ought to be to allow the brain to lie fallow for a season, and to reasonably develop his bodily physique against the time he returns to his pen and his books.

CHAPTER XX.

SLEEP—HYPNOTISM—IDIOSYNCRASIES—IN RELATION TO HEALTH.

THE state of sleep is characteristic of all animated nature, and a kindred phenomenon is observable in many plants. During this state the expenditure of nervous and muscular energy in animals is repaired against a new period of work. With the ordinary phenomena of sleep all are practically acquainted, and they need not now be discussed. But there are certain attendant physiological conditions which are not generally understood. The predisposing causes of sleep may be summed up in the following, *viz.:* (1) muscular or mental fatigue, or both; (2) a condition of quietness and rest; and (3) an attitude of muscular inactivity. Generally speaking, muscular fatigue can be repaired by resting the muscles during the waking condition. But the brain is in activity during the whole waking period. It therefore must be considered in two aspects, *viz.:* (1) simply as one of the organs of the body, the waste of which requires to be repaired; and (2) as an organ having special and peculiar functions to perform, and which demands a special and peculiar mode of repair. Obviously, sleep has to do with the nutrition of the brain as a thinking and perceptive organ. During the whole period of wakefulness, whether in

ideation, by emotions, sensations, impressions, or voluntary acts, through the channels of the sense organs, the brain is in constant activity. Hence in courting sleep we assume, as far as is possible, an attitude of body which is least liable to disturb the fading consciousness; thus we lie down, shut our eyes, and choose a quiet spot that our sense of hearing may not be kept active. Habit may modify these conditions, and man is able to adapt himself to conditions quite dissimilar from those mentioned. In going to sleep all of the senses do not go to sleep at the same time. Sight goes first in shutting our eyes, taste next, then smelling, then hearing, and last of all, the sense of touch. Neither does the body, as a whole, go to sleep at once. It begins at the points furthest from the centres of nerve control. It is for this reason that cold feet operate as a grievous hindrance to sleep. Certain physiological changes occur in the action of the heart, in the respiration, and in the bodily temperature. The number of heart-beats per minute is diminished; in like manner the respiratory action is less frequent; and a fall takes place in the bodily temperature usually about 1° Fahr.

CAUSATION OF SLEEP.

Many theories have been propounded regarding the proximate cause of sleep. We will briefly consider one or two of these. Since all theorists are agreed that the object of sleep is the recuperation of brain and nerve energy, an important factor is the condition of the blood circulation of that organ. Round this several

theories cluster. One of the very oldest and one of the most recent of these, consider that venous congestion of the brain is the cause. Another, which is supported by many observers, and by not a little experimental research, teaches that anæmia or comparative bloodlessness of the brain is the proximate factor. It is fairly certain the condition of the brain circulation during sleep is one of anæmia, and from this and other facts, certain conclusions have been come to regarding the conditions of the brain blood-current which are most favourable to the onset of sleep. These are as follows: (1) A lessened flow of blood; (2) in consequence, a lessened supply of blood; and (3) an exhausted condition of brain-tissue. The first condition results from causes of a positional and functional kind; the second, from the physiological law of nutrition, that a resting organ demands less blood than one active; and the third is a periodic fact. Some years ago, Sir James Paget propounded the law of rhythmic nutrition, which, simply, is this, *viz.*, that the nutrition of an organ, which has a rhythmic action, is accomplished in a special way to suit the special needs of the organ. Hence the heart is nourished in the "pauses" between the contractions. So with the brain. If we take a period of twenty-four hours, and call it a cycle, the brain rhythm would alternate between a condition of wakefulness and one of sleep—a condition of action and one of rest. During wakefulness the brain is the organ of mind, and of nerve energy; during sleep it becomes merely an organ of the body, composed of so many nervous tissue cells and fibres, having automatic control, however, over several bodily functions. During

the period of active abeyance of function, the waste of the previous wakeful period is being repaired, until a moment of time arrives when some external stimulus reaches the brain through one of the organs of sense, and consciousness results.

AMOUNT OF SLEEP REQUISITE FOR HEALTH.

King Alfred's division of the day—"eight hours' work, eight hours' sleep, and eight hours' play"—so far as sleep is concerned, is an excellent average arrangement. One general principle may be laid down, *viz.*, that the younger the person is, the more sleep is required. Infants sleep, in health, from eighteen to twenty of the twenty-four hours. Young children, up to the age of two and a half years, require not less than fourteen hours daily; until school age, twelve hours; in adolescence, ten hours; and from that period till middle life, not less than eight hours. The aged sleep less than the young and middle-aged, but for them ten to twelve hours' daily rest in bed is beneficial in conserving their waning physical strength. The general reason for the longer periods of rest in those of tender years is that new growth as well as repair need to be attended to, whereas, as middle life is approached, it is only the daily waste that requires to be repaired. Many persons cultivate the habit of having less than eight hours daily for sleep. This may be borne with apparent impunity for a variably long period, but, in the end, evil effects are certain to follow. The brain worker, *a fortiori*, ought to secure eight hours' sleep daily, for it is of prime importance that the principal tool he uses should be bright, keen,

and ready for work. Insomnia and general nervousness are too often the indications of inadequate brain rest or of mental worry. Both may be prevented, in large measure, by attention to the proper hours and periods of sleep, and by making every other engagement subordinate to these. The self-administration of hypnotic drugs ought to be strenuously resisted and opposed, and, at the earliest manifestation of sleeplessness, the advice of an experienced physician obtained. Not a single word can be said in commendation of the too prevalent modern habit which converts the night into the day at the expense of sleep. Such is fraught with inevitable mischief.

HYPNOTISM

(Gr., *hypnos*—sleep)

Is the modern designation of psychical states, which formerly were known by the names of animal magnetism, electro-biology, Braidism, and Mesmerism, the last two from the surnames of men who practised and wrote concerning the art. Although the phenomenon has been known since the days of the Egyptians, and has been periodically investigated ever since, it is only within the last fifteen years that it has received the attention of scientific observers. Hypnotism is very difficult to define. It may be said to be a sleep-like condition induced by artificial means, but based upon physiological conditions of the brain, and which is wholly unconnected with any electro-biological or magnetic force. The precise form it will take in a person under its influence cannot be predicated. One person may assume a cataleptic condition, while another may be able to walk or

perform complex movements at the will or suggestion of the operator. Public exhibitions of hypnotism are forbidden in Prussia, and ought to be prohibited in this country. It is a power which might be used by the irresponsible or criminal for purposes of gain or evil, and already hypnotic suggestion has been pleaded in France as a defence in a criminal charge. As a therapeutic agent it has been used beneficially, and, upon occasion, has taken the place of an anæsthetic in surgical operations. But in both respects it is still on its trial. For all these reasons, therefore, its practice ought to be confined to those who would be responsible to the State for its proper use. The principle of hypnotism is this—the concentration of the mental energy of the subject on an object, or an action, through the organ of vision, the other brain-centres being meanwhile inhibited, the production of fatigue in the visual centre—the only channel by which the person is conscious—and the induction of drowsiness and hypnotism, or sleep. There is more than this, however, for the operator is able to act on the will of the operated, thereby showing a degree of volition, but uncontrolled. There are certain psychic conditions allied to sleep and hypnotism which cannot be overlooked, such as dreaming, somnambulism, and catalepsy.

Dreaming comes on in sleep, and is characterised by some degree of mental activity, minus the government of the will; hence, dreams are usually of a distorted, irrational, and inco-ordinate character. Reverie is a dreamy condition in the waking state, and is produced by fixation or concentration of the mind on a certain object or train of thought, the person, mean-

while, being apparently and actually oblivious, in whole or in part, of external objects.

SOMNAMBULISM (Lat., *somnus*—sleep, *ambulo*—I walk) is a more complex condition. The subject of it may not only walk during sleep, but he may perform actions demanding complex co-ordination of muscles, skill, and apparently even calculation, all the time being unconscious to external influences. Somnambulism is a dream carried into action, the action being automatic, and self-originated.

In all of these conditions the will-power is in abeyance, and they are usually found in healthy, but excitable persons.

CATALEPSY is a condition wherein there is sudden suspension of volition, motion, and sensation, and is usually accompanied by a fixed condition of the limbs and trunk of the body in the position in which they were at the time of onset of attack. It is often allied with an abnormal condition of brain and nervous system; on the borderland, indeed, between health and disease.

IDIOSYNCRASIES.

(Gr., *idios*—proper, *syn*—with, and *krasis*—temperament.)

An idiosyncrasy is something which is proper or peculiar to the temperament of the individual. It may be mental or physical. These peculiarities are not easily explicable from the physiological standpoint, but they have some relation to inherited conditions, or to impressions received in early childhood, which have left a lasting mark. They may exhibit themselves in the effects produced after partaking of certain substances,

after the perceptions of certain odours, or by the irritation produced in the presence of certain conditions of atmosphere. Trousseau, in his classic work on clinical medicine, narrates cases of persons who were seized with acute asthma, one, if he chanced to be in a bedroom when the feather-bed was being shaken, another, a chemist, if ipecacuanha was being powdered, or even dispensed, in his pharmacy, and a third—his own case—if he went into a room which had the odour of violets. Such cases are of nervous origin, and heredity has, doubtless, a large share in the production.

CHAPTER XXI.

EFFECTS OF OCCUPATION ON HEALTH.

Of the many factors, the sum of which determines the longevity of man, none is so potent as that of his daily occupation. This is true both in relation to the individual and to man in the mass. The ill effects of employment are probably more apparent in these days because of the segregation of workers under entirely artificial conditions, in factories, yards, and workshops. Coupled with the artificial environment, the high-level pressure and competition of the labour market act as a contributing strain on the average workman. Centralisation of population and centralisation of labour have mutually interacted upon each other to produce these results. This is especially true of productive industries where the commodity is made out of the raw material. Much less change is apparent in the primitive occupations, as farming, fishing, etc., as these callings can only be followed in the open. It has been alleged that the change which has taken place in the character of each man's labour during the past century has been harmful to the workman. Then the workman was a craftsman who personally undertook all the processes necessary to produce the finished article; nowadays he only takes part in one process or one stage towards its

completion. This has reduced the worker from the position of an artist to that of a mere automaton, and the craftsman's pride in beholding the work of his own hands, and the relief experienced in the change of incidence of work, are thereby lost. However that may be, the variety of occupations to-day is, indeed, very large. It has been computed that there are about 12,000 different occupations, no doubt largely owing to the subdivision of labour.

All occupations may be divided into three classes in respect of the bodily powers drawn upon, *viz.:* (1) those in which the nervous system is most employed; (2) those in which the muscular system; and (3) those in which both, in varying grades of combination, are used. To the first class belong brain workers generally, as authors, composers, and professional men; to the second the "hewers of wood and drawers of water," and unskilled labourers generally; and to the third skilled workmen generally. It would probably be correct to say that the bulk of occupations belong to this last class. Occupations may be subdivided also in respect of the harmful effects produced by, or incidental to, them. Dr. Ogle gives an excellent working classification on this basis, which we will follow:—

I. Where the workman adopts a cramped or constrained attitude, which prevents the healthy action of lungs and heart.

II. Where he is exposed to the action of poisonous or irritating substances used in the trade.

III. Where he is called upon to work excessively, either mentally or physically.

IV. Where he is compelled to work in confined spaces, and in foul air.

V. Where, from the nature of the occupation, he is liable to contract harmful habits.

VI. Where he is subject to risks to life from accident.

VII. Where he works in atmospheres containing particulate floating matter.

As examples of the first may be cited colliers and miners, clerks, seamstresses, hand-loom weavers, lace-makers (on cushions), glovers, shoemakers (on the last), and workers at benches or machines, in a sitting attitude generally. In all of these, more or less pressure is exerted on the chest, which is often most marked in the case of shoemakers, in whose case the last produces permanent indentation of the breast-bone.

Of the second class, workers in arsenic, mercury, zinc and copper, lead, "chrome," and phosphorus, chemical workers exposed to the fumes of chlorine or sulphur gases, rubber workers to the fumes of carbon bisulphide, and those exposed to the vapours of tar, pitch, or resin, may be taken as examples.

TABLE I.—COMPARATIVE MORTALITY OF MEN, 25 to 65 YEARS OF AGE, IN DIFFERENT OCCUPATIONS, 1881-2-3.

Occupation.	Comparative Mortality.	Occupation.	Comparative Mortality.
Clergymen, Priests, Ministers	100	Carpenters, Joiners ...	148
Lawyers	152	Cabinet Makers, Upholsterers	173
Medical Men	202	Plumbers, Painters, Glaziers	216
Gardeners	108	Blacksmiths	175
Farmers	114	Engine, Machine, Boiler Makers	155
Agricultural Labourers ...	126	Silk Manufacturers... ...	152
Fishermen	143	Wool, Worsted „	186
Commercial Clerks	179	Cotton „	196
„ Travellers ...	171	Cutlers, Scissor Makers ...	229
Innkeepers, Liquor Dealers	274	Gunsmiths	186
Inn, Hotel Service	397	File Makers...	300
Brewers	245	Paper Makers	129
Butchers	211	Glass Workers	214
Bakers	172	Earthenware Makers ...	314
Corn Millers	172	Coal Miners	160
Grocers	139	Cornish „	331
Drapers	159	Stone, Slate Quarriers ...	202
Shopkeepers generally ...	158	Cab, Omnibus Service ...	267
Tailors	189	Railway, Road Labourers...	185
Shoemakers	166	Costermongers, Hawkers, Street Sellers	338
Hatters	192		
Printers	193		
Bookbinders...	210		
Builders, Masons, Bricklayers	174		

TABLE II.—COMPARATIVE MORTALITY FROM PHTHISIS AND RESPIRATORY DISEASES OF MEN IN VARIOUS DUST-INHALING OCCUPATIONS.

Men from 25 to 65 years of age.	Phthisis.	Lung Diseases.	Phthisis and Lung Diseases.
Fishermen (as standard)	55	45	100
Carpenters, Joiners	103	67	170
Bakers	107	94	201
Wool Workers	130	104	234
Cotton ,, ...	137	137	274
Cutlers, Scissor Makers	187	196	383
File Makers	219	177	396
Masons, Bricklayers	127	102	229
Stone and Slate Quarriers	156	138	294
Pottery Makers	239	326	565
Cornish Miners	348	231	579
Coal ,, ...	64	102	166

Of the third class, dock labourers, stevedores, athletes generally, porters, engineers, and others are representative. It has been clearly demonstrated that more harm ensues when the work is severe and inconsecutive than where it is steady and continuous. Where the muscular strain is solely confined to certain groups of muscles, as in shorthand writers, pressmen generally, musicians, telegraphists, etc., nerve disturbance, as "writer's cramp," is apt to follow.

Tailors, hatters, bookbinders, printers, machinists, laundresses, shopkeepers, as grocers and drapers, are typical of the fourth class, inasmuch as they work usually in confined, and often foul, air spaces.

Of the fifth class, where vicious habits are contracted from materials used, or products manufactured in the

trade, the occupations of innkeepers, brewers and distillers, barmen and barmaids, and liquor dealers generally, carry with them the temptation to contract the alcoholic habit; that of tobacco manufacturer, the abuse of tobacco; and that of druggists, the use of opium, cocaine, ether, or other harmful drugs.

Of the sixth class, little need be said, except that certain occupations are more dangerous from accident than others, such as mining, quarrying, railway workers, or workers generally in large machine shops. To these may be added caisson workers, submarine workers, as divers and tunnellers under compressed air; and in the making of explosives.

The seventh class embraces a large number of occupations, and the factor, common to them all, which is provocative of harm, is floating matter in the air surrounding the worker, which, when inhaled into the breathing apparatus, produces lung diseases, and, when deposited on the skin, maladies of the skin. The character of the air-particles determines the intensity of the harm produced. The dust particles are either sharp, blunt, or filamentous. In the following occupations are found sharp particles, *viz.:* steel grinder (dry process), stone cutter, sand or glass paper maker, potter, button maker, file maker (by hand), ore miner, quarrier; in the following, blunt particles: wood or ivory turner, sawyer, collier, miller, baker, foundry worker; and filamentous, in those of hemp dressing, flax working, hair and wool sorting, warehouseman, draper, cotton worker, and wool worker. The evil results of substances deposited on the skin are sometimes seen in those engaged in the soot traffic, as in "chimney sweep's

cancer," in paraffin workers, as skin diseases; and in "chrome" workers, as ulcerative disorders of the nasal septum, and hands and arms.

The mortality arising from any occupation depends upon the following factors, *viz.:* (1) the initial fitness of the employee; (2) the nature of the occupation; (3) the environment of the employment; and (4) habits of a vicious character which may be contracted by the workman. While it is difficult to attain absolute correctness in mortality rates of occupations, sufficient accuracy is possible to compare the relative incidence of the death-toll. One of the causes of this difficulty is that many occupations, because of their light and easy character, attract the initially weak, disabled, or deformed. This is true of such employments as clerk, tailor, watchmaker, and others. Again, certain other occupations have attractions for men who have saved money in their original occupation, but in which their health has broken down, as innkeeping or liquor selling. Hence, the mortality rate of a given occupation may not be the result solely of the conditions of that occupation, but partly of that, and of the previously depreciated health or physique derived from a former occupation, or which has existed initially.

Of the accompanying tables, two which are from Dr. Ogle's paper (*Transactions of Seventh International Congress of Hygiene*, vol. x., pp. 12 *et seq.*) are more eloquent than words. The first table shows the relative mortality of different occupations, and the second, the mortality from lung diseases in occupations having different air surroundings; the third table we have compiled to illustrate the various deformities or disabilities which arise in certain occupations.

TABLE III.—OCCUPATIONS WHICH CAUSE PHYSICAL DEFORMITY OR DISABILITY.

Occupation.	Deformity or Disability.	Proximate Cause.
Boiler Makers, Riveters, or Workers in any concussive noises.	Deafness	Repetitive concussion of ear drum, etc.
Shoemakers	Indentation or depression of breast-bone.	Pressure of last.
Tailors	Peculiar gait in walking.	Turk-like attitude of lower limbs when at work.
Clerks, Students, Scholars, Sedentary Employees generally.	Lateral curvature of spine.	Faulty attitude when occupied at work.
Telegraphists, Shorthand Writers, Instrumentalists.	Muscular cramp of fingers or hand.	Continuous strained use of digit muscles.
Clergy (preachers)... ...	Affections of throat and voice.	Unnatural use of muscles of voice-box, and voice.
Miners, Jewellers and Watchmakers, Scientific Instrument Makers, Microscopists, Seamstresses, Engravers.	Affections of eye and vision.	Strain on visual apparatus.
Cooks, Gardeners, Car and 'Bus Conductors, Shopkeepers, and persons generally who stand at work.	Varicose veins and ulcers of lower limbs.	Congestion of veins from effect of gravity and muscular strain on lower limbs.
Soldiers, Athletes, Porters, Dock Labourers, etc.	Diseases of heart and large arteries.	Strain on these organs.
Bridge-pier Builders (in caissons), Divers, and Workers under compressed air, Balloonists.	Diseases of circulation and nervous system.	Unnatural atmospheric pressure.

CHAPTER XXII.

HOUSE DRAINAGE IN RELATION TO HEALTH—THE SANITARY FITTINGS OF THE HOUSE—WASTE WATER AND SOIL DISPOSAL.

HAVING made provision for the plentiful supply of fresh air, light, and water to the home, equally careful arrangements must be provided for the safe disposal of house-refuse and night-soil. The nature of the fittings for these will be entirely determined by the fact whether or not the house is to be contributary to a water-carriage system of sewage. By this is meant, a system of sewers wherein waste water and excretory products are carried away from the houses, which are connected to the sewers by the house drains, to the outfall—the vehicle being the waste water from the houses and the rainfall. Where no such system is in operation, each house must have its own arrangements separate from others. The former system usually prevails in populous places, the latter, in isolated dwellings, or in small collections of houses. The food-waste, fire-ashes, and other debris are, or ought to be, in each system, kept apart from the excreted products. It will, therefore, be necessary to discuss the subject under two heads, *viz.:* the disposal (1) of night-soil, and (2) of house-refuse.

Disposal of night-soil by the water-carriage system

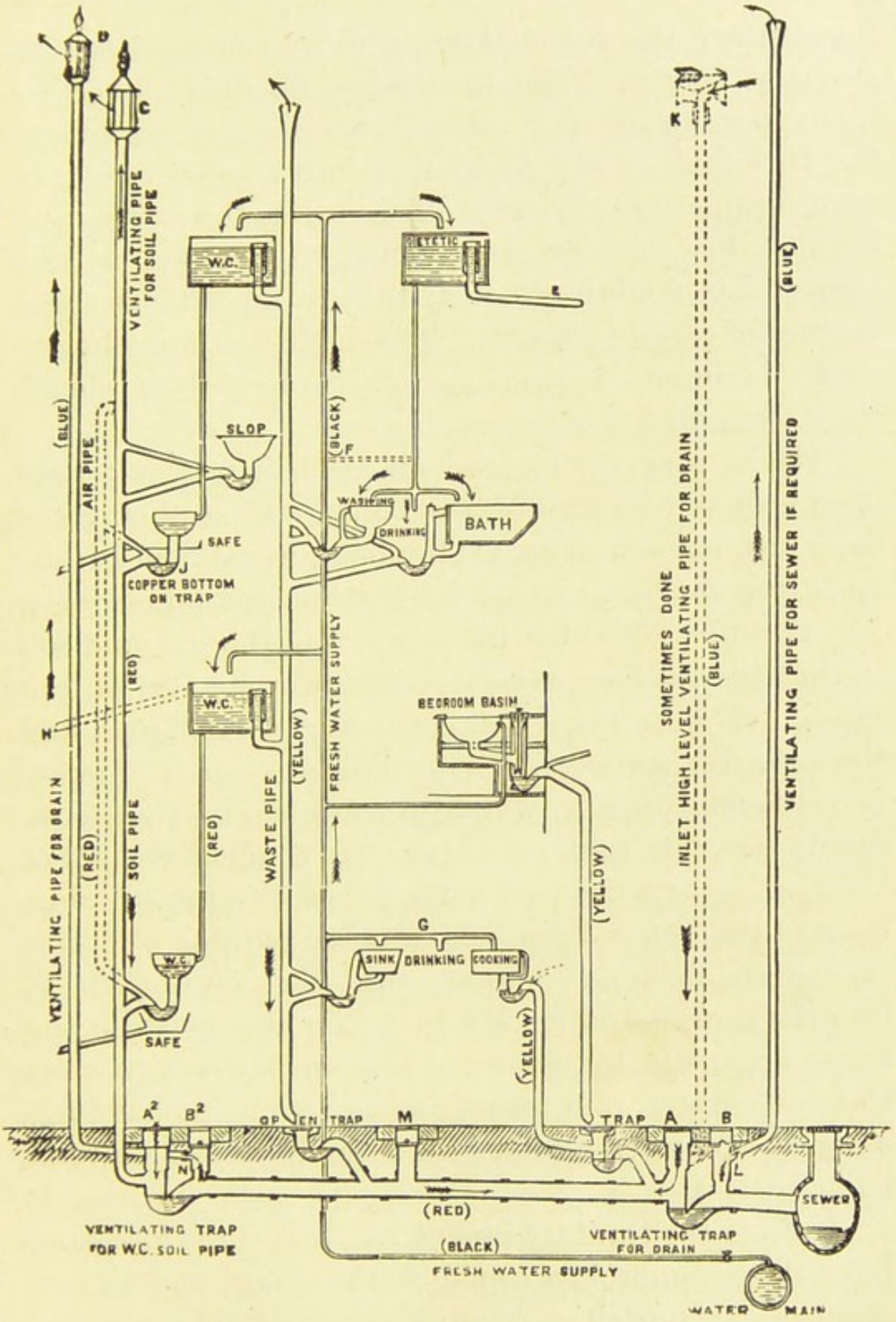


FIG. 36.—General System of Water Supply and of Waste Water and Soil Disposal.

The relative positions of fresh water main and sewer are only diagrammatic. In actual operation the latter is usually at a lower level.

necessitates the installation in every home of certain sanitary fittings. The knowledge on this subject of many persons, if not, indeed, of most, is limited to the fact that "soil" disappears into a pipe, which, in turn, disappears into the ground outside the house; and beyond this they do not inquire. Ignorance on this subject has doubtless not a little to do with the prevalence of certain diseases. The intelligent householder ought to inform himself more regarding these points, since forewarning is forearming.

The sanitary fittings which at their one extremity open into the interior of the house, and at their other open into the sewer, are (1) the bath, wash-hand basins, and kitchen sinks, and (2) the water-closet and urinals. The channels by which waste water in the one, and soil in the other, are conveyed to the sewer are lead or iron pipes. The former is called the waste-water pipe, and the latter the soil-pipe. A third pipe, or series of pipes, is commonly present, which also opens into the house drain, *viz.*, the rain-water pipe, or conductor. All of these unite, at some part near the base of the building, to form the house drain, which, after running a shorter or longer distance, empties into the sewer. It is necessary, once and for all, to distinguish between the house drain and the sewer. The house drain receives the waste water, rain water, and soil from one building, whereas the sewer receives these products from several buildings.

If, from the sanitary fittings of a house, the foregoing pipes ran an unbroken course to the sewer, foul air and gases of decomposition and microbes would inevitably find their way into the house interior, by reason of the

higher temperature of the latter, and would be detrimental to the health of the occupants. The object of sanitary fittings, therefore, ought not only to be the conveyance of excretory products from the house, but also the prevention of the return of harmful products to the house. This latter is provided for by means of what are called *traps*. The foregoing diagram illustrates the foregoing points, and also the fresh water house supply, and is self-explanatory. (Fig. 36.)

Having considered the sanitary arrangements generally, it will be necessary to review the various fittings of (1) the waste-water system, and (2) the soil-pipe system. Belonging to the former are (1) the bath; (2) wash-hand basin; (3) kitchen sink; and (4) waste-water pipe.

In many houses the bath-room also contains a water-closet and wash-hand basin in addition to the bath, owing to exigency of space. For obvious reasons, when possible, the water-closet should have an apartment separate from the bath-room. In tenement houses—that is, houses of flats entered by an entrance common to all, and inhabited by different householders, such as are common in all Scottish cities, and now, also, in London—the bath-room is too often a "pokey" place, and imperfectly lighted, the bath itself being often fixed in the darkest corner. This ought not to be. The bath-room ought to be well lighted and well ventilated. Reference to Fig. 37 will show the various fittings as above.

The bath itself ought to stand clear of the floor on short pedestal feet, so that the space below and around it may be easily cleaned. It should not be surrounded by

woodwork, for within this enclosed space dirt and decomposing soapy water are apt to collect. There should be an ample supply of hot and cold water—the former

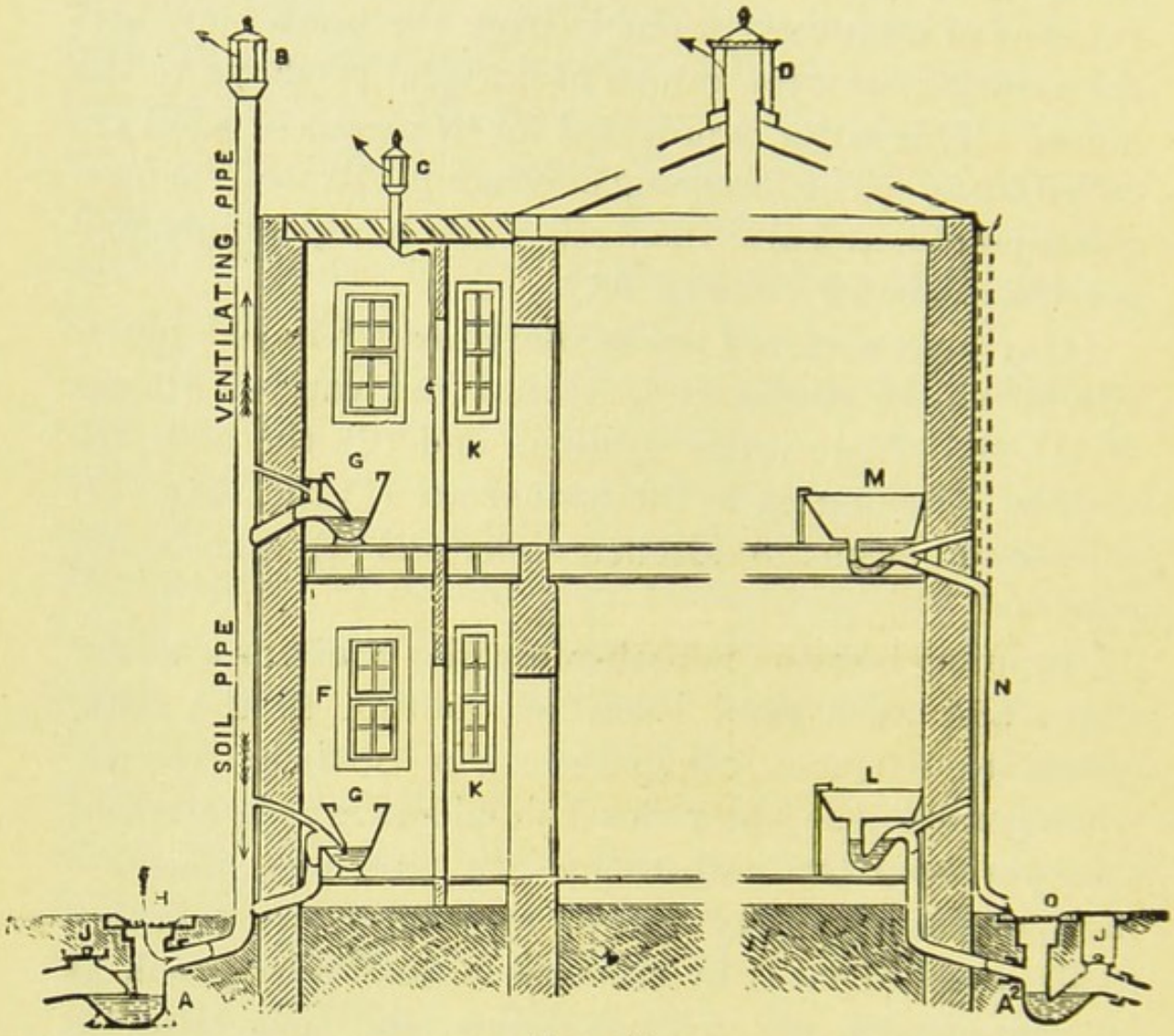


FIG. 37.

This diagram, which represents the disposition of the sanitary fittings of a house, is self-explanatory in large measure; G, G, represent closet-rooms, cut off from rest of house by corridors, K, K; M is the bath; L, housemaid's sink; A, A, traps disconnecting main pipes from house drain; N is the waste-water pipe, which ought to be continued above the eaves as is the soil-pipe. The fixed ventilator at top of soil-pipe is sometimes substituted for the plain trumpet-shaped opening.

preferably from the general house supply. For houses with no hot water supply, instantaneous heaters have been devised for baths, whereby, by a series of Bunsen burners which heat a convoluted pipe through which cold water

passes, the water is heated. (Fig. 38.) Care must be exercised in the use of these, owing to the generation of CO_2 and CO gases, which have already caused fatal accidents from suffocation.

From every old-fashioned bath—other than the water supply pipes—there are two pipes for carrying off waste water, *viz.* : (1) the waste pipe, which leads from the bottom of bath, and by which the bath is emptied ; and

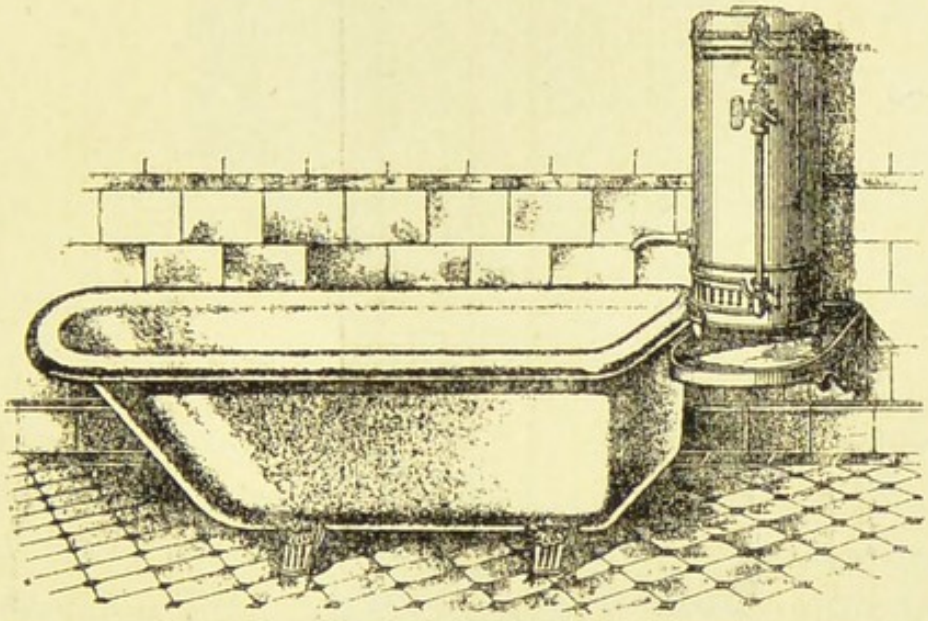


FIG. 38.—Doulton's Water Heater, which is fitted with an automatic arrangement which prevents the gas being lit until the water is turned on, and by which the flame is lowered by failure or great reduction of pressure of water supply. It heats water to 105° F. in 10 minutes at a cost of ¾ths of a penny.

(2) the overflow pipe, by which, in case of overflow, the overflow water is carried away, and thus flooding of the bath-room is prevented. This pipe, therefore, leads from the top part of bath. In the old form of "built in" bath, the bath itself is usually placed on a leaden tray, which is intended to catch stray water. This tray empties into a pipe called the tray pipe, or save-all pipe, which is put at the lowest point of the tray. These pipes are united together under the floor to form one

bath waste pipe before it joins the main waste pipe, and after the junction, must be trapped from the main waste pipe. The foregoing must be considered as applicable only to the older forms of baths. In the most modern

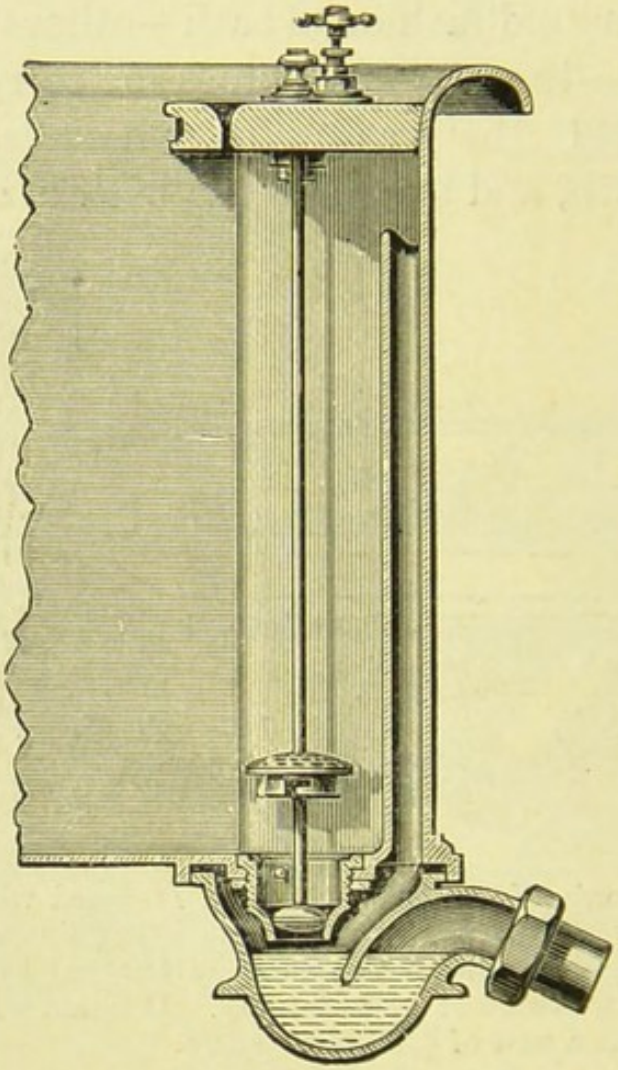


FIG. 39.—Shanks & Co.'s "Modern Waste" applied to baths.

The waste opening is plugged, the bath is filling, and as soon as the water level reaches above the shaded line, the water runs down the overflow channel (behind the waste plug) into the trap, which serves for both waste and overflow channels.

baths, the waste and overflow are combined in an ingenious manner, as in Fig. 39, by Shanks & Co.; other makers, as Doulton & Co., have an equally ingenious system.

Wash-hand basin; This fitting, to all intents and

purposes, is but a miniature bath, and, like the bath, ought to have its parts exposed, and to be provided with a waste and overflow pipe. The "tip-up" basin, which being mounted on a swivel, may be quickly emptied by the act of tipping, is valuable, inasmuch as the sudden

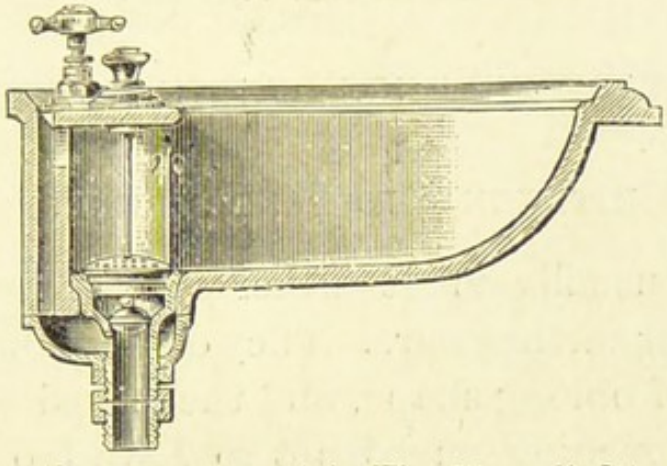


FIG. 40.—Shows the arrangement in Fig. 39 applied to the wash-hand basin.

rush of water assists to keep the pipes clean; otherwise, it possesses no advantage over the ordinary plug-basin. The "Aseptic" basin of Shanks & Co. is an ingenious contrivance for hospital use. The waste pipe from the basin must also be trapped.

CHAPTER XXIII.

THE SANITARY FITTINGS OF THE HOUSE (*continued*).

KITCHEN AND PANTRY SINKS.

THESE are usually made either of cast iron, plain or enamelled, or earthenware. They ought to be sufficiently capacious, of oblong shape, and the grated or perforated waste-pipe opening ought not to have too large holes, lest débris of food descend and block the pipe. They ought to have a "waste" and an "overflow" pipe, and should not be surrounded by woodwork. From kitchen operations greasy matters find their way by the sink into the waste pipe, and, when cooled, are liable to block the pipe. To prevent this a special form of trap has been devised. One of the best is Buchan's grease trap, of which Fig. 41 is an illustration: A is the inlet pipe from sink — the arrows indicate direction of flow; B is the grease chamber, in which fatty matters solidify, and which may be removed by the movable lid, E; C is the outlet pipe, by which grease-free water escapes into house drain; D and P are openings by which the trap may be cleaned. The congelation of fat is effected by making the inlet pipe higher than the outlet, and the tongue of the trap nearest the outlet lower than that nearest the inlet. Its operation is very efficient.

MAIN WASTE-WATER PIPE.

This pipe, into which all branch pipes from previously mentioned fittings enter, may either pass downwards on the inside of the house wall, or on the outside. Most practical men are of opinion that, provided the pipe makes its exit from the interior to the exterior of the house above the ground level, and that it be disconnected from the house drain, either by opening over a trapped gully or into a ventilating trap, no objection can be offered to placing it on the inside of the house wall. In this position it is less liable to freeze, and it is less subjected to alternations of heat and cold, which

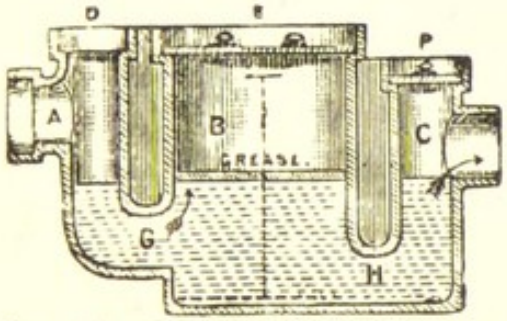


FIG. 41.—Buchan's Grease Trap.

slacken joints and warp pipes because of the alternate expansion and contraction of the metal. To prevent freezing it is customary to keep the water dribbling in this pipe, but this often helps what it is intended to prevent. A thin layer of water passing down a pipe which has a northerly or easterly exposure, will quickly freeze in its course during severe frost. This, by gradual accretion, soon blocks the pipe. It is an open question whether the waste pipe should open over a grated gully on the ground level, or into a ventilating trap below the ground level. In either case the trap prevents the return of harmful products from the house

drain. The determining factor ought to be the exposure of the pipe in respect of the points of the compass. If it be the south or west, the open method is preferable; if the north or east, the closed, because of the liability of the open gully becoming filled up with ice in frosty weather, and of the water from the waste pipe being diverted on to the surface of the yard or pavement.

RAIN WATER CONDUCTORS AND COURTYARD GULLIES.

These practically belong to the waste-water system. Sometimes the rain conductor is formed by the simple extension of the waste pipe to the eaves, where it is joined to the eaves-channels. In many cases, however, they are, necessarily, separate fittings. Whatever their position, they must be trapped at their junction with the house drain. Courtyard gullies carry off surface water. They are made of special form so that mud in suspension is allowed time to settle, when it may be removed periodically. From what has been said, the following principles may be laid down, *viz.:* (1) that all fittings intended to convey waste water should be connected with a main waste pipe only; and (2) there ought to be no connection with the waste-water pipe of any fitting for the conveyance of excretions. Hitherto this has not been general. It is by no means uncommon to find both classes of fittings united in the same main pipe. But waste-water fittings should only be united to a main waste pipe, and soil fittings to a soil pipe.

SOIL-PIPE SYSTEM.

The fittings which belong to this system are: (1) the water closet and slop closet; (2) the urinal; and (3) the main soil pipe.

WATER-CLOSET APARTMENT.

Much too little consideration has hitherto been given to the place occupied by this sanitary convenience. It is but far too common to find it placed in a cramped, dark, ill-ventilated apartment. Probably the reasons for this were want of thought and ignorance of the relation of drain connections and certain filth diseases. Hygiene has demanded more suitable conditions, and they are gradually now being realised. For tenement houses of the poorer class, one closet serves for three or four families, and in flatted houses of a better type there is a closet for each family. In either case, ventilation is but ill accomplished. In such circumstances the apartment is poorly lighted by a small window opening out upon a common stair landing. When this window is opened the current of air instead of being from the closet outwards, as is expected, is quite the reverse, owing to the difference of temperature of the interior and exterior of the house. This, obviously, is very objectionable. Indeed, it may be fearlessly said, that while there is no apartment of a house which more greatly demands free ventilation than this, there is none which receives less. The system most suitable for tenement closets is that denominated "cross" ventilation, which is secured by providing windows at opposite sides of the apartment and at right angles to the doorway. Compatible with comfort, every closet should always be well flushed with a continuous current of air.

The closet itself now requires to be considered. During the last twenty-five years this fitting has under-

gone an evolutionary process—one might well call it a revolutionary process. The process, however, has been slow, for a variety of reasons. The first closet—a valve closet—was patented in 1775 by Alexander Cummings. Bramah, the famous mechanician, also invented a valve closet. Since then many patents have been taken out by many inventors. The closets in use to-day may be divided into four typical classes, *viz.:* (1) the valve closet; (2) the pan closet; (3) the hopper closet; and (4) the "flush" closet.

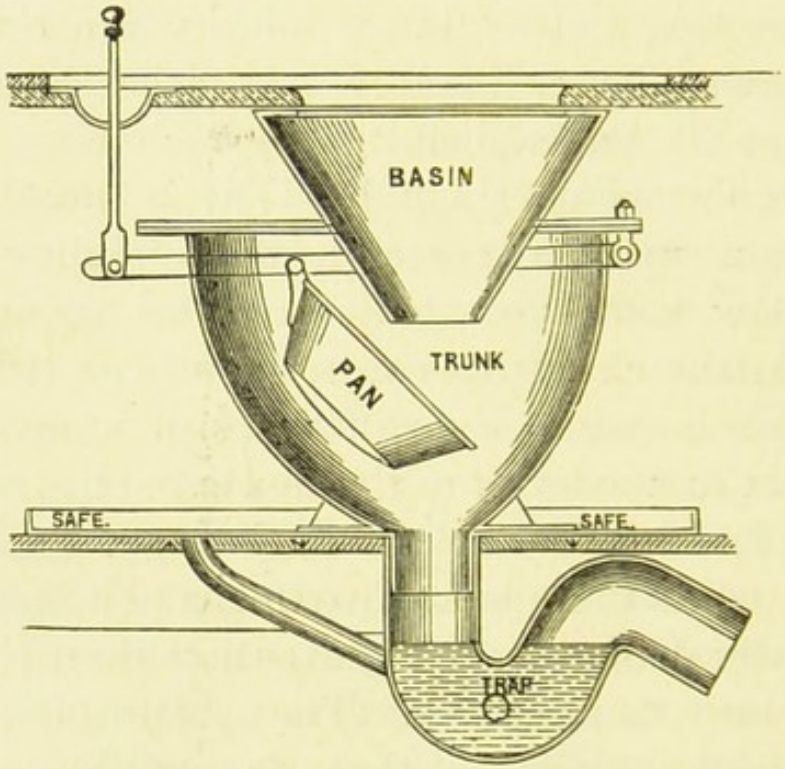


FIG. 42.—Pan Closet.

The valve closet has now, except in the case of one or two specially good forms, fallen into disrepute. Its chief merit is that the contents are suddenly projected, on release of the valve, into the trap; and its principal demerit is that the seat of the valve—which must be accurately fitting—is liable to be dislocated by any

substance which gets fixed therein, thereby allowing the water in the basin to gradually drain away. They are thus very liable to get out of order. Fig. 43 c shows a very good form.

The pan closet is still largely in use, but is giving way gradually to a less complicated and much safer form of closet. It is composed of the following parts, *viz.:* (1) an earthenware basin; (2) a copper pan which closes the bottom of the basin in which the water is retained; (3) the receiver, or container, or trunk, composed of cast iron, into which the basin and copper pan are fitted; and (4) the trap. Fig. 42 illustrates this form of closet, as used in Scotland. The handle, seen on left of figure, operates at the same time to open the cistern for flush water, and to depress the pan, thus emptying and flushing the basin at one pull. Of this closet an American writer once said: "It probably was not, although it might have been, the invention of the devil". It is, certainly, a most unhygienic fitting—first, because it is composed of parts that cannot be cleaned; and second, and chiefly, because the sides of the "trunk" become coated with decomposing excreta, the odour of which is projected into the apartment each time the handle is pulled. English writers have urged an additional objection, *viz.*, that the trap used is a D-trap. In Scotland, however, this objection has no force, since the siphon, or S-trap, is alone used.

CHAPTER XXIV.

SANITARY FITTINGS (*continued*)—DIFFERENT FORMS OF CLOSETS—THE SOIL PIPE.

THE hopper closet is mainly found in two forms, *viz.*: the long conical and the short hopper. The former is decidedly objectionable, by reason of it becoming easily fouled, and being imperfectly flushed. Less objection can be offered to the short form, and provided that the water flush is adequate, it is an efficient fitting.

The "flush" closet embraces several forms, which are often made of one piece of earthenware, composing both closet and trap, and which may be made of the plainest or most ornamental character. With the addition of a "hinged" seat, they may also be used as slop closets, as they have no valves or other mechanism liable to be put out of gear. Another merit is that they can be fitted into position without any surrounding woodwork. Pedestal in shape, they are divisible into two kinds, *viz.*, the "wash-out" and the "wash-down" forms. They are so differentiated by reason of the primary point of lodgment of the dejecta; in the former it is a projecting ledge, in the latter it is the trap itself. In the former class, therefore, much of the force of the water flush is spent in dislodging the contents of the basin, and there is a liability for the contents to be swept into the trap only, and not through it.

This objection does not apply to the wash-down form. Fig. 43 B represents one of the best forms of wash-down closet.

Another form of closet which has, of recent times, deservedly risen into notice, is the "Siphonic" closet,

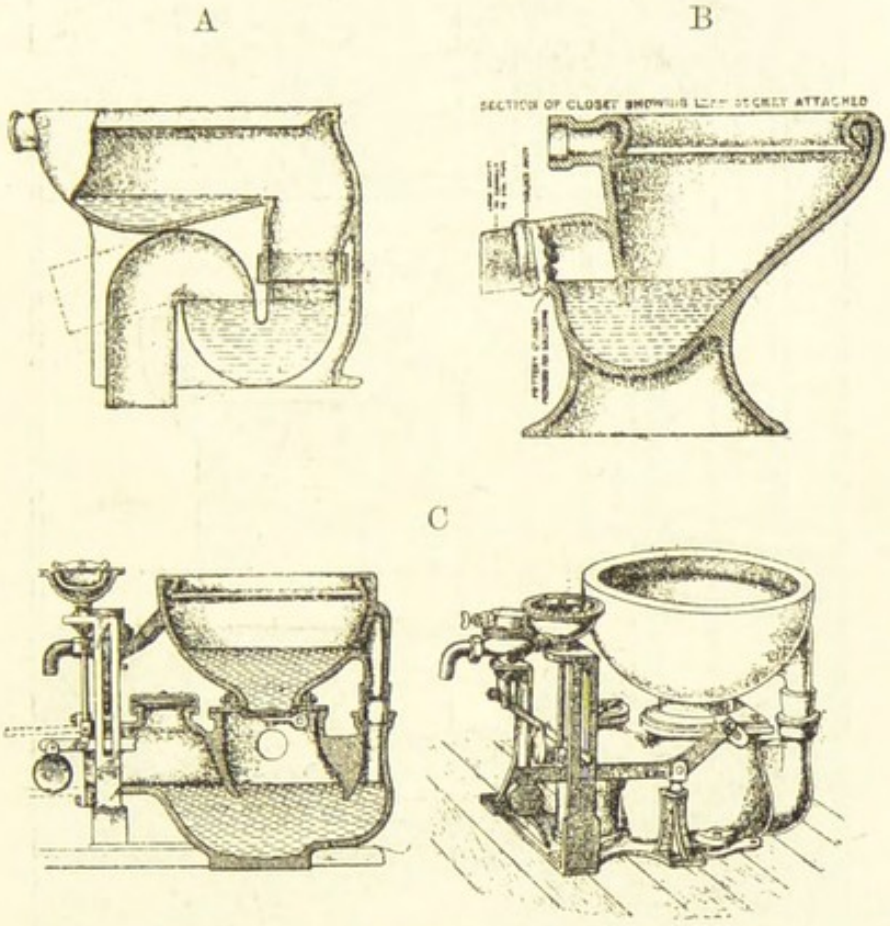


FIG. 43.

A, Doulton's Combination Wash-out Closet; B, Doulton's "Simplicitas" Wash-down Closet, fitted with patent metallo-keramic joint; C, Doulton's Valve Closet (plan and section).

so called because the contents of the basin are emptied by siphonic action, which ensures the thorough riddance of the dejecta at each time of using. When this form of closet was at first made it was defective in construction, inasmuch as it had double traps and sometimes an intricate mechanism for exhausting the air of the siphon.

The most modern apparatus, however, dispenses with both; and now they have only one trap with a deep

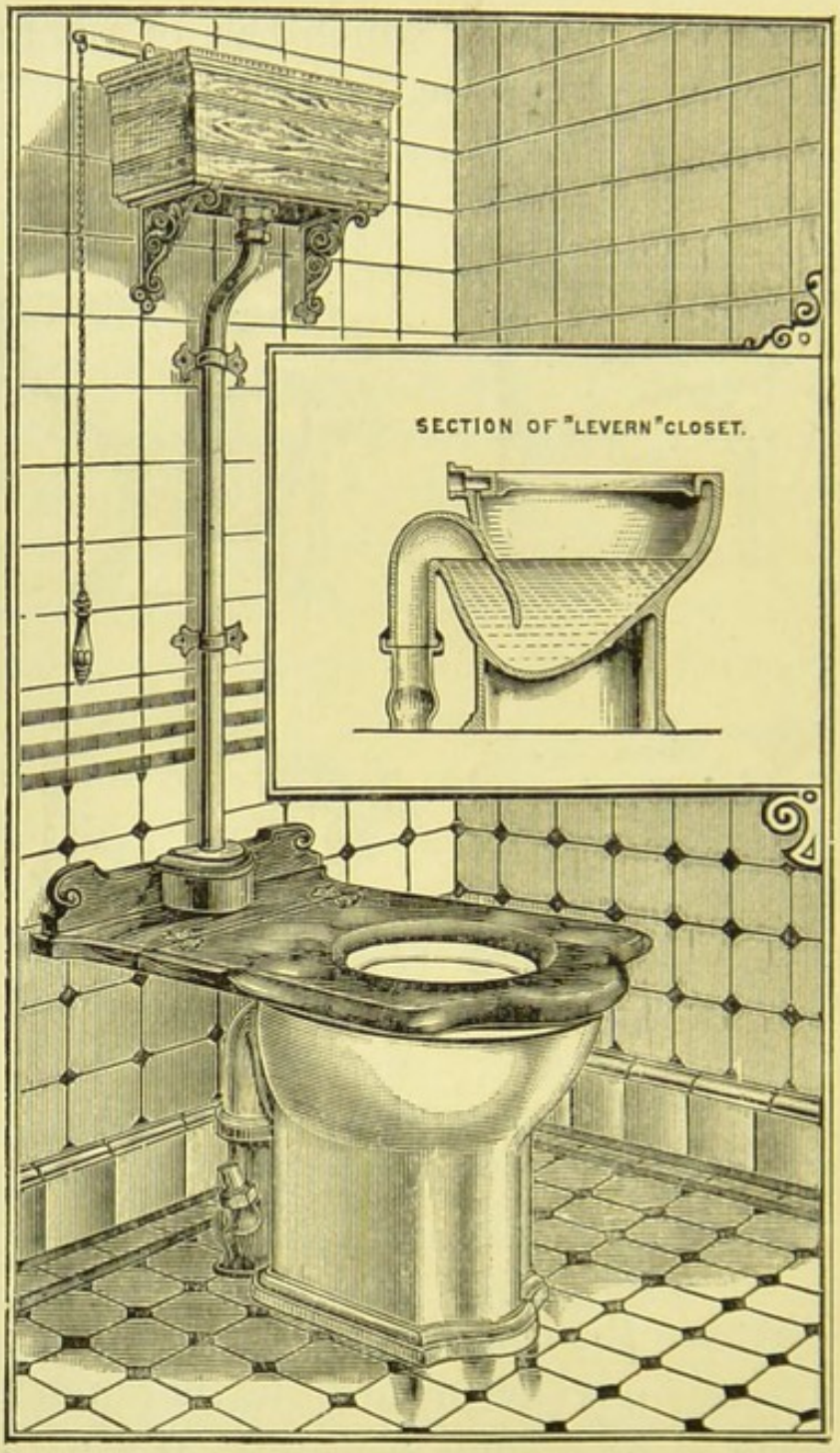


Fig. 44.—Shanks & Co.'s "Levern" Siphonic Closet.

water-seal, and a large basin surface. The action of the siphon is started by the direct action of the water

from the service pipe, and in the "Levern" closet, made by Shanks & Co., the lower part of the long leg of the siphon is of patented construction and made of lead. An essential adjunct to such a closet is an efficient cistern, which is usually sold with the fitting by the makers in order to ensure effective action. The objection against these closets, *viz.:* the risk of siphonage by throwing in slop water and thus leaving the trap unsealed, is overcome in this fitting in one of two ways, *viz.:* either by introducing an anti-siphonage pipe which prevents the foregoing risk but in no way hinders siphonage caused by cistern action, or by fitting it with Dicksee's patent arrangement, whereby if, by the addition of slops, the siphon action is started, cistern action is simultaneously set up, and thus the trap is always kept full of water. Shanks & Co., Doulton, and Jennings are among the leading makers.

While these general points of difference are pointed out, it must be said that between the best types of either form of closet there is not much to choose in respect of efficiency. Of all the types mentioned, preference, however, must be given to the wash-down closet, formed of one piece of earthenware and fixed in position without covering of any kind.

Whatever the form of closet in use, however, none can remain clean without periodical scrubbing with strong soda solution, after the use of which some effective disinfectant fluid should be used, when the trap, with proper flushing, will keep in good order for a week.

The characteristics of a good closet may be summed up in the following points, *viz.:* (1) It should be of a

form to enable perfect dislodgment of the contents

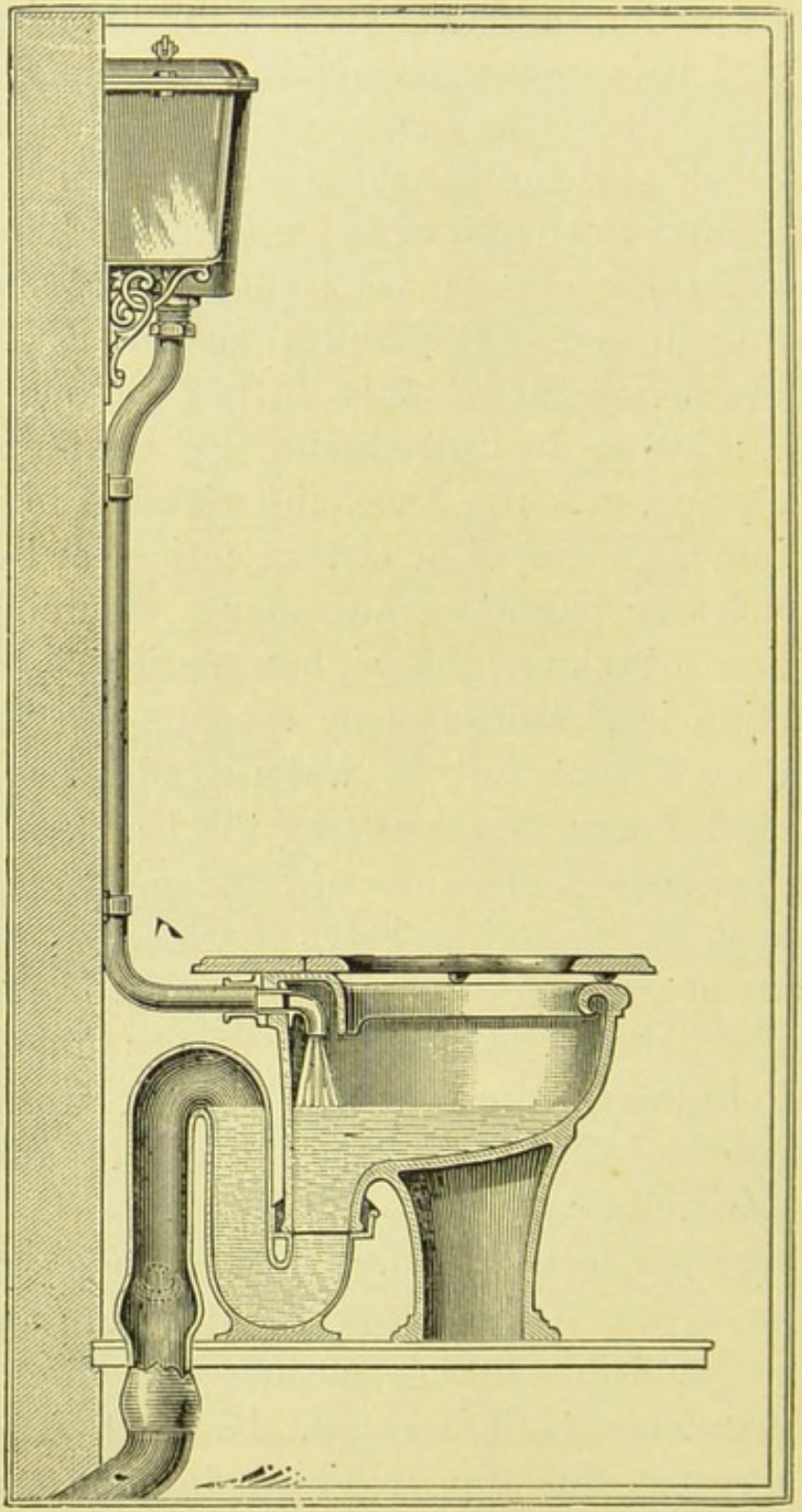


FIG. 45 A.—Section of Shanks' Siphonic Closet.

by the water flush; (2) this dislodgment should be sudden and complete; (3) it should possess a sufficient

trap; (4) all its parts should be easily cleansed; and (5) the water flush should be ample.

For schools and public conveniences, trough closets are often fixed up. These demand careful attention to flushing and trapping. Fig. 45 B shows the sectional elevation plan of one of Doulton's which is, like those of other makers on same lines, an efficient fitting.

SECTIONAL ELEVATION.

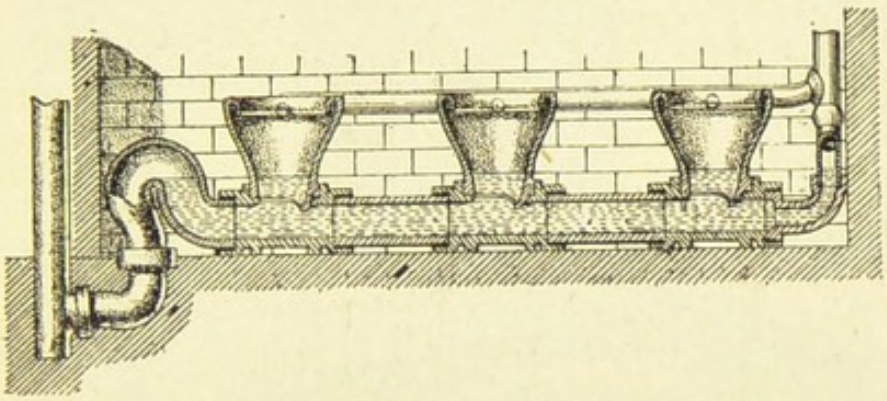


FIG. 45 B.—Doulton's Isolated Trough Closet.

THE WATER FLUSH.

The amount of water to be used at one act of flushing should never be less than two, and when possible, three gallons, and it should reach the closet by a flush pipe of not less than $1\frac{1}{2}$ in. in diameter, from a cistern intended for the closet supply, and for nothing else. Much water is sometimes needlessly wasted in this way, and water companies have been compelled to guard against this by restricting the size of the cistern. The most effective arrangements are where the contents of the cistern are suddenly projected into the closet on the "pull" being used; and periodical flushing is attained by the use of the "siphon" cistern, which acts automatically. In most arrangements, however, the amount of water flush

depends on the user, by the length of time for which the "pull" is held. Carelessness in this respect has much to do with the inefficiency of any fitting.

Attempts have been made, however, to overcome carelessness, by causing the flush to take place by closet-seat action, as in Fig. 46.

In order to secure effective flushing, another combination of cistern and closet has been made by Shanks & Co.

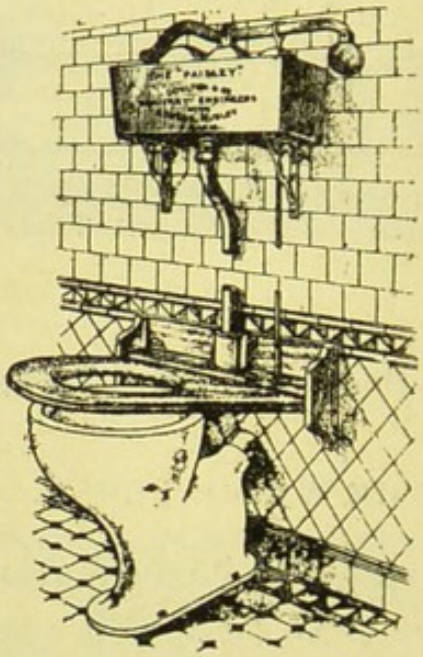


FIG. 46.—Arrangement of Closet whereby flushing is secured by closet-seat action.

Fig. 46 *bis* shows an elevation plan of the fitting. It is claimed for this cistern that when in action it is noiseless, that the flush is discharged suddenly, and that the mere movement of the lever secures that the whole contents of the cistern are discharged into the basin. This fitting may be put up where the architectural arrangements of the closet room do not permit of the cistern being fixed higher, as in Figs. 47, 48.

While a fitting, as in Fig. 47, provided with a hinged seat, may conveniently be used as a slop closet and as a urinal, it is but an imperfect slop closet, since it is unprovided with water supplies for the cleansing of utensils. Such a slop closet, as in Fig. 48, fulfils every such pur-

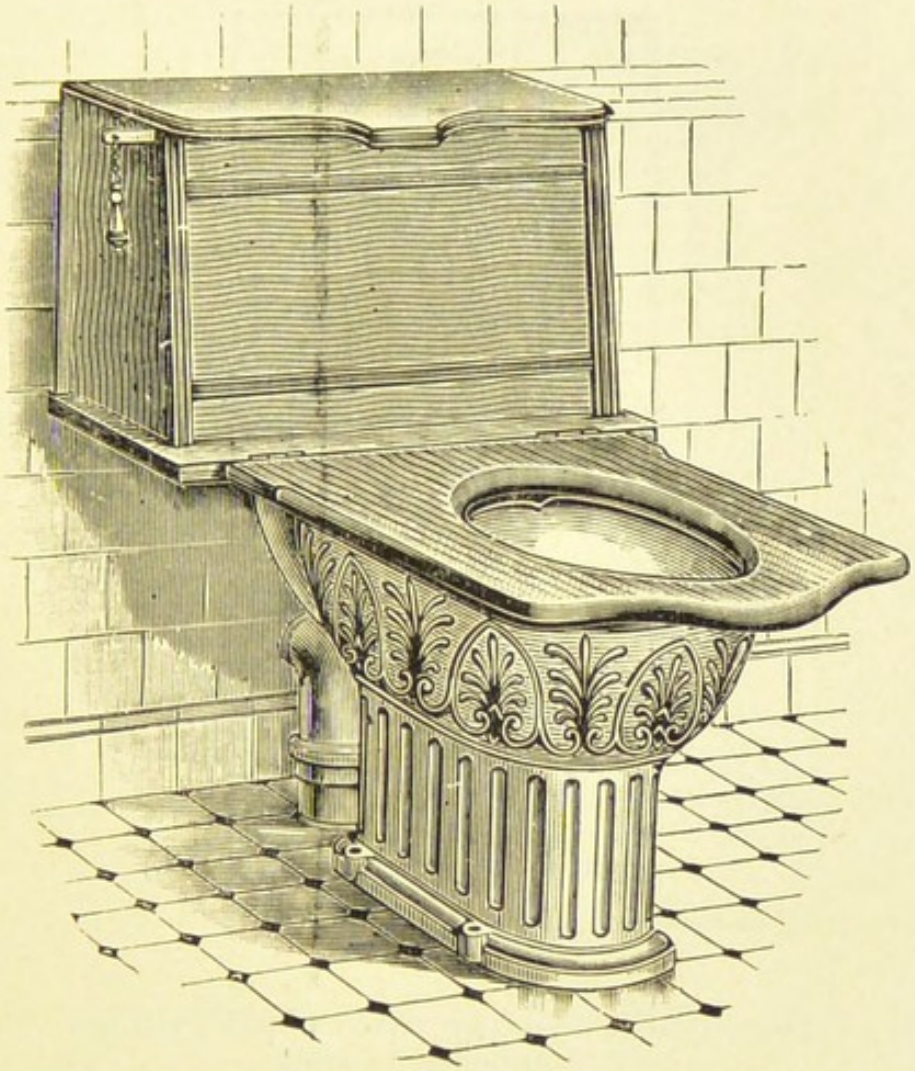


FIG. 46 *bis.*—Shanks & Co.'s Combination Closet.

pose, as examination of the diagram will reveal, although it cannot be used but as a slop closet. Such apparatus is of considerable usefulness in a large private house, in hotels, and in hospitals. A recent contrivance for use in infectious hospitals which can be fitted to it is a grid with perforated openings, which, when turned down

over the slop basin and the utensil placed over it mouth downwards, throws an upward stream of water into the utensil, and thus thoroughly cleanses it without the objectional use of the hands.

The cisterns shown in Figs. 47 and 48 are of the

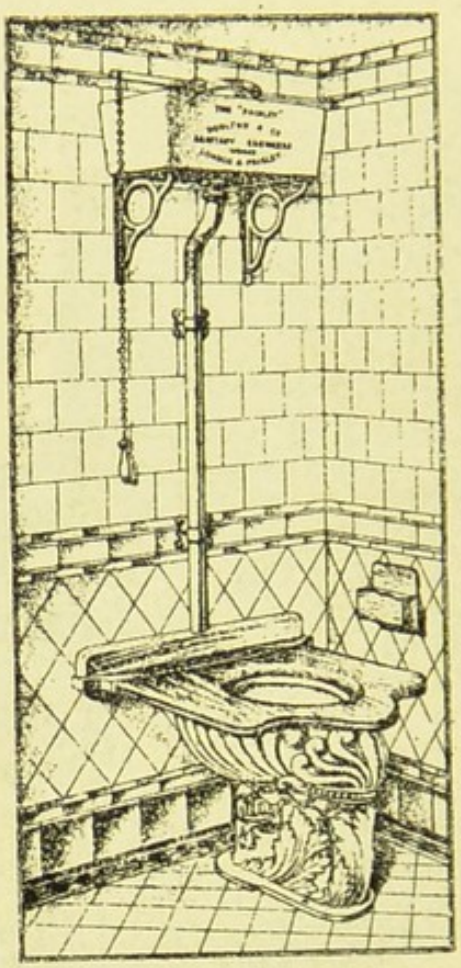


FIG. 47.—Typical form of arrangements of Closet Fittings. Doulton's "Simplicitas" Closet.

modern character, and are calculated to project a three-gallon flush into the basin.

The best type of cistern for closet flushing ought to combine the following features, *viz.*: (1) to supply at each time of action three gallons of water; (2) to fill rapidly after being emptied; (3) to project the water

suddenly and forcibly into the closet; and (4) to supply the same quantity of water at each action, irrespective of the user of the fitting.

The junction of the earthenware closet and the branch pipe to soil pipe—which is usually composed of lead—is one which demands the greatest care on the

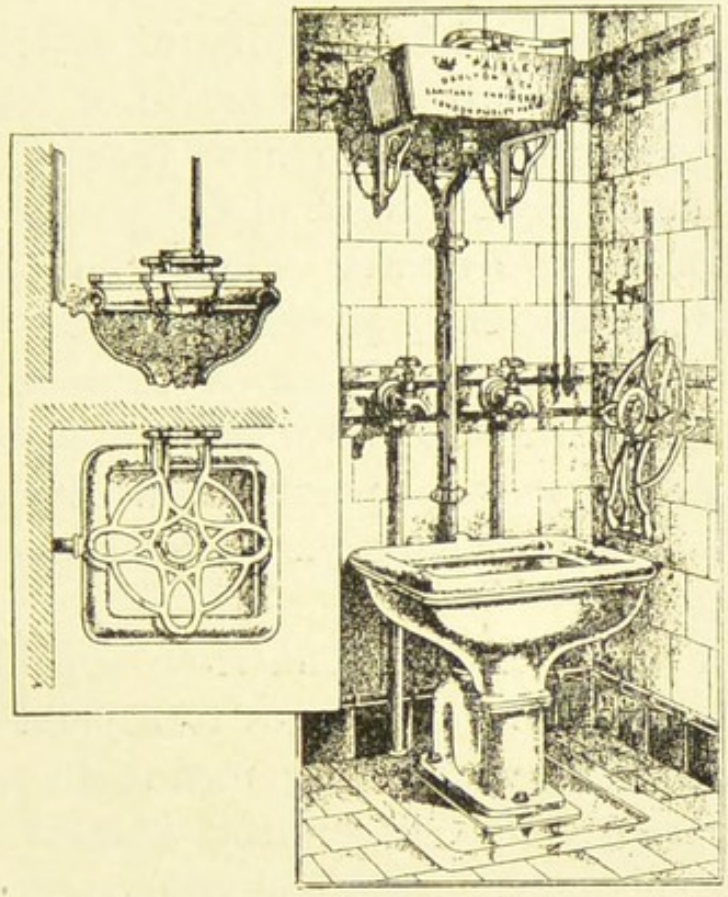


FIG. 48.—Doulton's Slop Closet.

part of a workman (1) because any breach in the joining material exposes the closet room to the air of the soil pipe, and (2) owing to the different expansibilities by heat of the substances connected. Common uniting materials such as red lead and others, for the above reasons, are apt to be imperfect, or to become so. This difficulty has quite recently been overcome by the new

metallo-keramic joint, patented by Doulton and others, Fig. 43 B. This forms a perfect connection, and from experiments we have made with it would appear to be a "fast" connection.

THE SOIL PIPE.

The main pipe used for carrying off dejecta is called the soil pipe. It is usually composed of lead or iron, and is jointed at intervals by rounded, flanged, or "filled" joints. It ought always to be placed on the outside of an outer wall of the house. The various fittings for the reception of excretory products are united to it by branch pipes, and each fitting is trapped from the branch pipe, and therefore from the soil pipe. Fig. 37 demonstrates the soil pipe passing down the exterior of the house wall and receiving the branch connection from the closets G, G.

The soil pipe should extend from a point at least three feet above the house eaves to a point below the level of the ground, where it is joined to an intercepting ventilating trap, which disconnects it from the house drain. The diameter of the soil pipe ought to be the same throughout its entire length, and right angles ought to be avoided, else ventilation will be interfered with. The opening of the soil pipe should never be located near attic windows. Inspection of the soil pipe ought to be periodically made, as all jointed pipes are apt to "shake," especially when exposed on the sunny side of the house, on account of the expansion and contraction which the metal undergoes. (Fig. 49.)

The size of the soil pipe must be regulated by the

amount of work it is expected to do, and has therefore direct relation to the number of fittings connected with it. For an ordinary house of two or three flats a four-inch diameter pipe will amply suffice ; for larger premises, such as hotels, etc., a five- or six-inch pipe.

The lead of branch soil pipes is attacked by the gases dissolved in the water which passes through them and

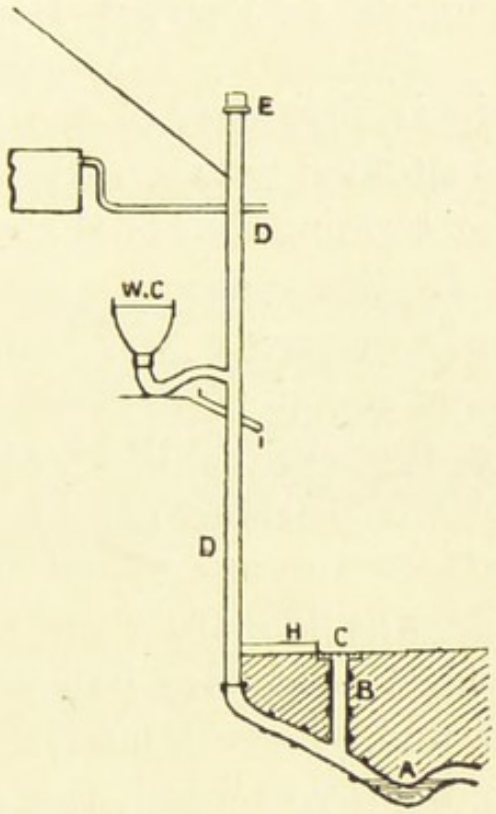


FIG. 49.

D, soil pipe ; A, trap ; B, ventilating "eye" ; C, grating.

by gases of decomposition. Corrosion often ends in perforation. When this takes place the house interior is exposed to the atmosphere of the soil pipe, and the inmates to consequent harmful effects. If the soil pipe be composed of iron, careful inspection of the joints with the lead branch pipes is necessary on account of the galvanic action which is liable to be set up between these metals.

CHAPTER XXV.

SANITARY FITTINGS (*continued*)—THE HOUSE DRAIN —TRAPS AND THEIR USES.

THE house drain is that part of the soil-carrying apparatus which is situated between the intercepting trap at the bottom, or termination, of the soil pipe and the common sewer in the roadway. Considerable care must be exercised in laying it, and it should be planned to have as straight a course as possible to the sewer. This is called the *alignment*. (Fig. 60.) It must be laid with a downward gradient from the trap or soil pipe—its highest point—to the sewer—its lowest point—so that the drainage will flow from the result of gravity. When laid too level solids are liable to be deposited, "silt" is formed, and, sooner or later, the drain becomes choked. If, on the other hand, the slope downward be too great, the volume of descending water from the soil pipe passing through the trap is apt to "siphon" the trap owing to the momentum—that is, the combined weight and velocity—of the passing column of liquid. The proper level is, therefore, adjusted by the eye of the experienced workman, or, better, by some instrument as figured in Fig. 50, which represents Moss-Flower's gradient indicator.

The bed upon which the soil pipe is laid ought to be composed of some immovable material to secure

solidity and to prevent disjointing of pipes from uneven "settling" of house foundations, which is especially liable to happen in buildings founded upon "made-up" or "filled-in" sites. Concrete, or cement, forms the best bed. The house drain is composed usually of either fire-clay or iron pipes, in lengths, each length being fitted into the other, and the joints made impervious by cement in the case of the former and oakum or tow and molten lead in the latter. The best constructed drain, however, is liable, upon occasion, to become blocked from negligence or carelessness either



FIG. 50.

A, brass-plate to indicate gradients; D, C, spirit level; D, E, drain pipe; F, G, drain limb of instrument for applying flush with pipe; H, tangent screw, for very accurate adjustments.

on the part of domestics or householders themselves, and the obstructing causes are of a very varied character; scrubbing brushes, washing-cloths, dusters, and other kindred articles often cause obstruction which must be got rid of. Where the drain is closed in its entire length this can only be accomplished by passing a long flexible iron shaft along the pipe from a part which has been opened for the purpose. This, however, is an unsatisfactory and expensive method. Provision, therefore, in the original construction may be made for such a contingency by putting in, at intervals, sections of

pipes, having movable lids, called "inspection pipes". Figs. 51, 52 represent these in position.

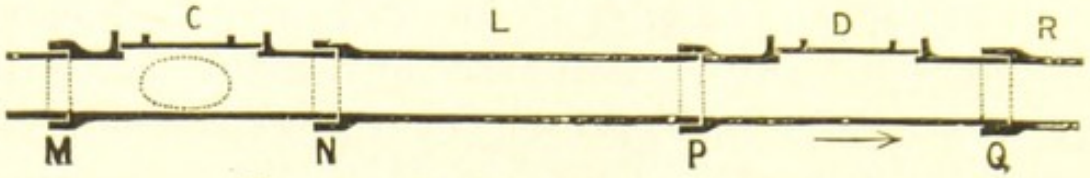


FIG. 51.—Buchan's Inspection Pipe.

D, C, movable openings by which interior may be examined; C is placed at a junction with a branch, indicated by oval ring; L, ordinary pipe length; M, N, P, Q, junctions of pipes.

A house drain ought to possess the following points, *viz.*: (1) it should be laid on a solid bed of concrete or cement; (2) it should have a sufficient gradient; thus, for a four-inch pipe a fall of 1 in 40; (3) there should be no right-angled connections, but oblique, in the direction of the flow; (4) its interior should be as smooth as possible; (5) it should be automatically flushed; (6) it should be disconnected from the soil pipe by an intercepting ventilating trap, which should not open on a pavement, or close to windows or doorways.

TRAPS.

Frequent use has already been made of the word "trap," and mention has been made of its being an essential part of the drainage system of the house. It

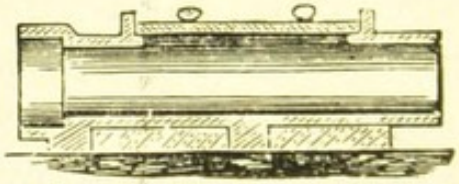


FIG. 52.—Shows Inspection Pipe with pedestal feet, laid on concrete bed.

is, therefore, necessary that explanation of its use be now given. The object of a trap is suggested in the word itself. It is an arrangement whereby something

is arrested or trapped, which it is desirable to arrest or trap. In relation to sanitary fittings that *something* consists of foul air and gases generated in pipes, which carry foul and putrescible materials, and micro-organisms. The medium by which these are trapped is water more or less pure, the point of arrest being situated between the house interior and the nearest adjacent foul pipe, or channel. If a glass tube be taken, and in a flame be bent twice in a round curve, and if, after it cools, the tube being held in a perpendicular position, water be poured into it, there will be formed a part of the tube in

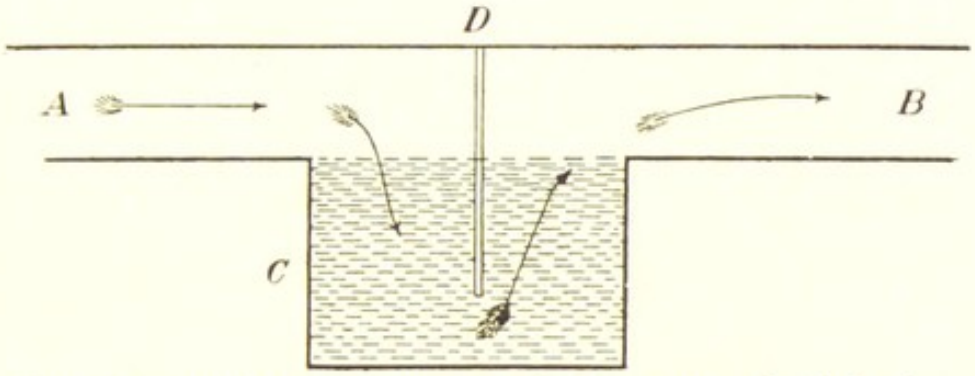


FIG. 53.—"Dipstone" Trap applied to square built drains.
A, inflow of sewage; B, outflow of sewage; C, water seal of trap; D, section of stone from roof of drain dipping into water seal.

which water will constantly lie, and through which air at the ordinary pressure will not pass. This forms the most elementary form of trap, consisting of a simple bend in a tube. Should air or gas attempt to pass from the lower end of the tube to the upper it is arrested or trapped by the column of water lying in the bend. Should the gas be passed under pressure, the trap would be forced; in other words, the force of the pressure would overcome the weight of the column of water in the bend of the trap. From this simple experiment and apparatus the essential features of a trap may be understood.

If, however, a branch tube be blown in the glass model, at the top of the upward bend, no pressure whatever will force the trap, as the air or gas finds a vent by the ventilating tube. (Fig. 56.)

A more primitive form of trap, in use when square brick built drains were in operation, is called the "dipstone" trap. (Fig. 53.)

When, however, the circular or pipe form of drain came to be adopted, the trap had to partake of a character suitable to the new form. Hence the most elementary form, a simple bend, or a depressed tongue, in the pipe formed the trap. Fig. 54 illustrates the "dipstone"

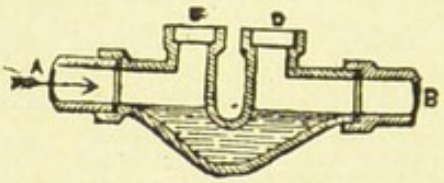


FIG. 54.—Honeyman's Somerset Trap.

A, inlet opening of drain; B, exit opening of drain; between them is the fixed column of water forming the trap, the depressed tongue acting as the "dipstone"; C, D, ventilating and cleansing "eyes" of trap.

principle adapted to the circular pipe, which was patented by Mr. Honeyman, a Glasgow architect, in 1868.

The column of water which lies in the bend of the trap is called the *water seal* or *water lock*. Experience with traps in connection with pipes through which water flowed with considerable velocity, soon showed that the water seal was liable to dislocation or "forcing" from different causes. The disturbing force was found to be either difference of atmospheric pressure or momentum of the flowing water; and the effect produced was the emptying, partial or total, of the water seal. This action, from its parallelism to the action of the siphon, came to be called the "*siphoning*" of a trap.

CHAPTER XXVI.

HOUSE DRAINAGE (*continued*)—TRAPS—SIPHONING OF TRAPS—FORMS OF TRAPS.

TRAPS may fail in their purpose from one of three main causes, *viz.*: (1) from "siphon" action; (2) from momentum; or (3) from evaporation of water seal. What is meant by "siphoning" of a trap? The action of the siphon having already been explained, little difficulty should be experienced in the comprehension of this. Let us consider the problem in its practical application to a soil stack into which a series of closet branch pipes enter at different levels, as in Fig. 55. In the first place, let it be clearly understood that "siphoning" most readily happens where the traps of the soil pipe and sanitary fittings are unventilated. Therefore, in the diagram, the soil pipe is not carried above the eaves, the traps of the various closets are unventilated, as is also the trap of the soil pipe at its junction with the house drain. Let us suppose, to begin with, that the trap of each closet is properly filled with water, thus trapping the atmosphere of soil pipe from that of house interior, and that the soil pipe and branch pipes are full of air. Between the trap of closet 1, and the unventilated trap of soil pipe, C, there is, therefore, an intervening column of air locked between these two water-sealed points. When closet 1 is used, what happens is what

is represented in the figure. The descending column of water (D) rushes into the soil pipe, and, like the piston of a pump, compresses the atmospheric column, already mentioned, which is water-locked at C. This atmospheric column, therefore, in front of the descending

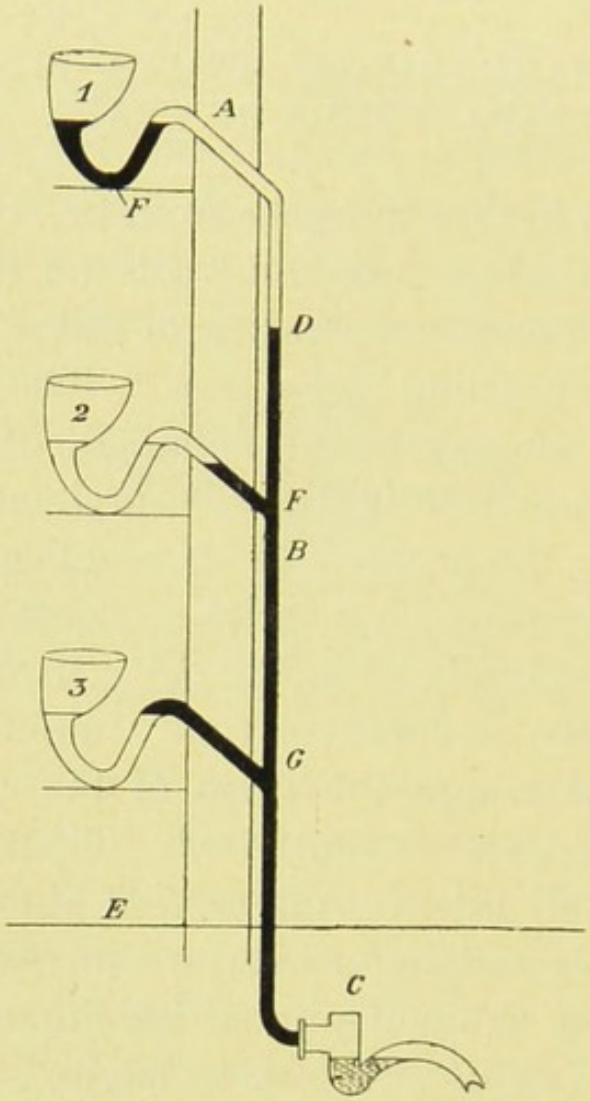


FIG. 55.—To illustrate "siphoning" of traps.

water column is at a greater pressure than that of the outside air, and the air column behind the water is at less pressure. When the water descends to D, and more particularly when it reaches the junctions of the branch pipes from closets 2 and 3 (F and G), the difference of

pressure is at once noticed in the water of the traps of these closets. And since the pressure at F and G is less than that on the surface of the water in the traps 2 and 3, the greater pressure drives the water out of the traps into the soil pipe after the descending column of water, and thus these traps are unlocked, or unsealed, or "siphoned," and are consequently left empty. Suppose, for example, the ordinary atmospheric pressure being 14·7 lbs. per square inch on the surface of the water in the traps 2 and 3, that the superficies of water in each trap be equal to 48 square inches, and the reduction of pressure within the soil pipe during the action of the flush be $\frac{1}{2}$ lb. per square inch, then the total pressure, by difference, on the surface water of the traps will be $48 \div 2 = 24$ lbs., and this increase of pressure drives the water of the trap into the soil pipe in its effort to establish atmospheric equilibrium in the soil pipe atmosphere. This phenomenon of "siphoning" takes place, under such circumstances, even more readily when a bath is being emptied high up in the waste pipe or soil stack, for then the pipe is running "full bore" with water. When traps are siphoned a straight path for the foul air of the soil pipe is opened into the house interior.

Momentum is the second common cause of rendering a trap useless. When the descending column of water in the soil pipe reaches the unventilated trap, C, it has attained considerable velocity, which is not reduced much by the basin of the trap; consequently, when the last portion of the column reaches the trap it is in a highly agitated condition, and since it is difficult to bring a body moving at considerable velocity to a

state of rest the whole column is likely to be swept through the trap, which is thus left partially or entirely empty.

The third cause is *disuse* of the trap, during which time evaporation of the water seal happens. This is apt to occur in town houses which are unoccupied wholly or in part for periods during summer, or, indeed, at any time. By reason of this evaporation the atmosphere of soil pipe and house becomes continuous, and not only foul gases, but also micro-organisms,

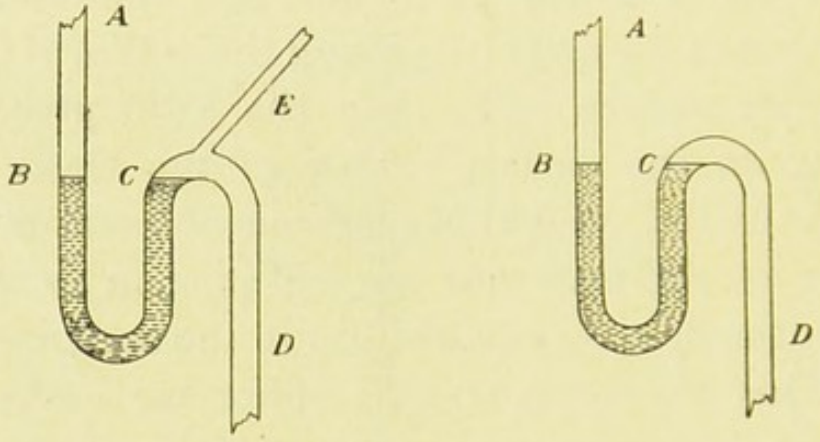


FIG. 56.

A, pipe of trap to fitting; B, C, level of water seal; E, ventilating pipe; D, branch pipe from fitting to soil or waste pipe.

owing to the dry condition of the pipes, find an easy access into the house.

Traps may also be rendered inoperative from being blocked with solid deposit owing to imperfect "setting," or to imperfect water flushing, or to insufficient fall in house drain.

From a knowledge of these difficulties experience has suggested remedies. For example, free ventilation of soil pipe and all traps connected therewith will prevent siphoning. Any temporary disturbance in the equilibrium of the atmosphere of soil pipe is thus

quickly and safely righted. The remedy for disuse is obvious. The means of ventilating the soil pipe having been already discussed, it will be enough now to consider the means of ventilating the traps of the branch fittings. Fig. 56 shows the position of the ventilating pipe in an ordinary trap of a lead pipe. It is always placed on the "crown" of the trap—on the soil-pipe side of the trap. Where a series of such venti-

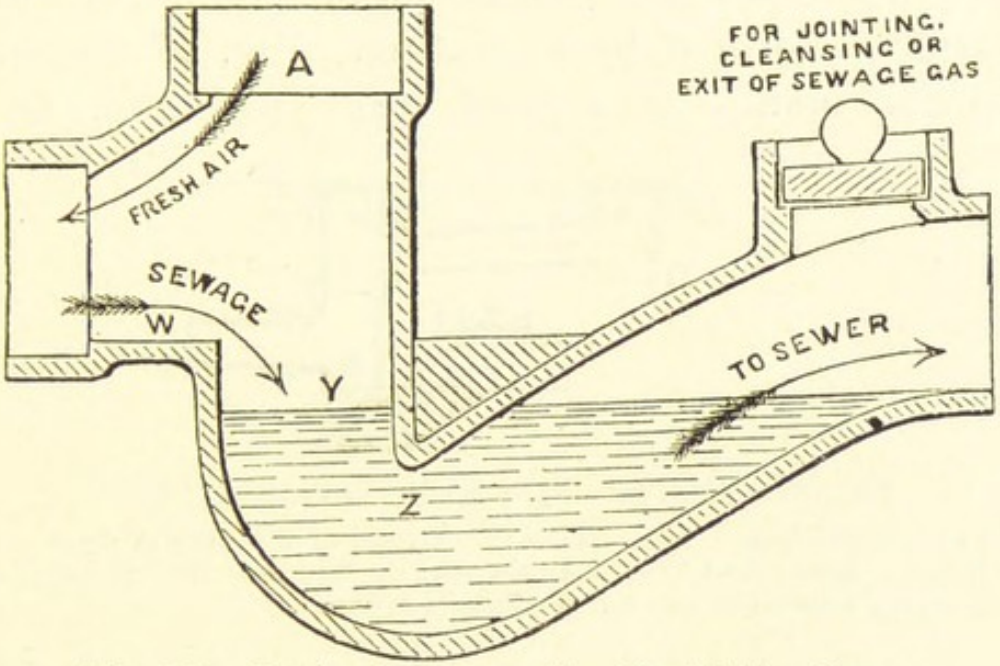


FIG. 57.—Buchan's Intercepting Ventilating Trap.

A, ventilating "eye"; W, lip to produce "cascade" action to cleanse bottom of trap of silt; Y, level of water seal; Z, tongue or "dip" of trap.

lating pipes exist, they are either passed singly through the wall into the open air directly or they are united either to a separate ventilating main pipe, or, separately, into the soil pipe at some distance above the entrance of each branch, this distance being regulated (1) by the maximum flush of water which can enter the soil pipe at any time, and (2) by the length of soil pipe which that amount of water will occupy. Thus, one gallon of water fills a pipe of 4 in. diameter to a height of 22

in., and a pipe of 4½ in. to nearly 17½ in. If the maximum flush be three gallons, and the pipe 4 in. in diameter, then 22 × 3 = 66 in. would be the minimum height above the entrance of the branch pipe at which the ventilating pipe of the trap of that branch should enter the soil pipe. In large traps which are placed in the ground at the termination of the soil pipe or waste pipe, ventilation is attained by a special opening in the trap which reaches the surface of the ground, and which is usually covered by a grating. Fig. 57 shows the essential points of a good trap; and Fig. 58 the

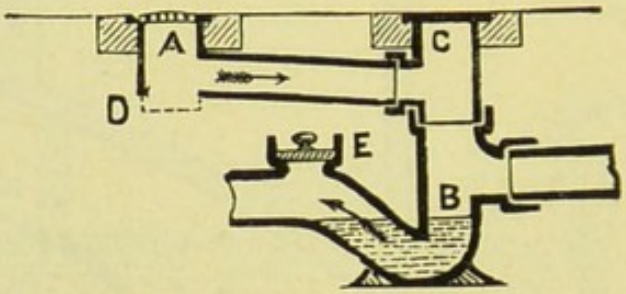


FIG. 58.—Buchan's Trap with Ventilating "Eye".

A is the ventilating "eye" which is carried to the ground level at some distance from the house, and the arrows represent the direction of the incoming current of air, and the flow of sewage.

arrangement for carrying the ventilation opening at ground level some distance from the house wall.

The essential points of a good trap are these, *viz.*: (1) it should be of a self-cleansing shape; (2) it should be ventilated, and thus not easily unlocked from any cause; (3) it should possess a sufficient water seal—not less than 2½ in.; (4) it should not be liable to "silt"; and (5) it should have an opening for cleansing purposes. In Fig. 57 the water seal is shown by the dotted lines, and Z represents the tongue or "dip" of the trap. The precise form of the trap is regulated by the

special function it is intended to serve, and the forms now in use are so varied that space forbids their consideration.

It is sufficient to say that there are many excellent forms in the market by well-known makers, and there is little to choose between the best of them.

CHAPTER XXVII.

ATMOSPHERE OF HOUSE DRAIN AND SEWER—MODES OF TESTING DRAINS—SEWER VENTILATION.

FREQUENT mention of the foul air of soil pipe, house drain, and sewer, and of its being a disease-producing factor, has already been made. Let us briefly inquire wherein the air of these parts of the sanitary apparatus is harmful. In the first place, it is to be remembered that these channels carry off materials in a putrescible condition, from which, when putrescence takes place, as it readily does in water, foul-smelling gases are disengaged, which are chiefly composed of compounds of sulphur with hydrogen, or ammonia, or both, as in a rotten egg. From constant exposure to these alone ill-health is more or less quickly engendered, shown by loss of appetite, malaise, weakness, pallor of countenance, and not infrequently, eruptive skin diseases. When present in concentrated form, as in sewers, they produce alarming symptoms, and sometimes fatal results. In addition to these malodorous gases there are other equally objectionable gases generated, which, however, only possess a faint, sickly, or fœtid odour. These are compounds of carbon and ammonia, and carbon and hydrogen. Of greater importance still than any of these are certain disease-producing micro-organisms. Diverse opinions are held in respect of the amount of mischief

produced by the agency of sewer air; but little doubt need be entertained on the question, since, indubitably, sewer air is harmful. There is no question, however, regarding the potency for harm of certain micro-organisms which are found associated with decomposing fæcal matter, and particularly with the discharge from patients suffering from enteric fever and diphtheria. Entrance of gases from soil pipe or house drain, and more certainly of these micro-organisms, into the atmosphere of occupied rooms, will sooner or later set up ill-health or disease, and it is to prevent these entering that water traps are used, since water arrests and holds in solution and suspension such gases and micro-organisms. A dry pipe or trap is, therefore, more dangerous than a wet one, and the atmosphere of sewer, drain, or soil pipe is always more dangerous in droughty weather than in wet, and in the case of micro-organisms, least harmful in a rainy season.

TESTING OF DRAINS.

It is advisable and necessary during the occupation of a house, to have the drain connections periodically tested in respect of their integrity. Systematic attention to this will often avert illnesses in a family. Whenever a house has been built, and before the drainage contract is taken from the hands of the contractor as being satisfactory, the whole plumbing and sanitary work should be tested. To this, no proper tradesman can offer any objection. It is to be hoped, also, that the time is near at hand when every householder, before occupying a house, will deem it necessary to have a

certificate of its sanitary competency given at the hands of a competent inspector.

The mode of drain testing resolves itself into one of three ways, *viz.:* (1) by water; (2) by smoke; or (3) by some volatile odorous substance. The water test consists in stopping the waste and soil pipes near the basement and each branch fitting with watertight, solid plugs, and then in filling, from the topmost part, the whole piping with water. Any imperfect joint will be revealed by leakage, and by the lowering of the original level of the water. This plan is only fitted for new buildings before occupation. But this hydrostatic test is always applicable to the house drain. The smoke test consists in filling the whole sanitary apparatus with strong-smelling smoke under some degree of pressure. To do this, the tops of the waste pipe and soil pipe must be properly closed. The smoke is then driven into the pipes at the ventilating "eye" of the intercepting trap, at the junction of soil pipe and house drain. Should leaky joints be present, they are detected by the appearance of smoke, and by its odour. In this way "faults" are tracked, and remedies applied. The apparatus used is called a smoke-testing or fumigating machine, and consists of the following essential parts, *viz.:* (1) the motor by which the smoke is impelled; (2) the smoke-generating receptacle; and (3) tubing to connect Nos. 1 and 2, and No. 2 with trap. The motive power may consist of a fan driven by hand, or of spirting jets of water which act automatically. Fig. 59 represents a machine of the latter form invented by the chief sanitary inspectors of Glasgow and mid-Lanarkshire. Such an apparatus works automatically when connected with a

water-supply pipe. The water tap is connected by tubing with the branch pipe. When the jet of water enters the top-shaped part, in the upper part of which the smoke-generating material is placed and lighted, it is split into a large series of fine sprays, which cause a current of air and smoke to pass on towards the pipe, and air to pass from the outside as shown by the top arrow, to fill its place. This is a very ingenious and labour-saving

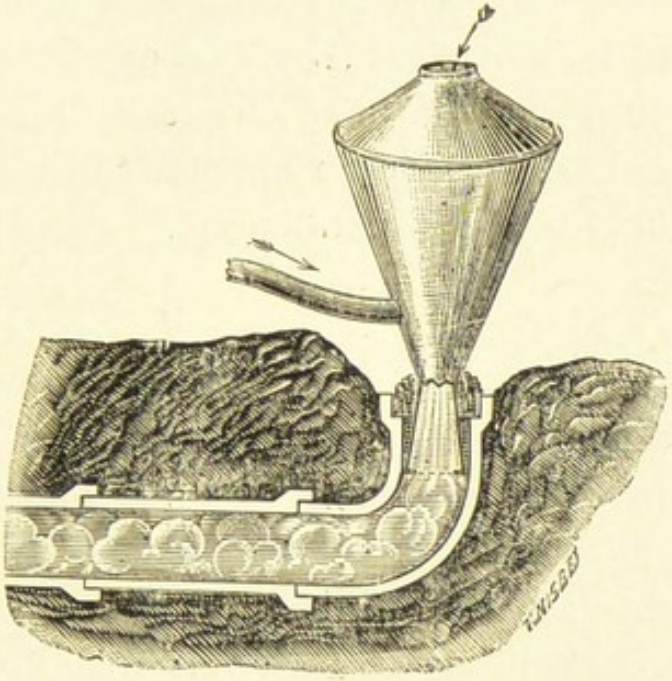


FIG. 59.—Fyfe and Dobson's Smoke-testing Apparatus.
The arrow indicates the ingoing water, which sets the smoke in motion.

machine. Other modes such as pouring odorous substances into the pipes to be examined, are absolutely useless.

SEWER VENTILATION.

This subject may be briefly dismissed in the following sentences: By means of manholes, about every hundred yards apart, situated in the centre of the street, an interchange is effected between the air of the sewer

and the atmosphere. Some of these manholes act as outlets of foul air, others as inlets of fresh, the incidence of their action depending on local wind currents, or the admission of hot water or spent steam from public works into the sewer. Such, however, at the best is but haphazard ventilation, and, generally speaking, too little attention is given to the subject. Doubtless the time will come when the sewer system will be composed of a closed system of channels, made to converge at fixed points, at which, by the exhaust power of a furnace burning at the base of a tall chimney, perfect ventilation will not only be effected, but also harmful sewer products be made innocuous.

PLAN OF DRAINS.

An exact plan of the drainage system of every house should be in the possession of its owner. From the want of such, considerable expense and trouble have been caused. To the uninitiated such a plan may appear a very complicated affair, but usually it is easier to read than an architectural plan. Fig. 60 shows a simple plan.

DISINFECTION OF DRAINS.

It is by no means a simple matter to disinfect a house drain, much less a sewer. The prevalent habit of adding small quantities of disinfectants from time to time is only delusive, since, owing to the dilution which they undergo, they become practically inoperative. The only approximately efficient way is to fill a bath with water, then to charge it with a concentrated solution of

some non-corrosive disinfectant, such as Jeyes' Fluid or Sanitas, mix the contents, and then suddenly discharge it by the waste pipe into the drain. It ought always to be remembered that certain disinfectants, when used too strong, such as corrosive sublimate or chlorinated lime, attack the metal of the pipes, the former especially

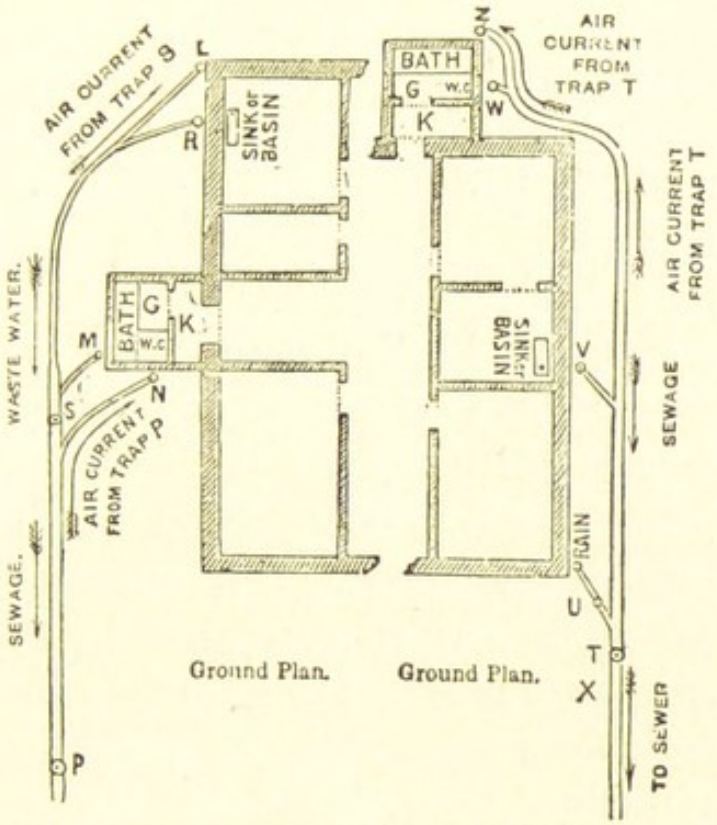


FIG. 60.—Drain Plan of Villa.

acting as a solvent of the solder. But of this more will be said when dealing with the disinfection of infective discharges.

The best and cheapest disinfectants of drains, however, are *fresh air* and a plentiful supply of water, and if these channels are well flushed with both, no consideration need be given to chemical disinfection.

CHAPTER XXVIII.

SEWAGE DISPOSAL—PRECIPITATION—IRRIGATION—FILTRATION—HOUSE REFUSE DISPOSAL—CONSERVANCY SYSTEMS—PRACTICAL HINTS FOR HOUSEHOLDERS AND NURSES.

DISPOSAL OF SEWAGE.

The proper disposal of the water-borne sewage of a populous place ought to be a matter of solicitude on the part of sanitary authorities. Hitherto but little attention has been paid, in many cases, to the fitness of place and mode of disposal. Not infrequently, if the place be situated on a river, a canal, or by the seashore, the main outlet sewers are simply turned into the waterway to pollute the river, canal, or foreshore, which is a contravention of the Rivers' Pollution Act. The Clyde at Glasgow, the Liffey at Dublin, the Seine below Paris, and other rivers, have become converted into elongated sewers, seething with fermenting corruption. It has often been alleged that such practice and results are not positively injurious to health. This is, however, contrary both to common-sense and fact; the only difficulty is to bring the proof home. That sewage can be satisfactorily disposed of in relation to a river has been demonstrated in the case of London and elsewhere. The chief objection to the initiation of like schemes in other cities is the financial one, but what citizens spend

in this way they are likely to save by healthier and longer lives. All applied methods for sewage disposal may be divided into three kinds, *viz.* : (1) by chemical treatment or *precipitation* ; (2) by *irrigation* ; and (3) by *filtration*.

The first mode consists in mixing with the sewage by mechanical means certain chemical substances in certain definite proportions, allowing the mixture to settle in settling-ponds, running off the clear supernatant fluid, sometimes passing this through filter beds, and ultimately discharging the clear effluent into a river or other water-way. Lime, alumina, and iron are the principal precipitants now employed, and they act both chemically and mechanically. The solid portion or sludge is, if possible, sold as manure, either in bulk or compressed in the form of cakes.

The second mode is adopted where, in the neighbourhood of a town, suitable land is easily and cheaply procurable. The sewage is conveyed to this land, and is run upon the surface of the sloping ground in channels which distribute it equally. Porous sandy soil is the best, since percolation quickly occurs. The solids are incorporated into the soil by agricultural operations. The percolated water finds its way into natural channels, just as the rain does. The land, so enriched, is utilised for the cultivation of certain kinds of crops.

The third mode is by filtration. To a considerable extent this happens also in the second mode. But in this process, where filtration is the principal feature in the clarification of the sewage, suitable land must be prepared after the fashion of a large filter bed, which is divided into a series of plots. The bottom of the bed—six feet from the surface—is laid at intervals with

agricultural drain pipes ; on top of this are placed large broken stones, over that gravel, and on the top of all the natural sandy soil. The sewage is distributed over these plots by surface channels, and in such rotation that each plot works for six, and rests for eighteen hours, by which means the soil is prevented from becoming clogged, and re-aeration is established. The percolated water finds its way into the artificially prepared channels at the bottom of the filter bed, and thence to a water-way. The solids are incorporated with the soil. This is known as intermittent downward filtration.

CONSERVANCY METHODS.

Whether or not a water-borne system of sewerage prevails in any populous place, a considerable amount of solid refuse from ash pits, etc., remains to be disposed of. In place of ash pits a daily dust bin service has been established in many towns. In smaller places, where the privy system obtains, and where the water supply is obtained from shallow wells often in proximity to these offices, pollution of the water sooner or later occurs with serious consequences to the consumers. In connection with farms and milk supplies this is a matter of the greatest moment, since nothing in sanitary science has been more clearly demonstrated than that milk is probably the most common vehicle of enteric fever. In Glasgow, alone, during the past twenty-five years, almost every epidemic of this disease has been traced to in-brought milk from insanitary farms. Where the ash pit and privy system prevails the contents should be removed at short intervals. Earth is

one of the most efficient of absorbents and deodorants, hence the earth closet is of practical value in such districts. In isolated country houses, fitted up with modern sanitary conveniences, the usual ultimate destination of the sewage is either a cesspool or a small stream. The latter outlet is wholly objectionable. A cesspool built of brick, set in cement, and founded on concrete, at some distance from the house, in a field or in the garden, is a more preferable destination, for, in the latter case, its contents can be used for horticultural purposes, and, in the former, irrigation may be carried out.

In populous places the problem of the disposal of house and ash-pit refuse, street sweepings, offal, and miscellaneous débris, has been solved by the establishment of municipal depôts, wherein manurial products are collected and sold, and ash-pit and other refuse burned in destructors. In this way hundreds of thousands of tons are got rid of yearly. Such works, too, may be carried on at comparatively small expenditure. All the power for steam and electric lighting in the works is generated from the cinders from the ash pits; the solder recovered from tins, and the manure, are sold, in this way reducing expenditure. With smoke-consuming apparatus, such a work can be carried on with no offence to the neighbourhood. In smaller towns, such refuse is usually carted to some piece of common land in the vicinity, and, in the open, is there set on fire, but the smoke which results therefrom is a distinct nuisance, being very malodorous.

HINTS TO HOUSEHOLDERS AND NURSES RESPECTING THE DISPOSAL OF HOUSE REFUSE.

In the first place, nothing except ashes, soot, and inorganic débris should be consigned to the ash pit. From the mistaken practice of throwing food-waste into that receptacle, a plague of rats is apt to follow. This may be avoided by following the foregoing advice. In the second place, food-scraps, which cannot be charitably disposed of, ought to be consumed in the kitchen fire; and in the third place, by sifting cinders, and by drying food débris, economy may be effected in the cost of heat-production, and the bulk of the ash pit refuse considerably lessened.

In respect of the use of disinfectants in closets for the disinfection of infective discharges from patients, it should be remembered that strong solutions of corrosive sublimate ought never to be put into that receptacle, or into slop closets, or sinks, unless and until they are abundantly diluted after the disinfectant has had time to do its work. This disinfectant, as also chlorinated lime, attacks the lead pipes and solder. Copious flushing should always follow. Where a privy or earth closet takes the place of a water closet, the disinfected discharges of a patient suffering from either enteric fever, cholera, or diphtheria, should never be placed in either, but should be interred in the soil in a remote part of a garden, or other available piece of ground, but not in proximity to a well.

CHAPTER XXIX.

CLOTHING IN RELATION TO HEALTH—MATERIALS EMPLOYED IN MANUFACTURE—THEIR USES AND VALUES.

THE primary function of clothing, of whatever kind, is to conserve the animal heat of the body, and it combines with this duty the subsidiary purposes of serving for decency, for the adornment of the person, and for protection against injury. Conservation of the body heat is especially necessary in temperate and arctic climates. In warm or equatorial climates, on the other hand, it fulfils the purposes of personal adornment and bodily protection chiefly. The study of clothing has received of late years closer attention than ever it did before, especially from the hygienic standpoint. The human body is capable of resisting heat and cold through a very considerable range of temperature, but it is more able to withstand extremes of heat than of cold. This might be predicated from the fact that the animal body is a great heat-producer in relation to its size, food being the fuel, and the bodily organs the furnace in which the fuel is burned by chemical action; but the total amount of heat generated within a given period is, however, limited at the best. The object of clothing, therefore, is to prevent this body heat being dissipated too rapidly from the body. The materials of which the different fabrics

are composed are obtained almost equally from the animal and vegetable worlds.

From the former are obtained (1) wool, mainly from the sheep species, but partly from the goat species, and from the camel, alpaca, and vicuna; (2) silk, from the cocoon of the silk-moth, and from other silk-yielding moths; (3) skins, which are used after preparation, with or without adherent fur; (4) hair; and (5) feathers of birds; from the latter (1) cotton, from cotton shrubs; (2) linen, from the flax plant; (3) jute and hemp, used for subsidiary clothing purposes; (4) guttapercha, or caoutchouc, from the india-rubber plant; and (5) straw, from wheat stalks and grasses, cut when green, and afterwards bleached.

These different stuffs are used either pure or mixed, and compose, in the main, the different fabrics of which body coverings are made. A rapid review of these coverings will show how these materials are utilised for body protection and heat conservation. For example, in the head-gear, straw, silk, satin, feathers, fur, wire, linen as artificial flowers, cotton, wool, felt, and like materials, find a place. Linen composes the collar and collarette, and it also, like cotton, wool, and silk, enters largely into the composition of underclothing. The outer person is clad in garments of wool, silk, or cotton. Leather is found in boots, shoes, vests, and other articles of attire, while guttapercha enters into the composition of foot-gear and overalls, for protection against damp. Furs serve the double purpose of adornment and heat conservation, chiefly for the former in temperate climates, and solely for the latter purpose in arctic climates. The materials of which textile fabrics are made differ both

as to their physical and microscopic appearances. A good hand magnifying glass will reveal these differences. Wool fibres appear as continuous stems, with circular markings, which give the edges of the fibre a notched character, owing to which they more readily lend themselves to the operations of twisting, weaving, and matting. Silk fibres look like clear threads, without any pith; cotton fibres have roughened edges, and show twistings in their length; linen fibres exhibit nodular points in their length; and it is difficult to distinguish between jute and hemp. Their different behaviour when treated with certain chemicals and dye stuffs further helps to distinguish between them.

PERMEABILITY IN RESPECT OF AIR.

Different cloth stuffs, of exactly similar size, when subjected to the same test, exhibit differences in the respective amounts of air which may be passed through them in a given time. Suppose flannel, linen, silk, and leather to be taken for the test. The result will show that 100 parts of air will pass through the flannel for 60 of the linen, 40 of the silk, and about 30 of the leather. The porosity or permeability of these substances will, therefore, be in the order named.

WATER-ABSORPTIVE CAPACITY.

If pieces of new silk, linen, cotton, and flannel of exactly similar size be taken and placed flat-ways and lightly upon the surface of cold water, they do not float for equal periods of time. Silk sinks almost at once, linen in about one minute, cotton in about four

and a quarter hours, and flannel does not sink at all. This experiment shows, approximately, the rate at which garments made of these respective stuffs will become saturated with damp. If worn materials be used in the experiment, and warm instead of cold water, absorption is relatively more rapid.

THERMIC PROPERTIES.

The heat-conducting capacity of different textile fabrics is by no means the same. Cotton and linen, especially the latter, feel colder to the touch than silken or woollen articles. They are, therefore, better heat-conductors than the latter; that is to say, in the same time they rob the body of more heat. This conductivity does not, however, depend so much upon the materials themselves as upon the closeness or openness of the woven texture. The "fluffiier" the material the more air is held within the interstices of the fabric, and hence the heat of the body is conducted away less rapidly.

The roughness of the fibre of wool as compared with those of linen, or cotton, or silk, by setting up some degree of irritation of the skin, and, therefore, a greater supply of blood to that part than usual, doubtless contributes in some measure to the greater sense of warmth of a woollen garment, and, for a like reason, is ill-borne by hyper-sensitive persons.

BEHAVIOUR TO SENSIBLE PERSPIRATION.

This is a matter of considerable practical importance. Cotton, linen, and wool behave differently. Experience

amply demonstrates that, when garments worn next the body, and composed of these materials respectively, become wet with sweat, a feeling of chilliness is more quickly perceived in the case of cotton and linen than of wool. Heat, therefore, is more rapidly abstracted from the body in the case of the two former than of the last. Hence chills are more liable to happen when cotton or linen is so worn. It may safely be reckoned that, in the same time, damp cotton or linen abstracts not less than 30 per cent. more heat from the body than does damp wool. They also act differently in regard to the solid and liquid portions of sweat. Cotton and linen retain more of the solids than flannel or wool, and, therefore, more quickly become apparently soiled than wool, whereas wool permits the "solids" to pass through, to soil the garment worn next above, while it itself remains apparently longer clean.

COLOUR AND ITS RELATION TO HEAT.

The colour of a garment has an important bearing on the amounts of radiant heat absorbed and reflected. White and the lighter coloured fabrics absorb less radiant heat than dark coloured or black, and reflect more; and the differences in amounts are graded by the tones of colour between white and black.

The dust-carrying capacity of clothing, and, therefore, facility for convection of infective material, depends in a large degree on the roughness or smoothness, and the openness or closeness, of texture of the fabric. The rougher and more porous the garment the greater the capacity for carriage of dust or contagia;

and the converse is equally true. Therefore, the dresses of nurses, while tending the sick, ought to consist of close-textured material, capable of being frequently washed and ironed, so that a glazed smooth surface may be formed, and thus a less suitable resting place for microbes be offered.

The colour of a garment has no relation to the odour-absorbing capacity of the fabric, as has been asserted. This has probably arisen from the fact that the average colour of the dress in cities is of a dark shade, and is usually associated with woollen fabrics, which, because of their porosity, absorb more odour than close-textured stuffs.

What should be worn to preserve health? is a most important consideration, as no one dress standard is equally suitable for all points of the globe. The discussion of the question will be simplified if we deal with it in reference to typical climatic conditions. There are four such typical kinds, the intervening grades being but modifications of one or other type, *viz.:* (1) the cold or arctic climate; (2) the hot, dry climate; (3) the hot, moist climate; and (4) the so-called temperate climate. These are but arbitrary divisions, and must not be confounded with the meteorological definitions of climate. In the first-named, the greatest struggle to maintain the body heat is experienced. This is not difficult to understand when it is remembered that such temperatures as 69° Fahr. and 81° Fahr. below freezing point have been recorded, and where, even in July, the thermometer hardly rises above freezing-point. Experience has shown that the cold can only be overcome by wearing woollen garments next the body; and over these the

skins of animals with the furry side inwards. No other forms of clothing will adequately conserve the body heat. In the second, the nature of the clothing is entirely different. The air being dry and greedy of watery vapour, sensible perspiration is usually absent. Comfort, therefore, will more likely ensue from the wearing of white, grey, or other light-coloured garments composed of cotton, linen, or wool, made loose fitting; light coloured the better to reflect the sun's radiant heat, and lined, preferably with a dark-coloured lining, to prevent the scorching effect of the solar heat rays, and loose fitting, to enable free interchange of air. Sunstroke is avoided by the pith hat, pugaree, or sombrero, or Panama straw hat. Where the climate is hot, but moist—the third type—where the air is commonly saturated with watery vapour, and where sensible perspiration is almost never absent from the body, except when in absolute repose, woollen garments are absolutely indispensable both for night and day wear. Loose fitting they may be, but of wool they must be. In the fourth type—the so-called temperate climate—more difficulty is experienced in regulating the proper clothing than in any of the previous, solely due to the unexpected fluctuations of temperature. Thus, we may have summer temperatures in winter and winter temperatures in summer. In these islands there is also the additional fact that the atmosphere is largely charged with watery vapour, and particularly on the west coast. These disadvantages, however, are compensated for by our proximity to the Gulf Stream, which alone prevents our winters from being of arctic severity. There is no season of our average year in which woollen underclothing can be dispensed with.

It may be thicker or thinner in make, close or open in texture, as the weather permits, but it must be constantly worn, consistent with the safety of the person. Indeed, nothing can be said too strong in urging this upon our populations, as attention to it would considerably minimise illness and temper its severity.

CHAPTER XXX.

CLOTHING IN TEMPERATE CLIMATES—OF CHILDREN —AND OF THE SEXES CONSIDERED GENERALLY.

As was stated in the previous chapter, woollen undergarments are an absolute necessity in a climate like ours, and for summer, as for winter, for the reasons already given. The objections urged against their use are usually (1) personal discomfort, and (2) effeminacy. It is true that certain hyper-sensitive skins cannot comfortably bear the friction of ordinary wool, but for these the finer vicuna wool acts as an excellent and comfortable substitute. The second reason is urged only by those who are ignorant of physiological laws, and it is one which ought to be combated whenever it is put forward. For those persons who are not robust, those who are predisposed to rheumatism or chills, those who are convalescent from illness, and for the infirm, they are indispensable; and for those who enjoy ordinary health they act as preventives of illness.

CLOTHING OF CHILDREN.

Very erroneous opinions are entertained by many parents respecting the clothing of children. These have their origin in the desire to rear "hardy" offspring. While the desire is praiseworthy, the modes

adopted to effect it are entirely wrong. It is pitiful to see children of well-to-do families imperfectly clothed as to their limbs, and, in addition also, as to the upper part of their bodies. Children are peculiarly sensitive to temperature changes, and bear the loss of body heat very badly, with the consequence, when clothed as indicated, that they are more liable to contract illnesses. The equilibrium between heat production and heat dissipation is easily disturbed in their case. The safest underwear for children is composed entirely of wool, and it ought to cover the trunk and limbs of the body almost entirely. This applies equally to children of both sexes, and to all seasons of the year. An objectionable habit commonly prevails of differentiating between the underwear of a female and that of a male child. This is unwarranted by nature, and is unphysiological. It is apt, too, to be perpetuated and accentuated as the girl grows into the woman. This must be protested against; for the difference in the bodily functions of the sexes demands greater protection for the trunk of the female body than of the male. Undervests which are usually sleeveless, and which leave the upper part of the chest entirely unprotected, are but too common, but they are none the less harmful. Much has been made of late years of the substitution of "flannelette" for wool. Probably cheapness has had to do with its popularity. But when it is remembered that it is made solely of cotton, loosely wound and woven, it is not safe, where perspiration is a bodily habit, for reasons already given.

Let us now consider in what respects our modern modes of dressing are compatible or incompatible with

health. Beginning with the head-gear, we find certain errors ready to hand. Fashion is largely to blame for these. The airy creations of the milliner may be "things of beauty," but in many cases they do not contribute to "joy for ever". Nature has compensated the gentle sex for the absence of adequate artificial head covering by providing an ample natural covering. This, probably, in a large measure, results from the airiness of the artificial covering permitting the hair to grow more luxuriantly. When, however, a woman comes to the shady side of forty years, penalties are often the result of a continuance of this fashion in the form of headaches, neuralgias, etc., which might be prevented by a judicious addition of less permeable material to the head-gear. Male head-gear also calls for criticism. Hard hats, undoubtedly, do not contribute to the comfort of the wearer for two reasons, *viz.:* want of adequate ventilation, and compression of the arterial blood vessels of the scalp at the fitting parts. There is little doubt that baldness is a common result from constant use of such hats, and from these causes much of the increasing baldness arises. That such hats are not worn from choice is shown by the alacrity with which, upon opportunity, they are cast aside in favour of head-gear of a softer and more pliant type.

BODY CLOTHING.

Compatible with health and the relative functions of the sexes, it cannot be gainsaid that the body clothing of the male is more suitable than that of the female. In the former the trunk and limbs of the body are more

uniformly covered, and there is less constriction of the trunk than in the latter. In the female the arms and upper part of the chest are imperfectly protected, and the lower part of the trunk is over-covered. The mode of suspending the lower garments too, is decidedly objectionable, as an unequal strain is put on the muscles of the back and abdomen. Considerable advantage would result if part of this weight could be suspended from the shoulder, after the manner of male attire. The "rational dress" movement is a distinct advance upon the older mode of clothing. Much has been written against the corset, and probably its general use has been too much condemned, but it will be a necessity so long as the under-garments are suspended from the trunk. At the same time, not a word too much has been said against "tight-lacing," which is provocative of much internal mischief, and tends to cripple healthy motherhood. By the substitution of lighter, but equally warm skirts, and by the use of the divided skirt, the corset need no longer remain of the unyielding character it possesses.

FOOT-GEAR.

Here, also, some measure of reform is needed. Hitherto the anatomy of the foot would appear to have been totally neglected. Indeed, we take much better care of the feet of our horses than of our own. The pointed boot—that which tapers to a rounded point—like the very square-toed boot—is based upon a total misconception of the shape of the foot. A happy medium between the two is what is needed,—a boot which, in other respects also, fits the foot as a glove does the hand, and which enables the foot to perform its various move-

ments comfortably. High-heeled boots are also to be condemned. Nature intended that man should walk on the sole of the foot, not upon the heel or the toes, and that the foot should equally bear the body weight. The curves of the spinal column were intended for this purpose, but the high-heeled boot, in throwing the weight of the body on the front of the foot, distorts the proportion of these curves. To satisfy hygienic needs, the boot ought to be fitted when the foot is placed on the ground supporting the body weight, and shaped in front as the foot is shaped. It should possess a broad heel situated under the heel of the foot, and of sufficient height to enable the foot to bear equally the weight of the body, and it should be capable of ventilation. This last point is difficult to attain, for where air can get out damp can come in, and modern polishes do but help to clog the pores of the leather; hence ventilation only occurs at the lacing, or at the gussets in elastic-sided boots. Much has been urged against the use of guttapercha for boot soles. In our view much of the criticism is only theoretical. Experimentally we have used boots the soles of which are made of alternate layers of canvas and guttapercha, and have found them equally as comfortable as leather-soled boots. They exclude damp better than leather, but they are not quite so yielding as leather. Were it not, indeed, for this objection, the "clogged" boot—the boot with wooden sole—is about the healthiest form. Special attention ought to be given to the foot-gear of children during the period of growth, as boots then very quickly become too small, from which deformed feet, or, at least, bunions, callosities, or corns may result.

DRESS FOR NURSES ON DUTY.

The dress of the nurse ought to combine cheerfulness of colour-tone, personal comfort to the wearer, ease of washing, and be made of a material which has the minimum liability to carry septic or infective matter. Cotton fabrics of fast colour, therefore, combine these conditions better than any other material, for they can be boiled and ironed, or pressed frequently, without harm to the fabric, which cannot be said of woollen gowns. Made plain, and presenting a glazed surface from the pressing, they afford a less suitable resting ground for microbes than do woollen ones. In nursing infective or septic cases, more than ordinary precautions must be taken. A linen, or thin *rubber* overall is very useful, as it can easily be put aside or put on on leaving or entering the sick-room. A nurse should never be allowed to pass from an infective atmosphere to the outside before her nursing uniform has been changed, a bath has been taken, and special precautions made in respect of her hair. Hitherto, too little attention has been given to the hair as a medium of carrying infection, and while we scrub and polish, and asepticise our hands and arms, we are too apt to forget the toilette of the hair. The hair of the head and face of the physician or surgeon, and the hair of the head of the nurse, have been rightly blamed as the occasional vehicles of contagion of puerperal fever; therefore the hair ought to receive special attention. By wearing a loosely fitting, ventilated cap of thin rubber, much after trouble might be prevented. If, in short, the "preventability" of preventable diseases is to become an accomplished fact, it is only in some such manner as the foregoing that this end will be secured.

CHAPTER XXXI.

PREVENTABLE DISEASES—EPIDEMIC—ENDEMIC—PANDEMIC—THEIR PRIME CAUSES.

THE term "preventable" applied to diseases is one of comparatively modern application, just as the word "preventive" has been prefixed to medicine as a synonym of sanitary science. Preventive medicine deals with the prevention of disease *ab initio*, and of the spread of certain diseases, by removing the conditions by which they may be generated, or propagated. In its practical application, it implies some measure of State control. The class of infective diseases, and, indeed, other general preventable diseases, have compelled the attention of the Legislature, which has passed a series of Acts of Parliament, from which has arisen a huge network of sanitary machinery. It may be said that, to some extent, all diseases may be prevented or avoided by proper care being exercised on the part of individuals. But this implies a knowledge which the average person does not ordinarily possess. However, errors of eating and drinking, objectionable physical habits, abuse of the body in any form, undue or careless exposure to chills, etc., are a few instances of causes of illness which are well within the power of individuals to avert. On the other hand, there are certain diseases, the causes of which are beyond ordinary control, but which may be controlled or regulated by

proper regulations laid down by a controlling authority, and carried out faithfully by individuals. The object of such is the protection of the people *en masse*, and to frustrate the negligence of the careless and ignorant. To this category, therefore, belong the preventable diseases, those due to combined overcrowding and filth, as typhus fever, or to overcrowding alone, as phthisis and other lung affections, or to insanitary conditions of the sewage-disposal system, as diphtheria and enteric fever, or to polluted water, or milk; and like diseases from like causes. To this class also belong those diseases which are communicable from animal to animal, and from animals to man. The principal characteristic of the specific preventable diseases is their communicability from man to man, and from animals to man, either by infection or contagion. This has been realised for ages, and long before their causes were known. Then, the causal factors were mysterious entities which were looked upon as inflictions of punishment by God for the sins of the people, the appropriate remedy for which were prayers and fastings. In the word influenza, we still retain evidence of the mystery of the cause of the disease — the *influence* which struck down the people. The last twenty-five years has done more to clear up the mystery regarding prime causes than the previous two centuries, and to-day we are able to lay our finger on the causes of several of the scourges of humanity.

Communicable diseases present themselves in one of three forms, *viz.*, the *epidemic*, the *endemic*, and the *pandemic*. The word epidemic (Gr., *epi*, upon; *demos*, the people) literally means something that comes upon the

people. An epidemic disease is, therefore, one which, independent originally of local causes, attacks a number of persons in a population within a short time. The cause belongs more to the people than to the place. The word endemic (Gr., *en*, among ; *demos*, the people) means something that prevails among the people, usually, however, as isolated cases. It is dependent upon local causes, and belongs more to the place than the people. The word pandemic (Gr., *pan*, all ; *demos*, the people) means something that attacks all the people of a country, or the peoples of all countries, about one time ; and the infective material is conveyed very largely by atmospheric agency, and also follows trade routes. Influenza is a typical pandemic disease, and its recent widespread visitation of the nations of the earth demonstrates its pandemicity. The following are the principal preventable diseases, *viz.* : small-pox, chicken-pox, scarlet fever, measles, rötheln or German measles, typhus, enteric, relapsing and yellow fevers, cholera, influenza, whooping-cough, diphtheria, erysipelas, puerperal fever, pneumonia, and mumps ; and, with a limited infectivity, tuberculosis. These may be called the infective type. Glanders, anthrax (known as wool-sorters' disease and malignant pustule in man), foot and mouth disease, venereal diseases, Egyptian and other forms of ophthalmia, leprosy, and rabies may be taken as instances of the contagious type. There are other diseases which may be deemed preventable, but which are due either to mal-nutrition or local climatic conditions, such as rickets, scurvy, malaria, gout, and rheumatism.

Let us now consider the causal factors of infective and contagious diseases. From time to time these

have given rise to a large amount of speculation, and various theories have been propounded to account for the phenomena which result from their malign action. The three principal theories are those with which the names of Bastian, Béchamp, and Pasteur are associated, and in that order they demonstrate the evolutionary stages towards truth. Bastian's view was that, when fermentation occurred in any liquid contained in a vessel from which air was excluded, the fermentative action was due to the chemical condition of the substances in the vessel, and not to anything that was introduced from without. The classical experiments of Tyndall and Pasteur, however, entirely demolished this idea. They conclusively proved that if an organic liquid was rendered sterile by boiling, and the vessel sealed against the entrance of air, the liquid would keep "sweet" for an indefinite time, thereby showing that the cause of the fermentative change was not in the sterilised fluid, but in something that came from the air, *viz.*, living micro-organisms. Béchamp thought that diseases of the fermentative type, *i.e.*, specific infective diseases, were the result of an organised and solid blastema (as he called it), microscopic in size, to which he gave the name microzyme (Gr., *mikros*, small; *zyme*, yeast); that these microzymes in the course of their development within the body generated a ferment which he called zymase, and that the two together formed protoplasm. He did not believe that infective diseases were caused by micro-parasites introduced into the body from without, but by the microzymes themselves, which, acting abnormally, produced a vitiated ferment, and became transformed into microbes. He further thought

that these microbes should not be looked upon as foreign bodies, but as entities existing normally in the body having abnormal action.

The doctrine of Pasteur and Tyndall, which came to be called the microbic theory, is, that the specific causes of these diseases are living micro-organisms, which, when introduced into the body, cause a series of phenomena to develop, the most prominent of which, due to the growth and multiplication of these organisms in the tissues or blood of the affected person, is fever. These organisms are, therefore, parasites, in respect that they live and thrive and multiply solely at the expense of their host.

Based upon these facts, Koch formulated the following test rules, whereby an infective disease should be so designated, *viz.:* (1) a microbe must be found in the blood or tissues of the person or animal that is suffering, or has died, from the disease; (2) this microbe, taken from the body, must be artificially cultivated, in a suitable culture medium, out of the body, in a series of generations, with no possibility of any other microbe being introduced during the process; (3) the microbe, from one of these cultures, on being inoculated into the body of a healthy animal, ought to reproduce the same phenomena of disease, as those exhibited in the animal or person from whom it was taken; and (4) the microbe must be proved to have multiplied in the body of the animal inoculated.

So far as our knowledge goes at present microbes breed true; that is to say, one does not become transformed into another form which has a totally different action. Inasmuch as after sowing turnip seed we can

calculate only on a crop of turnips, and not carrots, so does the microbe of tubercle, or cholera, or leprosy, cause tubercular disease, or cholera, or leprosy, and is not metamorphosed to cause pneumonia, or enteric fever, or small-pox.

CHAPTER XXXII.

MICROBES—THEIR PLACE, POWER AND EFFECTS—FORMS OF MICROBES—THEIR NATURAL HISTORY—MODE OF PROPAGATION—NATURE OF INFECTIVE MATERIAL—CONTAGIUM—INFECTIVE MICROBES—THEIR INTIMATE ACTION ON THE HUMAN BODY.

THE microscopic parasites which cause diseases of the infective and contagious type have been the victims of a shifting nomenclature. They have been called *microzoaria* (Gr., *mikros*, small; *zoa*, animals) by De Blainville; *microphyta* (Gr., *mikros*, small; *phyton*, a plant); *microzyma*, by Béchamp; *protista* (Gr., *protistos*, the very first), by Haeckel, from which *protophyta* and *protozoa* are derivatives; and since 1878, *microbes* (Gr., *mikros*, small; *bios*, life), by Sédillot; *bacteria* (Gr., *baktron*, a stick), by Cornil and Babés; *schizomycetes* (Gr., *schizo*, to cleave; *mykēs*, a fungus), by Wunsche; *micro-organisms*; and *germs*. The name microbe has this advantage, that it does not commit the user to any theory regarding its genesis, or whether it belongs to the animal or vegetable kingdom. This name will be, therefore, adhered to by us.

Microbes are found everywhere in nature, in air, earth, water, food, and within and without our bodies. They operate in curious ways and in diverse places, conservatively and destructively, and are both the

friend and foe of man. They rid the earth of dead and decaying matter which they themselves have brought into this condition; they produce profound chemical changes during these operations; in their grosser forms they produce alcoholic and acetous fermentations, they make our sweet milk turn sour, our butter to become rancid, our bread to become mouldy; they produce food for the growth and sustenance of plants, and they cause various plant diseases; and they are the prime causes of all the so-called zymotic or infective and contagious diseases of man and the lower animals. Some knowledge of them is, therefore, of the greatest importance.

They are beyond the ken of ordinary vision; indeed, to study them aright, it is necessary to call to our aid the highest powers of the microscope. They require to be magnified from 800 to 1500 times before we can understand how they grow, and what they are like. A fair average size of microbe measures 1-200,000th part of an inch, and it has been calculated that 400 millions of them could be comfortably accommodated side by side on one square inch of surface. It is only by using the most delicate scientific measuring apparatus that they can be measured.

They are extremely fastidious regarding the kind of nutriment upon which they will grow and thrive. One will live healthily on one form of food which would starve another. Some demand albuminous material, others can only thrive when this substance is excluded. So, also, with other conditions. One, for instance, grows best at a low temperature, another, when the temperature is higher. Some can only grow where air

is abundant (the *ærobic* kinds), others will only grow when air is excluded (the *anærobic* kinds). Their detection in the body or elsewhere is rendered easier by their susceptibility to dyeing or staining by aniline dyes; and even in this respect they differ, since one is susceptible to one colour of dye, and another to a different. From the foregoing facts, therefore, it will be apparent that their investigation demands laborious and painstaking research.

The forms of microbes also vary, upon which fact working classifications have been based. Such a classification is as follows, *viz.:* (1) The dot-like form, called *micrococcus* (Gr., *mikros*, small; *kokkos*, a cell or berry). They may appear as single dots (*cocci*), as double dots (*diplococci*), as four dots, like a wool-pack tied cross-ways with string, or as beads strung on a string (*streptococci*). (2) The rod-like form, called *bacillus* (Gr., *baculum*, a stick or rod). Some of them, however, show sufficient departure from the rod-like form to entitle them to separate names; thus the bacillus of glanders is called *b. mallei*, from *malleus*, a hammer, being hammer-shaped; and that of cholera the *bacillus comma*, from its likenes to that mark of punctuation. (3) The spiral, or corkscrew form, called *spirillum*. To the first form belong the microbes of fowl cholera, swine fever, measles, scarlet fever, small-pox, cow-pox, foot and mouth disease, pneumonia, erysipelas, puerperal fever and others. To the second, those of anthrax, tubercle, glanders, enteric fever, cholera, diphtheria, tetanus or lock-jaw, leprosy and others. And to the third, that of relapsing fever.

MODE OF PROPAGATION.

They propagate by throwing off seeds, or spores. In the dot-like form, the original cell simply divides, called *fission*. In the other forms, spores form in the interior of the mature microbe, and, roughly speaking, are shed as peas from a pod. The spores are even less in size than the parent microbes, but are more resistant to means employed for destroying them. For example, while the microbe is usually destroyed in boiling water, the spores may survive unless the boiling process be kept up for a time. What, therefore, used to be called the microbe theory is now substantiated into a potential fact which must be reckoned with at many points.

INFECTIVE MATERIAL.

It is by infective material that diseases are spread. It has been characterised by different names. From early ages, it was known that there existed a something by which disease was conveyed from one person or place to another. To this, various names have been given. It has been called *effluvium* (something which flowed forth), *miasma* (something which defiles), *influence* (as in influenza), *virus* (poison), *fomites* (fuel or touchwood), *infection* (Lat., *inficio*, to corrupt), and *contagium* (Lat., *con*, with; *tango*, I touch). These latter terms are used indiscriminately, and often synonymously. This is confusing, and wrong. Nomenclature in this requires to be made definite. Infective material, however, is essentially particulate in character, and may be borne by the air, or carried upon clothing or other media. So

long as they are in contact with moisture, microbes are held in retention and cannot be liberated until the dampness is dispelled. Aerial diffusion is, therefore, only possible in the case of dried microbes or spores. Being particulate, infective matter cannot penetrate any interposing barrier, even of paper, and much less through walls and doors.

The length of time after infective material has left the body of an infected person during which it is capable of doing mischief is largely determined by its environment. Abundance of fresh air and sunlight quickly destroys it, absence of these tends to keep it active; hence microbes are most plentiful in the dust of darkest corners. Destruction of infective material, therefore, resolves itself into annihilation of microbes and their spores.

The microbes of the different infective diseases have elect seats of operative activity within and upon the body, from which, too, the infective matter is chiefly shed. Upon this basis they may roughly be divided into three classes, *viz.:* (1) those in which the skin is chiefly involved; (2) those in which the upper internal mucous tract (the air passages, etc.) is involved; and (3) those in which the lower mucous tract (intestines, etc.) is implicated. To the first class belong erysipelas, scarlet fever, measles, German measles, small-pox, chicken-pox; to the second, scarlet fever, measles, diphtheria, whooping-cough, mumps, ophthalmia, influenza, pneumonia, and tubercle of lung; and to the third, cholera, enteric fever, yellow fever, and puerperal fever. While the infective material in each infective disease may be found in all the discharges of the patient, it is most abundant at the elect seats of operation. It

is shed from the body not only during the febrile, but also in the post-febrile, stages of the disease.

The evil effects which result from the action of microbes within the body are due to certain poisonous substances which are produced in the course of their growth and multiplication. Microbes live upon the albuminous fluids of the body, and hence the new substances formed—being derivatives of albumen—are called *albumoses*, or because of their poisonous action, *toxines*. It is these toxines which, formed directly in the blood itself, or absorbed into the blood from the tissues, are the cause of the symptoms. For example, the bacillus of diphtheria is located solely in the throat, nasal, or air passages, and it is there that the toxines are formed; which toxines, however, on being absorbed into the blood of the patient, produce the profound physical depression, and, not infrequently, after-paralysis. The toxine of the tetanus microbe causes convulsive contractions of the muscles of the lower jaw. They are, therefore, as lethal in their action as strychnia or morphia.

CHAPTER XXXIII.

INFLUENCE OF CLIMATE, SEASON, LOCALITY, ETC., ON INFECTIVE AND CONTAGIOUS DISEASES—MODES OF CONVECTION OF INFECTIVE MATERIAL.

CLIMATE may be defined as a resultant of the following factors, *viz.*: annual range and extremes of temperature, atmospheric pressure, humidity, prevalent winds, exposure, and certain other local conditions. In respect of diseases generally, it may be said that, in winter and spring, pulmonary ailments are most prevalent, and in summer and autumn those of the abdominal type. In respect, however, of influence of climate on zymotic diseases, we will follow the order of the list of these already given. Small-pox prevails most in winter and spring, least in the other seasons. The temperature has a notable effect on its spread and decline. Below 50° Fahr. the disease tends to spread, above that it tends to decline. Scarlet fever prevails most in the last six months of the year, the maximum being in the December quarter. A temperature of about 60° Fahr. favours the disease, a fall to 50° Fahr. tends at once to arrest it. Measles is a disease chiefly of November, December, January, May, and June months. The most favourable temperature for its spread is between 45° and 55° Fahr., while above 60° Fahr. or below 40° Fahr. it receives a check. In 1880 Babés isolated a micro-organism—a micro-coccus—

which he believed to be the prime cause of the disease. Typhus fever—largely due for its inception to overcrowding and filth—is most prevalent at those seasons when the poor and uncleanly herd most closely together. It is, therefore, more common in the winter months than in summer, although there is a rise in the mortality from it in July. The infective matter, although very virulent within close range of the affected person, quickly succumbs before fresh air and sunlight. From the patient a characteristic odour is given off, which is apt to adhere to clothing. The micro-organism of typhus has not yet been isolated. There is no disease of the infective type which has receded before the march of sanitary measures more than typhus; whereas, formerly, victims could be counted by the thousand, they do not now number beyond the tens. Enteric fever is most prevalent in the autumn months. It would appear as if the climatic conditions were then most favourable for the development of the Gaffky-Eberth bacillus. It is more a disease of rural than urban communities, and epidemics in the latter are usually imported from the former. October is the month of its maximum prevalence. The bacillus of the disease is usually conveyed by infected milk or water, hence the necessity for close supervision of milk and water supplies. The infective matter is thrown off from the body of the patient chiefly in the stools, hence great care should be exercised in their disinfection. Yellow fever is confined to climates very different from that of these islands. Its range of distribution over the earth's surface is limited to the West Coast of Africa, the West Indies and Gulf of Mexico, some parts of South America, and

to limited tracts of the Atlantic and Pacific sea-boards of North America. Within these limits it is usually endemic. Strangers are more liable to be seized than natives, since the latter have become acclimatised. Immunity is only established after long residence, and even then is imperfect at best. Second attacks, however, are rare. A temperature below 20° Cent. (68° Fahr.) prevents the diffusion of the disease. It is not a contagious disease; that is to say, a person who is suffering from it, or the body of a person who has died from it, will not convey the disease to others. It is communicable, however, all the same, by infected houses, ships, and localities. It follows sea trade routes. The micro-organism has not yet been isolated. Relapsing fever—sometimes also called bilious typhoid—is a disease which, of late years, has not been prevalent in this country. Its last visit was about twenty-five years ago. It has a remarkable coincidence, both as to time and place, with typhus, and seems, like it, to be contingent upon privation and overcrowding. Its prime cause—the *spirillum Obermeierii*—is named after Obermeyer, who discovered it. It cannot be successfully inoculated in the lower animals, except in the anthropoid apes. It is both contagious and infectious. In some epidemics laundry-women who washed the clothing of those affected were seized. Cholera is, in this and most other countries, essentially an epidemic disease, although in certain countries it is endemic. It produces a high mortality. This country has sustained four several sieges from it, *viz.*, in 1831, 1848, 1853, and 1866, with a few isolated cases in 1894-5. The freedom of this country during the last twenty to thirty years must be

mainly attributed to better water supplies and improved sanitation. It is essentially a water-borne disease. The intestinal discharges contain almost solely the infective matter. Stools, therefore, must be thoroughly disinfected, either by being mixed with sawdust and burned, or by chemical agents. The Finkler-Prior microbe and the "*comma*" bacillus of Koch have each, in turn, been blamed as the prime cause. Careful and prolonged research by various observers in different countries has established beyond reasonable doubt that the latter is the source of the mischief. Influenza has comparatively recently ravaged the countries of the world. It would appear to be uninfluenced by meteorological conditions, and climate to have as little effect as weather or seasons. It spreads with as much facility in Iceland as at the Equator, and knows no boundary by zones. It is often coincident with a disease called "pink-eye" in horses, which veterinarians believe to be influenza of horses. It would seem as if there was, at times, a causal relationship between these diseases in animals and man. It is both contagious and infectious. A microbe, said to be peculiar to the disease, has been isolated, but future research is necessary to verify or disprove this claim. Whooping-cough is commonly a disease of tender years, although by no means unknown to attack those of maturer years. Its mortality is highest among children; under one year, it amounts to about 60 per cent. of those attacked. It and measles kill more children than all the other zymotic diseases put together, and, not uncommonly, one is the sequel of the other. It is both contagious and infectious. In one isolated island in the West of Scotland, for

twenty years before 1892, the disease was unknown. In that year, however, it was conveyed thither, and out of a total population of 380 persons, 114 were attacked, at all ages up to twenty. An interesting fact, as bearing upon the contagious character of a common cold, has been frequently observed among the inhabitants of the remote island of St. Kilda, which is only approachable once or twice a year. Whenever a visit is paid by a ship, a large number of the islanders are seized with what they call "the strangers' cold". The micro-organism of whooping-cough has not yet been isolated. The mortality is highest in the first three and a half months of the year, and lowest in the summer months. This is doubtless due to the pulmonary complications which are more likely to arise from the inclemency of the winter months.

CHAPTER XXXIV.

INFLUENCE OF CLIMATE, ETC., ON INFECTIVE AND CONTAGIOUS DISEASES (*continued*).

DIPHTHERIA is a microbic disease which chiefly attacks the surfaces of the throat and air passages, although it may also appear on abraded surfaces on other parts of the body. Its connection with a microbe was long suspected before the specific organism was discovered and isolated. Laycock, so far back as 1858, first made the suggestion. A committee, appointed by the Royal Medical and Chirurgical Society of London to inquire into the nature and cause of membranous croup and diphtheria, reported in 1879 that while certain micro-organisms were found in the false membrane, they did not regard them as the causative agents. Oertel, in Germany, next found a microbe of the *coccus* form, which he believed to be the prime cause. Klebs, in 1873, discovered a bacillus in the throat of affected patients, but he failed to isolate it. Friedrich Löffler next investigated the cause, found the bacillus described by Klebs, and succeeded in isolating and cultivating it outside the body. He also proved the presence of the organism described by Oertel, and established that it was not the prime factor. The bacillus of this disease, therefore, came to be called the *Klebs-Löffler* bacillus. Koch did much to substantiate Löffler's conclusions.

It principally attacks those of tender years, although those also of riper years. It attacks the female more than the male sex, and the death-rate of the former is higher than that of the latter. It prevails more in rural than in urban districts, although in the latter it would appear to be increasing, whether due to increased facilities for inter-communication or from drain causes, or both, has not yet been definitely determined. It attacks the lower animals also, notably cats, and there are reasons for believing that it is associated with certain ulcerated conditions of the udder of the cow; hence it may be propagated by milk.

The toxine which the bacilli produce during their growth in the air passages is absorbed into the circulation of the patient, and gives rise to serious symptoms, such as profound physical depression, and paralysis; indeed, this latter effect is sometimes very marked, even where the throat mischief has been but slight. Localities, and even single houses, sometimes attain unenviable notoriety as being causative of the disease.

ERYSIPELAS, the microbe of which has been isolated as a streptococcus, is a disease which differs from the type of zymotics in that one attack does not confer immunity against a second; indeed, it would appear as if a person once attacked is rather the more predisposed to subsequent attacks. The same microbe has to do with the genesis of puerperal fever. The incidence of erysipelas is upon the skin of exposed portions of the body, and the organism gains an entrance by means of an abraded surface, sometimes very trifling in size. Popularly it is called *the rose*, from the inflamed condition of the skin. It attacks, by preference, the male sex, probably

owing to the fact that males are more exposed to causes producing skin abrasions. It is most fatal in the winter months. It has practically disappeared from hospital practice before antiseptic and aseptic precautions. The infective matter is chiefly found in the affected skin.

Puerperal Fever (Lat., *puer*, a boy; *pario*, to bear) is a communicable disease associated with lying-in women. The term embraces a variety of conditions, having one feature in common, *viz.*, septic poisoning. It is caused by the absorption of the above microbe, or of one of an allied type. Its infective character is most marked, and the infective matter clings tenaciously to the clothing and person of attendants, hence the most scrupulous care and thoroughness must characterise the disinfection of everything and every person associated with the case. It may arise from sewer air, which carries the specific micro-organisms, hence the sanitary equipment of the lying-in room must be carefully supervised. Careful aseptic toilet of the patient, absolute cleanliness of hands and instruments, and attention to the ordinary rules of sanitation will do much to prevent its inception and check its progress.

Pneumonia, in one of its forms, must be classed among the zymotic diseases. Friedlander and Talamon, in 1882, discovered in "croupous" pneumonia a certain micro-organism, and Gamaleia has proved that this "pneumococcus," called the *streptococcus lanceolatus*, must be reckoned as the prime cause. An epidemic of this disease prevailed in Middlesborough in the first half of 1888, of which 369 persons died. Klein, who investigated the cause of this epidemic, associated it with a bacillus, called the *b. pneumoniæ*. In several

particulars, epidemic pneumonia is identical with the pleuro-pneumonia of cattle.

Of other diseases of the microbic type, such as rabies, tetanus, leprosy, and malaria, much might be said. The two first are only conveyed by direct inoculation—rabies from the bite of a rabid animal, tetanus from infected earth, or other form of "dirt". They are not communicable as scarlet fever or measles is. Leprosy—due to a specific microbe—is communicable from one person to another by contagion. It is endemic in certain countries, as Norway, China, Palestine, etc. It chiefly invades the skin, in the first instance. Attempts to cultivate the bacillus out of the body have only recently succeeded. Malaria is due to micro-organisms which are located in the soils of certain districts of certain countries, which have one feature in common, *viz.:* saturation with organic débris. It used to be endemic in the Fen districts of England, as it is to-day in the Campagna near Rome. Malarial fever has different types. Much investigation has been made as to the causes. The bacillus of Klebs and of Tommasi-Crudelli, the corpuscles of Laveran, and the amœbæ of Marchiafava, have all been considered blameworthy. The disease is not communicable from person to person. The cause usually gains entrance into the body by inhalation, and the usual vehicle is the air. It essentially belongs to the soil of the locality, but it may be conveyed from place to place in transported earth. There is no reason to doubt the possibility of its being carried from place to place by clothing or other substances which have been exposed to the infected atmosphere.

GLANDERS is a disease of horses. When it appears in a stud it quickly spreads, and necessitates, by law, the destruction of the affected animals, in order that the plague may be stayed. It is communicable to man by direct contagion, in whom it is ordinarily fatal, as in the case of Dr. Hoffmann, of Vienna, in 1889.

ANTHRAX, or SPLENIC FEVER—so called in the lower animals, or wool-sorters' disease or malignant pustule, its synonym in man—is usually a fatal disease of both. Thanks, however, to the researches of Pasteur, Koch, and others, a protective vaccine has been discovered which has prevented untold suffering to animals and has saved huge sums of money to agricultural economy. Its connection with man was first detected when an investigation was made into a strange disease of wool-sorters at Bradford, and in hair-sorters elsewhere—hence its name; and, again, when certain individuals who deal with the hoofs and hides of animals were attacked by an angry-looking boil, or pustule, which often proved fatal—hence the second name. Their common identity was established by the presence in each of the *bacillus anthracis* in the blood of those attacked. The spores are among the most resistant of means of destruction. All the parts of the body of the infected animal carry the bacillus; hence blood-smeared hides, hair, or hoofs, when dried, convey the disease.

TUBERCULOSIS is a disease common to man and many of the lower animals, and is caused by a specific bacillus, *b. tuberculosis*. To a limited degree it may be considered contagious, and to a lesser degree infectious. In cases where contagion has been proved to be the

cause, two conditions have been found to prevail, *viz.*: unhygienic apartments and propinquity of persons, as husband and wife, sisters, or brothers. It is popularly reckoned to be an hereditary disease, but it is so only in an extremely limited degree. Usually it is not directly transmitted from parent to offspring, but the predisposition is. The bacillus is found abundantly in the expectoration of phthisical persons, and in the milk of tuberculous cows when the udder is attacked by the disease; hence such dried sputa and milk may be sources of infection. A third possible source is the use of imperfectly-cooked flesh of tuberculous animals. Opinion is still much divided on this point. Some opine that the whole carcase of the animal affected even by limited tubercle is dangerous to health, others, that after extirpation of the affected organ, it may be used as food quite safely. The recent report of the Commission on Tuberculosis supports the latter view, as did also the Victorian Commission, while the Congress on Tuberculosis held in Paris sustained the former view. In consequence of this diversity of expert opinion, the action of sanitary authorities has been divided. In Berlin, where dead-meat inspection is practically perfect, a middle course is adopted. By a Ministerial decree of 1892 it was enacted that when the flesh of animals contained general tubercle the whole carcase was to be condemned; where, again, only one organ, or two organs lying contiguous in the same cavity, were affected, the carcase was not to be deemed unfit for human food, but was deemed to be flesh defective in quality. It was then thoroughly cooked, under police supervision, and sold at a reduced price. This procedure, therefore, protects the consumer,

while, at the same time, it restores to the municipal economy what, under the more rigorous view, would have been lost to the food supply. This course is at once reasonable and safe from any point of view.

The propagation of tubercular disease in our infantile population must be largely attributed to tuberculosed milk. Cows confined to sheds in towns or cities are more liable to this disease than those fed in the open. Experience abundantly proves this. Hence the necessity for constant and careful supervision of cows in town cowsheds by the sanitary authorities, as is prevalent in certain cities of Denmark and other countries.

Again, from the desiccated expectoration of phthisical persons, infection is likely to arise by reason that the microbes are then capable of being air-borne, and those susceptible, of being attacked. These become important considerations when it is recollected that over the world one-seventh of the total number of annual deaths is due to the action of this microbe. Of recent years attempts have been made in various countries—limitedly, it is true—to cause disinfection of infected sputa; but many obvious difficulties emerge. In Germany, France, America, and in certain of our own cities, public attention has been called to this danger, and instructions have been printed and publicly distributed, in order to aid in minimising the danger, the main points of which are as follow: (1) That the infective material of the consumptive is located in the sputum; (2) that it is only capable of doing harm when the sputum becomes dry; (3) therefore such sputum should be received on pieces of paper, or old cotton, or linen, and burned, or received into small spittoons and mixed with sawdust before

burning; and (4) when phthisis begins, the patient to be warned not to swallow the expectoration. A consumptive patient should sleep alone in a room occupied by himself solely, and the expectoration should be treated as described. We have no sympathy with the proposal to shut up within the wards of an isolation hospital every one who is the pitiful victim of tuberculous disease, but we advocate strongly the disinfection of the personal and bed clothing, and room, of every person whose death has been registered as due to tubercular phthisis. Such measures, coupled with an increase of open spaces in our cities, closer attention to ventilation of occupied rooms, greater insistence on smoke consumption, and rigorous periodic examination of the milch cows of town sheds, would undoubtedly assist in lowering the spread of this baneful malady.

CHAPTER XXXV.

CHARACTERISTICS OF INFECTIVE MATERIALS OF ZYMOTIC DISEASES—INCUBATION—INVASION—INFECTIVITY—INFECTIOUS DISEASES IN RELATION TO SCHOOLS.

As we have already shown, the infective material of zymotic diseases consists of the microbe, or its spores, or both. Each infectious disease has what is termed its striking distance, *i.e.*, the area from the infected person within which the infective material will operate prejudicially on a predisposed person. But in this respect these diseases vary. For example, one has a short striking distance, another a long, and a third an intermediate. Typhus fever is illustrative of the first class. The zone of infection is confined to the immediate person of the sufferer. Small-pox is an example of the second class. It seems well established that a small-pox hospital situated at too close proximity to populated houses is a menace to the occupants of the latter. If propagation by other means be eliminated, it would appear that the spread of infection in the neighbourhood can only be accounted for by air-borne infection.

The factor which more than all others determines this area of infectivity, is the mode or channel by which the infective substance leaves the body. In typhus it

is eliminated by the mucous discharges, and by the skin, and in a form readily oxidised by the atmosphere. In erysipelas, scarlet fever, measles, and some others, it is thrown off in the exfoliated scurf-skin during convalescence, but in the febrile stage by the mucous discharges from mouth and nasal passages. In diphtheria it does not spread far from the body of the patient, being discharged in the moist mucous throat discharges, and is consequently held in retention. This is still more marked in enteric fever and cholera; hence the non-contagious character of these diseases is well established both in theory and in experience: when, however, these discharges become dry they are in a position to be dangerous. Indeed, it may be concluded as a general principle that where the infective material is eliminated in a dry medium, its infectivity is more pronounced, because being more easily air-borne, than where it is thrown off in a moist or distinctly wet medium; and, in like manner, contagiousness is increased or decreased.

All infective diseases pass through three stages, which have been called, respectively, *incubation*, *invasion*, *infectivity*. These are, however, but arbitrary terms, and by no means indicate sequential conditions, since in certain diseases infectivity is consentaneous with incubation and invasion. The duration of these periods differs in different diseases. Cholera probably has the shortest incubation period, and rabies one of the longest. Infectivity may be said to be existent in any given case from the time the microbe multiplies in the body until it has been expelled.

INCUBATION may be defined as that period which comes

between the growth of the specific microbe in the body and the production of fever, the result of its growth and multiplication within the body. It may be divided into two stages: first, the latent stage, during which the presence of the microbe is not marked; and second, the invasive stage, during which the harmful effects of the micro-organism become apparent. The former has to do with the growth of the microbe itself, the latter with the effects of its growth upon the health of the patient. These, however, are only useful academic terms. Whatever view we take of incubation—in other words, of the "hatching" or "brewing" stage, as it has been called—experience shows that its duration varies in different diseases. Some have short, some long, and others intermediate incubation periods.

SHORT INCUBATION PERIODS (one to six days).

Anthrax (in man)	1 to 1½ days
Cholera	1 to 3 ,,
Diphtheria	2 to 5 ,,
Erysipelas	1 to 4 ,,
Glanders (in man)	1 to 4 ,,
Influenza	1 to 6 ,,
Foot and mouth disease	3 to 5 ,,
Puerperal fever	3 to 5 ,,
Scarlet fever	2 to 4 ,,
Relapsing fever	about 5 ,,

LONG INCUBATION PERIODS (seven to twenty-one days).

Whooping-cough	7 to 14 days
Typhus fever	7 to 14 ,,

Small-pox	10 to 15 days
Chicken-pox	10 to 15 ,,
Rabies (in animals)	6 to 24 ,,
Enteric fever	12 to 20 ,,
Measles	8 to 12 ,,
German measles	10 to 14 ,,
Mumps	14 to 21 ,,
Yellow fever	2 to 10 ,,

VARIABLE INCUBATION PERIODS.

Malaria	6 to 20 days, or longer.
Rabies (man)	3 to 70 ,, ,,
Tuberculosis	very variable, usually long.
Tetanus	,, ,, within 10 days.

INVASION is the period between the intervention of the febrile symptoms and the appearance of the rash—where a skin eruption is a usual phenomenon. In scarlet fever, it is from one to two days; in small-pox and typhus, from two to three days; and in measles, from three to five days.

INFECTIVITY is that period during which the infected person discharges from his body infective material which is capable, under suitable conditions, of causing the same disease in others. Its duration is, to some extent, limited by the intensity of the attack, and the time which elapses before the complete restoration to health of the person attacked. In olden times, it was held to last for forty days. From this our word quarantine is derived (Ital., *quarantana*, a space of forty days). This was a workable and fairly safe general

conclusion, as, with but few exceptions, forty days would cover the infective period of the known infectious diseases. But the period of infectivity of any given case should not be regulated so much by a fixed time-limit, as by the time when the body has got rid of the débris which usually carries the infective material. This is especially true of the eruptive infectious diseases, and of diphtheria.

THE INFECTIVE PERIOD MAY BE TAKEN TO LAST IN

Cholera—during the whole period of discharges and for a week thereafter.

Small-pox—during the whole illness till after the last particle of the last crust has fallen from the body, and for ten days thereafter.

Chicken-pox—the same.

Scarlet fever—during the whole illness until last particle of exfoliated skin has been shed—six to eight weeks.

Measles—during period of incubation, through febrile and eruptive stages, till all skin has fallen—twenty-one to twenty-eight days.

German measles—the same.

Whooping-cough—during the whole period of attack, even before "whooping" is noted—six to eight weeks.

Mumps—during whole illness, till ten days after the glands have fallen—not less than twenty-eight days.

Enteric fever—during whole illness, until restoration to health.

Diphtheria—during whole illness, till ten days after the bacillus has disappeared from throat or nasal discharges—four to six weeks.

Erysipelas—from beginning of "rose" appearance of skin, till ten days after peeling of skin has ceased—not less than four weeks.

Before a patient can be safely restored to his friends, his person and clothing must have undergone adequate disinfection, and before the room can be considered habitable, it, and its contents, must also be suitably disinfected.

These questions become of considerable importance in relation to school attendance. How soon, after exposure to an infectious disease, may a child who has not before had the disease, be permitted to return to school? It is to be deplored that definite opinions do not obtain generally on this point, and the legislature has done nothing to produce uniformity. In England, the Medical Officers of Schools Association has helped on a forward movement in this direction by the code which it published some years ago. If carried out, it would at least secure uniformity of action, and even in this respect its object would be praiseworthy. We heartily concur in its provisions, the substance of which answers the above query, and which are as follow:—

After thorough disinfection of the person and clothing of a child, he or she may be permitted to return to school: In diphtheria, after 12 days; measles, 16; German measles, 16; small-pox, 18; chicken-pox, 18; scarlet fever, 14; whooping-cough, 21; and mumps, 24 days, after exposure to infection.

CHAPTER XXXVI.

INFECTIOUS DISEASES—MODES OF SPREAD—MODES OF PREVENTION OF SPREAD—PROPHYLAXIS—NOTIFICATION—ISOLATION—QUARANTINE—DISINFECTION.

STARTING from the universally acknowledged fact that infective diseases are transmissible from person to person, the liability to attack is determined, first, by the person coming within the area of infection, either from the patient or material which has been in contact with him; and second, by his predisposition, susceptibility, or vulnerability. Those infective materials which succumb quickly to fresh air and sunlight, have a limited infectivity; while, on the other hand, those which are most resistant are capable of existing in suitable media outside of the body, as in soil, food, water, etc., and have, therefore, a larger field of infectivity.

The modes by which infection may be transported are as follow: (1) by direct contact with the infective person—hence called contagion; (2) by contact with anything which has been in contact with the infective person, or which proceeds from the apartment in which he is treated; (3) by intercommunication between infected animals and man; (4) transportation by insects, as mosquitoes, gnats, etc.; (5) in water or food; and (6) by the air.

Visitation to the houses of the infected sick, or the

wilful exposure of children to others who are suffering from a mild type of disease (in the erroneous assumption that all children must sooner or later contract the disease, and the sooner it is over, and of a mild type, the better), is chiefly to blame for the spread of infective diseases. Advancing education, however, is altering both practices. There is no guarantee that exposure to a mild type of disease will be followed by an equally mild seizure in the exposed child, for it is a common experience that children of the same family, even, do not contract attacks of equal severity; and this is equally true of children of different parents. Under the second head, the clothing, or books, or toys of the infective person may act as vehicles of infection. While the clothing may be disinfected, it is always safer to consign to the flames such toys and books as are admitted into the sick-room. For the above reason, Public Health Acts make it penal to expose in a public place any child who is suffering from infective disease, or for any person so to expose himself, or to sell or pawn any article of infective clothing. The room occupied by the infective sick is deemed infective until disinfection has been effected, and what applies to the room applies to vehicles used for the transportation of such persons, and to the contents of the room or vehicle. Under the third head are included such diseases, already spoken of, which are communicable from animal to man. The agency of insects in the transportation of this class of diseases is now well established, particularly insects which seek their food in excrementitious matter, or which suck the blood of the person. Under the fifth head are included such infective diseases as are generated

from the partaking of infected water or food. Cholera and enteric fever are typical of this class. It ought to be well known that milk, being an organic fluid, is one of the best natural absorbents of infective or septic matter, and, moreover, offers an excellent nutrient medium to many microbes. Unused milk from a sick room, therefore, ought to be treated as slops, and should not be taken by healthy persons. In impending or prevailing epidemics of cholera or enteric fever, a simple and effective plan to render milk or water harmless is to boil it before use, and to re-aerate the latter as previously described. Considering also the possibility of the transmission of scarlet fever and diphtheria by milk, this precaution becomes of greater importance. Indeed, it is a question whether it should not be done as a routine practice. The chief objection to boiled milk is its taste; this, however, would be minimised by the use of milk sterilisers, in which the milk is rendered sterile at a temperature short of boiling-point. Sterilisation of milk is now carried out on the large scale in Copenhagen, Berlin, and other places on the Continent, before it is sold. The operation is easily carried out by placing the milk in a large bottle, placing the bottle in another vessel containing water, and heating until the temperature of the milk reaches 170° Fahr., at which temperature it ought to be maintained for, at least, fifteen minutes; then stoppering the milk bottle, allow its contents to gradually cool, when it becomes absolutely safe for use. For children, and, indeed, for all persons who use milk largely, this practice has much to commend it. The last mode of conveying infection is by atmospheric currents. A necessary condition to

infective material being air-borne is that it must exist in the dried condition. As we have pointed out, when it is enveloped in a moist or wet medium it cannot become air-borne. The convection of infective material by the air is clearly demonstrated in malaria.

The proximate modes by which infective material enters the body of a susceptible person are (1) *inoculation;* (2) *inhalation;* (3) *absorption;* and (4) *ingestion.*

The means by which the spread of infective diseases is prevented are the following, *viz.:* (1) *prophylaxis* (Gr., *prophylasso*, to prevent); (2) *notification;* (3) *isolation* and *quarantine;* and (4) *disinfection.*

Prophylaxis, or the prevention of disease, is operative generally during health, but especially during the interval between a threatened epidemic and its actual outbreak. Prophylactic measures include (1) general instructions to the people as to means whereby the attack may be avoided; (2) special attention to the working efficiency of sanitary measures; and (3), if deemed advisable, the establishment of a cordon between infected and non-infected countries or districts. The other modes come into operation immediately the first case of the outbreak appears, and they aid in checking or limiting further extension of the disease.

Notification of infectious diseases supplies a powerful instrument to sanitary authorities, first, in enabling them to "locate" the area of the disease, and to ascertain the number of persons affected; and, second, to concert suitable measures of isolation and disinfection to prevent its extension. In some populous places the duty is laid solely upon the parent or guardian, or solely upon the medical attendant, while in the Notification Act of 1889

the duty is laid equally upon both, failure to notify, after knowledge of the fact, carrying with it a penalty.

Isolation and quarantine are means of prevention, which, although they do not mean the same thing, subserve the same purpose. The former means the separation of the infective sick from the healthy, in such circumstances as will prevent, as far as can be, the spread of the disease, and for such periods of time as infectivity prevails; quarantine, the separation from the healthy of persons or things which, although themselves not yet actively infected, may be the passive carriers of infection from an infected area, for such space of time as will demonstrate whether or not the former will become actively infected, and as will enable disinfection to be employed in respect of the latter. The practice of quarantine nowadays does not cover the period of time involved in the literal meaning of the word, and is usually, although not solely, carried out in respect of sea-going traffic. Ships which come from an infected port are required to lie out at sea, or in the port roadway, within a prescribed anchorage, until crew and passengers have been examined by the port sanitary authority, and until—if sickness has occurred during the voyage—the ship and cargo have been disinfected. If, on the other hand, a clean bill of health be presented, and the number of days which have elapsed between the date of sailing from the infected port and the date of arrival at the quarantine station be in excess of the incubation period of the disease, the introduction of which is feared, all that remains to be done is disinfection of ship and cargo. If the number of days be less, and if a sick bill be presented, then the crew and passengers are not allowed on shore till the period of incubation is past.

It has been found desirable in populous places to provide retaining houses, which are practically quarantine stations, wherein to place persons occupying small houses in which infective disease has broken out, and where they may be retained, at municipal expense, until the disinfection of the infected premises has been overtaken, and until the incubation period of that disease is over. This, in our view, is an important item of sanitary equipment, for it deals with that population amongst which insanitary conditions most likely prevail, and which, therefore, demands most supervision.

Isolation is either effected at home or in special hospitals for the reception of the affected sick. The possibility of adequate isolation in the home depends (1) upon adequacy of room space; (2) efficient separation of sick-room from the rest of the occupied rooms; (3) proper nursing by one whose sole duty is in the sick-room; and (4) suitable means of disinfection of clothing during the currency of the illness. Under ordinary circumstances, it is impossible to have adequate isolation in houses of three apartments, or less. It is, then, a safer practice to send the patient to an isolation hospital. Even in larger houses the problem is difficult.

Disinfection, as the word implies, means the operations which are carried out against the infection (so as to destroy it), whether it be of the body of the infected person, his clothing, bed-clothing, or of the room he has occupied, and its contents. Efficient disinfection includes them all. From the imperfect carrying out of such measures in regard to any one of these, disease may be disseminated, and disinfective measures more usually err on the side of inefficiency than of over-carefulness.

CHAPTER XXXVII.

DISINFECTION AND DISINFECTANTS.

DISINFECTION includes those processes the object of which is, in one way or another, to destroy infective matter, and the nature of the process is largely regulated by the material which encloses or bears the infective matter. A disinfectant is an agent which destroys the power of infective matter to do further mischief. This term, unfortunately, has been used with but little discrimination to cover a number of agents of the most valuable and of the most valueless character. This has doubtless arisen from the nebulous conceptions which existed regarding the entity of infective matter. Often associated with disagreeable odours, it was supposed to be rendered inert by the use of deodorants. Since, however, the microbic constitution of infective matter became established, all such views have had to undergo revision, and the disinfecting power of any substance to be determined by its capability of destroying micro-organisms and their spores.

Disinfectants ought to be divided into three classes, *viz.*: *deodorants*, *antiseptics* and *germicides*. A deodorant (Lat., *de*, from; *odor*, an odour) is something which destroys an odour, and is generally used to express that which deprives a bad odour of its disagreeableness. To this class belong camphor, musk, lavender, and like volatile odorous substances, tobacco,

vinegar, eau de cologne, toilet vinegar, turpentine, terebene, permanganate of potash, or soda, as in Condy's Fluid, and others. In it may also be placed certain chemical substances which unite with their deodorant properties, that of acting germicidally or antiseptically, according to their strength. All deodorants act in one of three ways, *viz.:* (1) by submerging a bad odour by their superabundance, or by their more penetrating odour; (2) by oxidising odours, and converting them into new chemical substances; or (3) by changing a chemical substance having a bad odour into another substance which is odourless. Tobacco is a good illustration of the first; camphor, turpentine, and the essential oils, of the second; and copper and iron sulphates (blue and green vitriol), of the third. The two former classes operate best in gaseous media, the last in liquids.

Antiseptics (Gr., *anti*, against; *sepo*, to make putrid) are substances which, added to a putrescible substance, prevent the onset of putrefaction by lowering the virulency of the microbes contained in it. The length of time during which the condition of asepsis will continue depends upon the original strength of the antiseptic used. Usually the strength used is insufficient to do more than merely weaken the vitality of the organisms themselves, while it is does not minimise the potency of their spores. If the strength, however, be sufficient, the substance acts as a germicide, whereas less strong as an antiseptic, and still less strong as a deodorant. To this class belong carbolic acid and its allies, since it is not sufficiently soluble in water to act as a germicide.

Germicides, or germ-killers, destroy the microbes of disease, some of them also destroying the spores. The potency of the germicidal agent depends entirely upon the strength in which it is used, and upon its applicability for this purpose, in the medium in which the microbes are located. To this class belong, of chemical substances, perchloride of mercury (corrosive sublimate), biniodide of mercury, chlorine gas, chloride of lime (so called), bromine vapour, and possibly chloride of zinc (as in Burnett's Fluid). In addition, and when used in sufficient volume for aerial disinfection, may be named sulphurous acid gas, iodine vapour, and in the disinfection of liquid or semi-solid substances, the sulphates of iron, copper, and zinc, cupralum, carbolic acid, sanitas, thymol, menthol, creosote, and the mineral acids, in sufficient strength.

Boric acid, boroglyceride, glacialine, sulphocarbolates of zinc and other metals, the sulphites and hyposulphites, are, at best, mild antiseptics.

Since our objective point in disinfection is the annihilation of microbes and their spores, it is essential that we should be acquainted with the substances which will, and those which will not, so act, since the market has been flooded with so-called disinfectants which often by no means effect what is claimed for them. Indeed, seeing that effective disinfectants are of such public importance, they should be brought under the schedule of the Foods and Drugs Adulteration Acts, so that the public may be protected.

The following substances act efficiently as germicides when used of the named strengths : —

TABLE OF EFFICIENT STRENGTHS OF DISINFECTANTS AS GERMICIDES.

Disinfecting Substance.	Strength and Medium in which to be Used.
Mercuric chloride (corrosive sublimate)	1 in 1000 of water (70 grains per gallon). Solution to be aided by addition of common salt, and coloured with laundry blue. This may be used for disinfection of linen and liquid excreta. In 1 in 4000 for washing woodwork and floors.
Mercuric iodide	1 in 1000 of water for infected linen and stools. 1 in 2000 for hands and liquid excretions. 1 in 4000 for woodwork and floors. Solutions ought to be rendered odorous by addition of small quantity of thymol, menthol, eucalyptol, or wood-naphtha.
Chloride of lime or bleaching powder	4 parts per 100 of water (6 oz. to 1 gallon of water) for solid and liquid excreta. When used for the former, to be permitted to soak for about one hour before vessel is emptied. 1 part per 100 of water is excellent for washing of hands after visitation to sick-room and handling of patient.
Carbolic acid	5 per cent. solution in water (1 in 20). Official strength used in Berlin, 1 in 18. To destroy bacteria, a 10 per cent. solution is needed. Water, however, will not dissolve so much.
Copper sulphate	5 per cent. solution in water. To be used for disinfecting stools. Contact not less than one hour.
Zinc chloride (Burnett's Fluid)	1 in 10 of water (for stools), and as above.
Sulphurous acid gas (compressed in cylinders at three atmospheres)	Exposure for twelve hours to 4 volumes per cent. in a moist medium. 1½ lbs. of sulphur per 1000 cubic feet of air space = 1·75 per cent.
Chlorine gas (in cylinders)	·5 to 1 volume per 100 volumes of air.
Hydrochloric acid vapour	·05 to ·1 volume per 100 volumes of air.
Bromine	1 in 2000 of water for solid excreta. Objectionable to user by reason of irritancy of vapour given off.

The utmost care must be exercised in the use of most of the above disinfectants, as they are all poisonous in the strengths indicated.

CHAPTER XXXVIII.

DISINFECTION AND DISINFECTANTS (*continued*)—HEAT AS A DISINFECTING AGENT.

In addition to chemical germicides, which act either by oxidation, or deoxidation, we have in heat a very valuable disinfector and bactericide, when applied either by dry air, moist air, or water. It is best adapted for the disinfection of personal clothing, bed clothing, and room furnishings, such as carpets, rugs, cushions, etc., which have inadvertently been left in the infected room during the currency of the illness. For clothing which will not be injured, boiling in water for a space of twenty minutes, at least, is one of the best modes of disinfection. This is suitable for cotton and linen fabrics. For woollen fabrics, feathers, hair mattresses, etc., exposure to moist heated air, or steam, is the most suitable. This is usually done in a specially constructed apparatus, which is commonly provided by the local sanitary authority. Dry heated air alone, or even under pressure, has been found by different experimenters in different countries to be ineffectual for this purpose, unless at such a temperature as would be likely to scorch the materials. Consensus of opinion, arrived at by direct experimentation, is now solely in favour of moist heat. In an efficient disinfector, where moist steam is used, the following are essential points, *viz.*: (1) that

the steam under pressure should permeate every pore of the article to be disinfected; (2) that the temperature of the steam should be between 221° and 250° Fahr.; and (3) that the apparatus be so arranged that, alternately, hot dry air and moist steam, within the foregoing range of temperature, be passed into the chamber containing the articles to be disinfected. The machine,

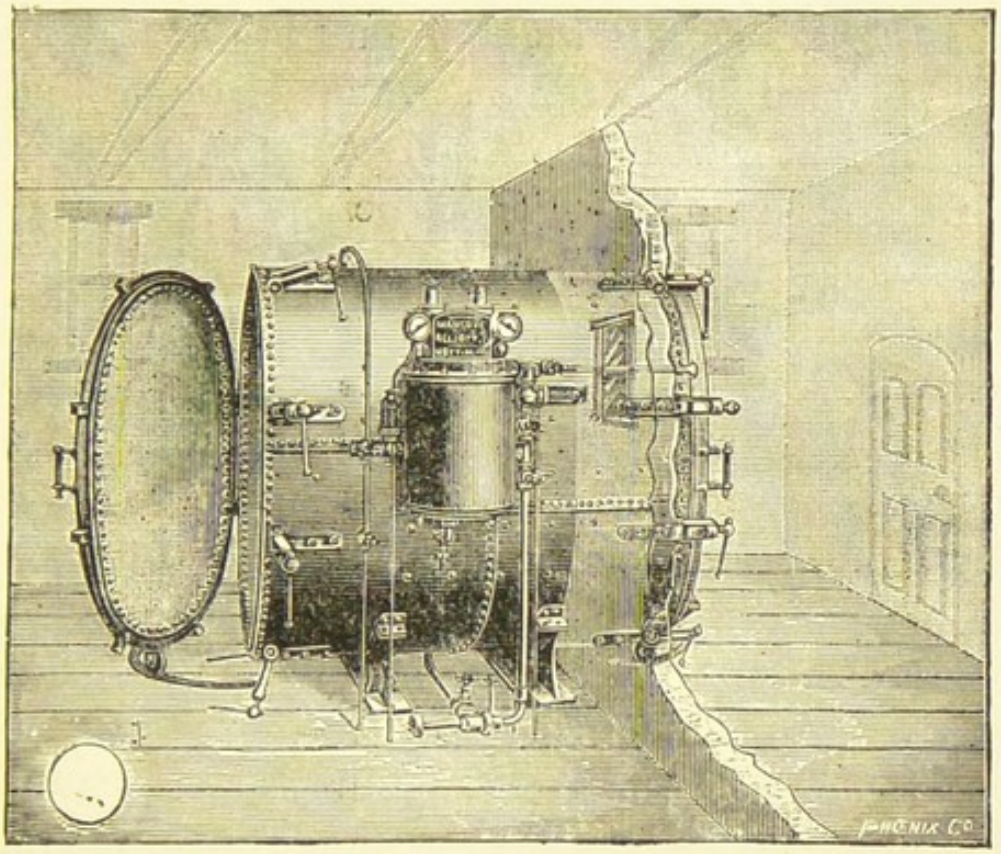


FIG. 61.—Washington-Lyon's Patent. Alliott and Patons' Patent.

or disinfector, constructed on the Washington-Lyon principle by Messrs. Manlove, Alliott & Co., of Nottingham, is one of the best, and a description of the mode of using it will suffice for this class of apparatus, of which there are several kinds with insignificant differences, and many makers. (Fig. 61.) The disinfector, which is oval in shape, and constructed of steel,

consists of an outer and an inner chamber. The former is called the "jacket" of the latter, inasmuch as it envelops the inner chamber. When the apparatus is working it is filled with steam at a pressure of 20 lbs. per square inch, and of a temperature of 267° Fahr. In the inner chamber is a movable cradle or basket, constructed of galvanised iron wire, in which the articles to be disinfected are placed. By means of suitable mechanical arrangements, communication may be established between the outer and inner chamber, both for filling the latter with steam and for emptying it partially of air. The disinfector, then, being in working order, let us follow from beginning to end of the process the mode of disinfecting, say, mattresses, pillows, etc. The inner chamber door is opened, the cradle is pulled out, and the articles are placed in it. It is again pushed back into the chamber, and the steam-tight doors are closed. Steam, under the conditions already mentioned, having been meanwhile circulating in the outer chamber, the air of the inner chamber is partially exhausted by the action of a steam nozzle, the effect being to create a partial vacuum in the inner chamber. At this stage the communication between outer and inner chamber is opened, and the steam rushes into the latter under considerable pressure, and forces itself into the interstices of the mattresses, etc. This part of the process lasts for not less than twenty minutes, the time being extended if the nature of the articles to be disinfected demands it. The communication between the two chambers is now closed, the steam in the inner chamber is now blown out, a partial vacuum is again established, and hot air takes the place of the steam. This hot air takes

up any moisture which may have become condensed on the articles, which hereafter are taken out of the disinfector, the process of disinfection having been completed. Where large quantities of materials require to be disinfected daily, it becomes important that there should be no commingling of the infective with the dis-

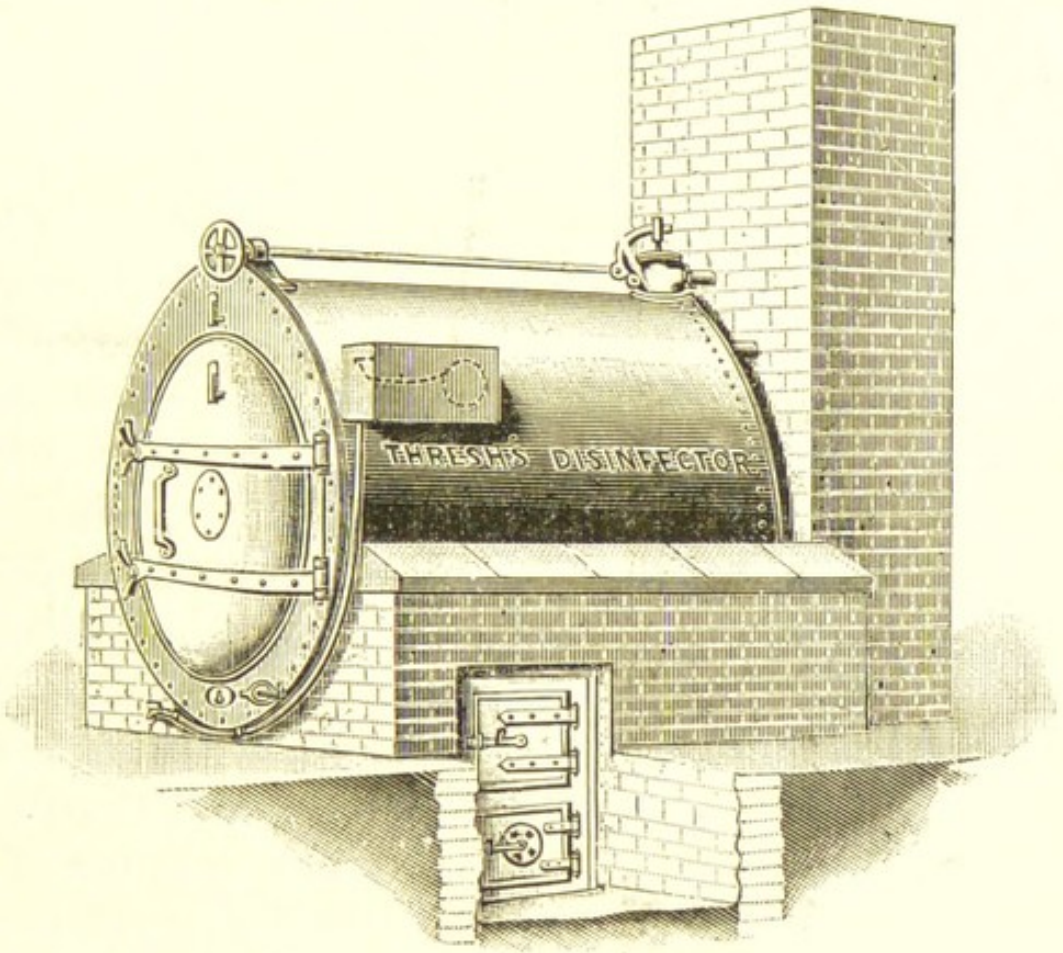


FIG. 162.—Thresh's Disinfector.

infected articles. This is arranged by separating the inlet side of the machine from the outlet side (which are at opposite ends of the machine in this case) by a partitional wall, which is built at right angles to the length of the machine. Into the inlet opening the infective clothing is placed, which, after the process of disinfection is complete, is taken out by the outlet opening on

the other side of the wall. In this way, effectual separation of the infective from the disinfected material is ensured.

Another kind of disinfector, Fig. 62, based upon a different principle, has been recently invented by Dr. Thresh, medical officer of health for Essex, which is worthy of some attention, inasmuch as there are claimed for the machine efficiency, simplicity, and the non-requirement of skilled labour, coupled with safety. The principle upon which its construction is based is that water, containing a saline substance in solution, boils at a higher temperature, although at the same pressure, than pure water. The saline substance used in this machine is calcium chloride, and the machine is so contrived that the calcium salt originally put in may be used over and over again for a considerable time, water being gradually added to it by an automatic feed cistern. The temperature at which this saline solution boils is 225° Fahr., and the steam which is generated is made to circulate in a pipe which passes through this boiling solution. The machine itself, like the one already described, consists of an outer and inner chamber. The outer chamber contains the boiling saline solution and the pipe already mentioned. Into the inner chamber are placed the articles to be disinfected. When the temperature of this inner chamber reaches the temperature of the boiling solution, *viz.*, 225° Fahr., the steam at the same temperature is made to enter, and thus it disinfects the materials. The time allowed for disinfection is practically the same as in the Washington-Lyon machine. When the disinfection is complete the course of the current of steam, by turning a lever,

is now changed from the inner chamber into the flue of the machine, and thus, again, the inner chamber is converted into a dry air chamber. Thereafter the disinfected goods are removed. The ingenuity of the inventor has been shown in the strength of the saline solution used, the boiling-point of which is constant at 225° Fahr. This temperature, as has been pointed out by Dr. Barwise (who has experimented practically with the apparatus) in a paper in *Public Health*, "is not high enough to prevent condensation of the steam on the articles to be disinfected, and is sufficient to subsequently dry them". It is claimed for this machine by Dr. Barwise that it attains (1) uniformity of temperature; (2) rapidity of penetration; (3) maximum temperatures within the articles disinfected; and (4) dryness of articles disinfected. And the *Lancet* Special Sanitary Commissioners report of it that "the machine fulfils the conditions of a really efficient disinfector for all practical purposes" (*Lancet*, 11th January, 1896).

CHAPTER XXXIX.

DISINFECTION—NATURAL DISINFECTANTS—PRACTICAL DISINFECTION OF EXCRETORY PRODUCTS OF PATIENT, OF CLOTHING, AND OF ROOM—GERMAN AND FRENCH MODES OF DISINFECTION.

SOMETHING now remains to be said regarding natural disinfectants, or germicides. It is very probably true that in our anxiety to accomplish the destruction of micro-organisms by artificial means we have somewhat overlooked those natural processes which effect the same end, and in a kindred fashion. Considering the omnipresence of disease-producing micro-organisms, the wonder is, not that these diseases are produced, but that they prevail in so light a manner, speaking comparatively. It is undoubted that this is brought about in large degree by the effects of air and sunlight in destroying such microbes. Of air as a germicidal agent it may at once be said that when fresh and abundant it so dilutes and oxidises infective matter as to reduce the virulency of these organisms, if not, indeed, to destroy them. The presence of ozone in the air materially assists such oxidation processes, but, unfortunately, it is but rarely to be found in the air of populous places. It is well known that micro-organisms are found in fewest numbers out at sea, and, doubtless, this is owing in large part to the existence of ozone. As has been already shown the area of in-

fectivity of certain diseases is limited by the presence of air, and for the reason that the oxygen of the air renders the infective matter inert. This is notably the case in typhus and some other diseases. The anærobic forms of microbes cannot exist alongside of air, while the ærobic forms cannot exist without it. The microbe of tetanus is an example of the former class, that of diphtheria of the latter. Light is a valuable adjuvant to air in microbe destruction. Experiments have proved that exposure to light is fatal to several microbes, notably those of erysipelas, enteric fever, and others; while exposure to sunlight destroys that of tubercle in a few hours, and that of anthrax in a short time. If others be not actually destroyed, their vitality and virulency are at least minimised. These facts teach the necessity for good ventilation and lighting of our homes, and indicate the value of open spaces, good building regulations, and the prevention of smoke-production in our populous places.

The practical application of the principle of disinfection next falls to be considered. Given a patient suffering from an infective disease in a sick-room, the process of disinfection must not only be concurrent with the illness, but it must succeed the vacation of the room by the patient. As a leading, guiding, and safe principle, it may be said that everything that proceeds from the body of such a patient during the currency of the illness must be deemed infective, and be accordingly disinfected.

Let us consider in some detail the discharges from each disease which demand disinfection.

SMALL-POX.—All discharges infective. Nasal and throat discharges to be received on cotton or linen rags,

and burned. Stools, vomited matters and urine, to be disinfected with one pint of 4 per cent. solution of chloride of lime, or a like quantity of 1 to 1000 solution of corrosive sublimate. The virus being concentrated in the skin eruption, the pustules ought to be daily coated with benzoated lard or eucalyptolised vaseline, especially during the "scabbing" stage. Crusts, when shed, to be carefully burned.

CHICKEN-POX.—As in small-pox.

SCARLET FEVER.—In acute stage, throat and nasal discharges to be treated as above. In "peeling" stage, body of patient to be sponged daily with equal parts of sanitas and tepid water, and to be washed twice weekly, at least, with carbolised soap and warm water. Special attention to be paid to toilet of hair, ears, and flexures of limbs.

MEASLES.—In acute stage, throat, nasal, and bronchial discharges to be treated as above. In convalescent stage, skin, as in scarlet fever.

GERMAN MEASLES.—As in ordinary measles.

TYPHUS FEVER.—All discharges infective. To be treated as above, in respect of skin, and other bodily products.

ENTERIC FEVER.—Stools chiefly infective, and must be disinfected with solution of chloride of lime or corrosive sublimate of above strengths. Carbolic acid is not an efficient disinfectant of the bacillus of this disease, unless used very strong.

CHOLERA.—To be dealt with as in enteric fever.

INFLUENZA.—Generally as in measles, especially as to mucous discharges.

WHOOPING-COUGH.—Nasal, throat, and bronchial

discharges chiefly contain infective matter. To be treated as above.

DIPHTHERIA.—Nasal and throat discharges, chiefly infective, ought to be burned.

ERYSIPELAS.—Chiefly in skin; disinfection accomplished usually if iodine treatment be adopted. "Peeled" skin to be burned.

PUERPERAL FEVER.—Specially located in discharges from genital tract; ought to be received on antiseptic wood-wool pads, and burned; local antisepsis and lavements under advice of physician; other discharges disinfected with solution of corrosive sublimate.

TUBERCULAR PHTHISIS.—Sputum to be received on paper or rags, and burned, or into a spittoon containing sawdust, and burned.

In order to properly disinfect solid, semi-solid, or viscous discharges it is necessary either to mix the disinfectant with the discharge mechanically, or allow the disinfectant to soak for at least half an hour, in order that germicidal action may the better operate, before emptying into the slop or water closet, which, after flushing, ought each time to be subsequently disinfected. The quantities and strengths of disinfectants to be used have already been indicated.

When the period of infectivity is safely over, the convalescent patient must be transferred into another room, in order that the apartment he has quitted, and its contents, may undergo disinfection. If care has been exercised during the illness, little risk to the other members of the household is likely to happen. But immediately prior to removal, the patient must be washed all over, and after having been carefully dried,

ought to be wrapped in a fresh warmed blanket, which has been handed into the room just when needed. He should then be received by another person at the door of the room, and conveyed to his new apartment, which previously has been suitably warmed to prevent chills. In scarlet fever, and in diphtheria especially, the patient should continue to use for some time after apparent recovery some antiseptic gargle.

The room just vacated and its contents now demand attention. The clothing which the patient has left behind, that of the nurse, bed clothing and room furnishings, must be disinfected either *in situ* or be removed by the sanitary authority for that purpose. In rural and smaller urban districts, where no provision is made for this by the sanitary authority, the disinfection must be dealt with by the householder. The plan to carry out this is as follows: Articles of clothing, bed clothing, etc., should be steeped in the room for a couple of hours in a solution of 1 in 2000 corrosive sublimate, should then be roughly wrung, and, in a covered vessel, be removed to the wash-house, to there undergo the usual cleansing process, after which they should be hung in the open air, or laid upon the grass for twenty-four hours. Mattresses, pillows, etc., should be freely sponged with the same solution, removed to a place at some distance from the house, and then left exposed to the air, under cover if need be, for several days. All old articles may be burned, and in small-pox ought to be, whether old or new.

The woodwork, floor, and furniture of the room, the walls and ceiling, still remain to be disinfected. The former are usually left until the air of the room is

disinfected. This so-called aerial disinfection is an entire misnomer; indeed, at best, it is but a delusion. If ventilation during the currency of the illness has been attended to, little fear need be entertained of its infectivity. What do require attention, however, are the microbes and their spores, which by this time have become constituent parts of the dust which has settled in the crevices and corners and other points of lodgment in the room. In other countries than ours little or no attention is given to aerial disinfection, while much has been paid to the deposited dust. Hence, two main

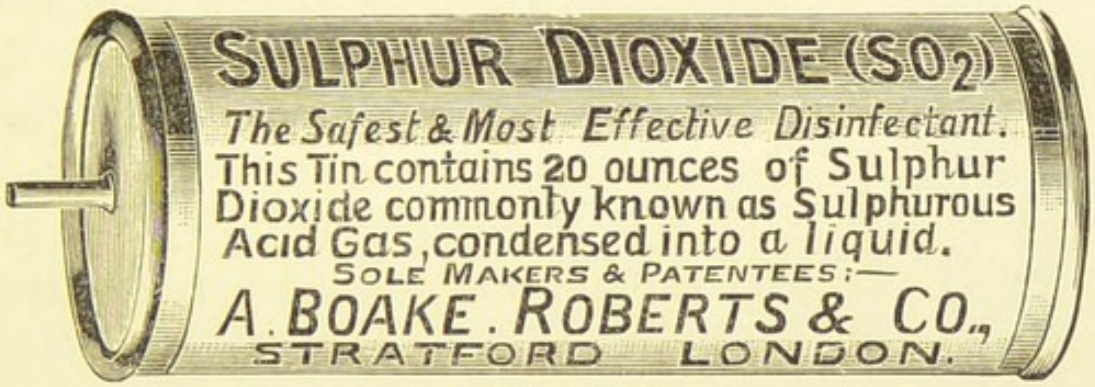


FIG. 63.

plans of room disinfection prevail: one, devoted mainly to aerial disinfection as in our own country; the other, devoted entirely to disinfection of room dust, chiefly in France and Germany. Each plan demands some explanation.

The English Local Government Board recommends that $1\frac{1}{2}$ lbs. of sulphur, mixed with a liquid combustible, as alcohol—some add nitre—should be burned for every 1000 cubic feet of air space in a room (which has been made as air-tight as possible), and the resultant sulphurous acid gas be allowed to operate for 12 to 24 hours. It has, however, been clearly pointed out that

this amount of sulphur only gives in the space named 1·75 per cent. of gas, whereas 4 per cent. is necessary for bactericidal effect. Apart from this, however, the burning of sulphur is by no means an easy matter. This uncertainty of action is easily overcome, if, instead of solid sulphur, cylinders or siphons of compressed liquid sulphurous acid gas are used. Fig. 63 shows such a cylinder, and Fig. 64 a siphon.

The gas is compressed at a pressure of about 45 lbs. per square inch, and when a cylinder is to be used all that is necessary to liberate the gas is to cut the projecting soft lead pipe with a knife.

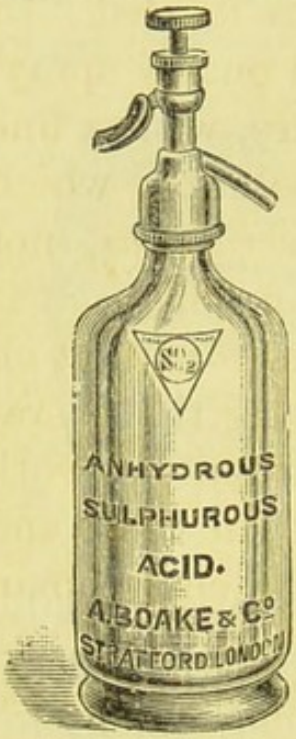


Fig. 64.

Before using sulphurous acid gas, however generated, and in order to render it more efficient in action, the walls and ceiling of the room ought to be moistened with water, otherwise much of its potency is lost.

Instead of this gas chlorine gas is sometimes substituted. It is even more effective than the former, but it acts corrosively on metallic substances, and its fumes are exceedingly pungent and irritating. Doubtless, when it can be put up in the compressed liquid form, its use will be revived because of its greater potency.

After the room has been subjected to the influence of sulphurous acid or chlorine gas for 18 or 24 hours, it may be entered by a person wearing a damp flannel cloth over mouth and nostrils, who should then throw wide open the window, and the damper of the grate.

The room should then be left until the irritating fumes have sufficiently disappeared to enable persons to work therein. Whereupon the floor, woodwork, and furniture ought to be freely washed with 1 in 4000 corrosive sublimate solution, the wall paper stripped, and the ceiling lime-washed, the windows remaining wide open all the while, night and day.

The other main line of treatment is directed against the deposited dust of the room, on the principle that the infective microbes and spores are there located. In Paris, disinfection of the room is carried out by spraying the apartment, including the furniture, with a fine spray of 1 in 1000 corrosive sublimate solution, which is ejected from a machine called a *pulverisateur*, not unlike in appearance to a small fire extinguisher. It is either carried on the back of the operator, or is set on the floor on wheels. The workman, during the operation, wears an overall uniform, which, when the work is done, is taken off, packed in a small tin case, and returned to the disinfecting station. The charwoman does the rest.

In Berlin a dry method of dealing with the deposited dust is first carried out. The material used consists of chunks of ordinary German bread, forty-eight hours old; and the workman, using the crust side of the bread as a handle, rubs systematically the walls and ceiling of the room. The dust becomes detached from the rubbed surface on to the bread, which is then burned. The walls are next sprayed with a $2\frac{1}{2}$-5 per cent. solution of carbolic acid, the floor, woodwork, and furniture with the same solution, and thus room disinfection is completed.

These appear to us to be more rational and more effective modes of disinfection than is ours of aerial disinfection. The cost may be somewhat greater, but that is not worthy consideration when efficiency is our object. The chief objection to the free use of corrosive sublimate solution is its possible harmful effect on those who work with it, and on the inmates of the room after rehabitation. Experience in Paris has, however, shown that if the workmen are instructed as to its nature and effects, such risks are reduced to a minimum; and no harmful effects on the inmates have been recorded after reoccupation of a room so treated.

CHAPTER XL.

SANITARY LAW RELATING TO INFECTIVE DISEASES.

IGNORANCE of the law is no plea for contravention of it, therefore every householder and every nurse should be acquainted with at least its general principles. A district nurse may have many opportunities of combating the ignorance which prevails in this respect, and will thus become of great assistance to the sanitary administration. Most of the sanitary legislation that presently is on the Statute Book has been passed by Parliament during the last fifty years, and it is to be deplored that such enactments do not all equally prevail in the constituent parts of Britain and Ireland. At the same time, the same general principles of sanitary law obtain all over the Kingdom. The main provisions of all these Acts are intended to conserve the public health by the removal of anything which may imperil it, and to prevent the origin and the spread of infective diseases. Our attention will be especially directed to the latter. In none of the Public Health Acts is there any definition of what constitutes an infectious disease, and up till 1889, when the Notification of Infectious Diseases Act was passed, there was no attempt even to give a list of these diseases. In that Act—a permissive Act—the diseases scheduled were small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever or scarlatina,

and typhus, typhoid, enteric, relapsing, continued, and puerperal fevers. It will be observed that some diseases, as measles, whooping-cough, chicken-pox, influenza, and mumps, are omitted from the list, but a Local Authority may, by provision of the Act, after due resolution and publication of its intention, add these or others to the scheduled list; and it must be remembered that the provisions of the Public Health Acts equally apply to these as to the former list. The provisions of Public Health Acts deal (1) with the infective person; (2) with the infective place; and (3) with infective things. They may, therefore, be considered in this order.

I. In Respect of the Infective Person.—It is forbidden, under a penalty, (1) for any person suffering from an infectious disease to wilfully expose himself in any public place or conveyance, without taking proper precautions against spreading the disease; (2) to enter a public conveyance without giving the owner, or person in charge, due notice, when it shall be within the option of the owner, etc., to refuse, but who, if he conveys such person, is entitled to be indemnified by said person against loss incurred thereby, and for expenses of disinfection; (3) to expose any person who suffers from an infectious disease in any public place, etc. All these provisions are most necessary, and every sanitary authority ought to make examples of all transgressors. On one occasion we found a person who was convalescent from small-pox, but whose body was still marked with "crusts," promoting his convalescence by journeying to and from the city and one of the suburbs of Glasgow in an omnibus. It is needless to say that he received smart punishment.

Removal of Infective Persons.—Where an isolation hospital has been provided, any person suffering from such a disease who is without proper lodging or accommodation, or who is lodged in a room occupied by others besides those in attendance, or who is on board any ship or vessel within three miles of the coast, may, on a warrant of a magistrate, be removed to such hospital. In like manner a person in a common lodging-house may be so removed. Again, persons who have occupied or who occupy the same room as an infective person, may be removed to other suitable accommodation provided for them by the sanitary authority. These provisions are to be interpreted by the existence or non-existence of means of efficient isolation and facilities for disinfection. It is forbidden for any one, who himself is suffering from an infectious disease, or who himself directly, or by others indirectly, has come in contact with an infective person, to be concerned in the production, distribution or storage of milk; and in London an infected person is forbidden to follow or take part in any occupation which is connected with any food-production, the products of which are likely to spread the disease. All of the foregoing provisions apply to the living infective person only. What of the dead? No precautionary or prohibitory provisions exist in any of the Public Health Acts regarding the removal, in a public conveyance, for burial of an infective dead body. In England and Ireland, however, the Infectious Diseases (Prevention) Act requires that due notice shall be given to the owner or driver, and the person giving notice shall be bound to pay the costs of disinfection of the vehicle used. Where a public mortu-

ary has been provided, and where any dead body in any room is certified to be inimical to the health of the occupants of the room, such body, on a warrant, may be removed to the mortuary. Again, in view of the Irish custom of "waking" the dead, and of the danger which may arise therefrom, such a practice is prohibited in certain local Acts (as Glasgow), when the death has resulted from an infectious disease.

II. In Respect of the Infective Place.—As we have already seen, public conveyances used for the carrying of the infective sick must undergo disinfection. In like manner, the room occupied during an infective illness must also be disinfected—(1) either at the expense of the householder, or (2) from the public rates. While it is common for the latter mode to be carried out, it ought to be remembered that the duty, according to the Acts, devolves upon the householder. At the same time, no sanitary authority which does not provide the necessary facilities and materials can ever expect disinfection by private persons to be thorough. Again, any person who knowingly lets any house, room, or part of a house or shop which has not been properly disinfected after occupation by an infective person, or who withholds such information on being asked, or who makes any false statement regarding the same, shall be liable to heavy penalties.

III. In Respect of Infective Things.—Any one who, without previous disinfection, knowingly gives, lends, sells, transmits, or exposes any bedding, clothing, rags, or *other things* which have been exposed to infection from infectious disorders, shall be liable to a penalty. This does not apply to articles transmitted

with proper precautions for purposes of disinfection. The following may be taken as illustrative cases, *viz.*: (1) trafficking in anything from an infected room; (2) carrying infected articles through the public streets, or sending such in a public conveyance; (3) washing infected clothing in a wash-house which is common to other houses, or sending such clothing to a public laundry; (4) making fabrics for warehouses or for private persons in an infected house, and carrying the same to the warehouse or private person when made; (5) pawning infective articles; (6) selling food of any kind in a shop attached to a dwelling-house in which infective disease is present; and (7) transmitting infected bedding or furniture to upholsterers or public cleaning establishments.

The term "other things" would include infected rubbish, such as excreta, poultices, wall-paper, or vomited matters cast into a receptacle in a public place without previous disinfection. But to make this perfectly clear the Infectious Diseases (Prevention) Act contains a special provision to the above effect.

In respect of school attendance, the Glasgow Sanitary Acts make it an offence for a parent or person in charge of any child who is suffering from infective disease, or who resides in a house where such disease exists, or has existed within six months, to knowingly or negligently permit such child to attend school without producing a medical certificate which states that the child is free from disease and infection, and that the house has been properly disinfected; and it is made equally penal for a teacher or person in charge of any school to knowingly permit such a child to attend school.

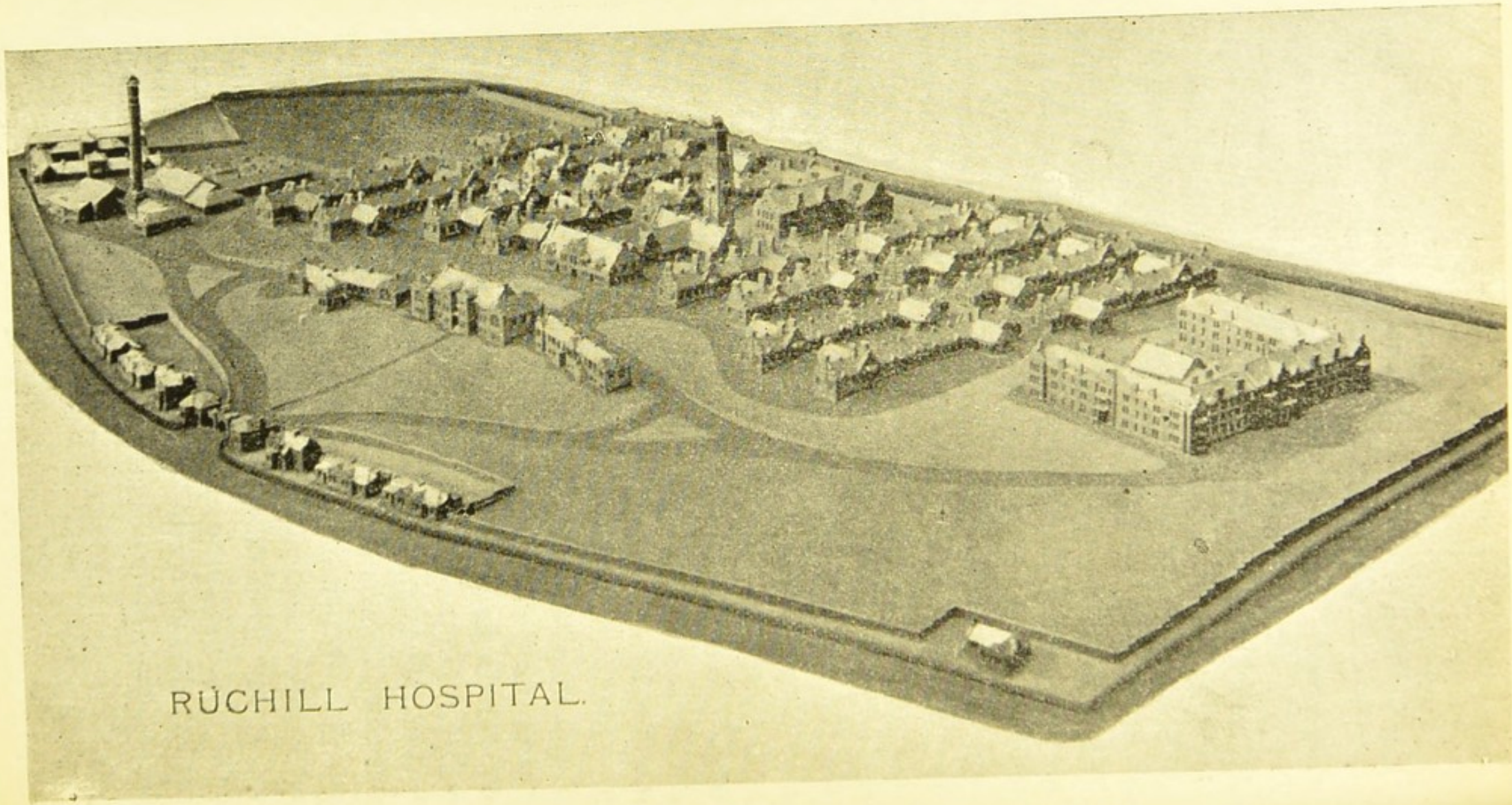


Fig. 65.

CHAPTER XLI.

ISOLATION HOSPITALS.

GENERAL CONSIDERATIONS.

Local Authorities in Scotland are not bound to establish isolation hospitals. The Acts simply declare that they "may provide" such hospitals or temporary places for the reception of the sick. In England and Wales, however, the County Council can compel their erection when necessary under the Isolation Hospitals Act, 1893. Experience has amply demonstrated that without these hospitals no Local Authority can adequately cope with the repression of infective diseases or fulfil modern demands. The points to be considered in the establishment of an isolation hospital, when its erection has been determined, are, briefly, as follows, *viz.:* (1) size; (2) situation and site; and (3) incidence of accommodation, both as respects sex and disease.

SIZE.

Generally speaking, they should be of such a size as will provide *one* bed per 1000 of population, but this ratio may be increased or diminished in respect of the capability of providing efficient home-isolation. Glasgow, for example, for a population of nearly 650,000, meanwhile provides 740 beds, which, by the

end of 1898, will be raised to 950 beds. The ratio of beds per population is more difficult to determine in rural than in urban districts, and especially in the former, where the inhabitants are widely scattered. The number of hospitals and their localities must be largely determined by the distances to be traversed by removed patients. Hitherto, this has been met by the erection, during panic, of temporary wooden structures, most of which are unsuitable, and which, moreover, never can be of the utility of permanent buildings.

SITUATION AND SITE.

Obviously, to serve the needs of a populous community, the hospital must be situated within easy distance of the centre of population to minimise the risks of removal and yet be sufficiently removed to overcome objections, such as nearness to inhabited houses, and the risks of infection thereto. The outskirts of a city, therefore, indicate generally the situation to be chosen, as likely to afford a more open site, and consequently, unconfined air-space, and more "elbow-room". The propinquity of an isolation hospital to dwelling-houses has been proved to be prejudicial to the inhabitants of the latter. This has been shown in respect of most of the infective diseases, but especially of small-pox. Dr. Thorne Thorne gives an example of the former in the case of the Children's Hospital at Pendlebury—an excellent modern hospital—which has its main hospital devoted to the treatment of the ordinary diseases of children, and a separate pavilion for infective diseases. He showed that children in the ordinary wards con-

tracted infective diseases, apparently from the infective pavilion. This has been also shown in respect of small-pox hospitals, and, notwithstanding much that has been written to the contrary, we are of opinion that the truth of this cannot be traversed. To avoid this risk, the Local Government Boards of England and Scotland demand that no building which is a constituent part of an isolation hospital shall be nearer than *forty* feet to the boundary wall. In respect of small-pox, a larger zone is necessary, *viz.:* from 120 to 150 feet.

The site chosen, while to some extent dependent upon local circumstances, ought to combine, as much as possible, the following conditions, *viz.:* (1) an open subsoil; (2) a gentle sloping ground surface; and (3) an exposure protected from the east and north, and open to the south and west. These conditions, coupled with abundance of good water and pure air, will go far to contribute to the healthiness of the hospital. The *area* of the site ought to bear a direct relation to the proposed number of beds. The Local Government of England suggests as a typical relation, eight beds per acre. Hitherto, this has seldom been realised. The maximum, however, ought not to exceed twenty beds per acre. Taking a few well-known hospitals at random, we find that the Glasgow Belvidere has thirteen per acre; Heathcote, Leamington, eleven; Ealing, twelve; Sheffield, forty-eight; Dunfermline Combination, fourteen and a half; Willesden, six; and Glasgow Ruchill, twelve.

INCIDENCE OF ACCOMMODATION.

In rural hospitals, facilities must be provided for the treatment of at least three different diseases at the same time, and in urban communities for a larger number than this. In both, this accommodation must be duplicated for the sexes. The total number of beds to be provided will be regulated by the number of population for the needs of which the hospital is erected.

An isolation hospital of any pretensions ought to have buildings suitable for the following purposes, *viz.*: (1) administrative block for hospital staff, dispensary, stores, etc.; (2) wards for the treatment of different diseases during acute illness and during convalescence, for the separation of the sexes, and for probation of doubtful and non-infective cases; and (3) accessory buildings, which include laundry, wash-house, mortuary, stables, disinfecting apparatus, offices and inquiry room.

Of the administrative department nothing need be said, except that it should provide commodious space for residents, nurses, etc., and should occupy a central or convenient position to the wards.

WARDS.

These are now built of the pavilion type, and mostly one storey in height. Sometimes exigencies of space, economy, and other considerations compel them to be erected of two storeys, but, whenever possible, this should be avoided. One pavilion ought to be distant not less than fifty to sixty feet from the next. In the opinion of some, each should be connected with the rest

by connecting corridors, which should consist merely of covered ways entirely open at the sides. In our opinion, these are neither advisable nor necessary. Should the small-pox department be included within the general hospital area, it ought to be separated by a boundary wall, in addition to the sanitary zone of 150 feet already mentioned. Compatible with reasonable economy, the small-pox pavilions ought to be separated farther from each other than those of the other infective diseases.

WARD SPACE.

The cubic and superficial, or floor, space allotted per patient ought to be considerably greater than in a general hospital, on the principle that free dilution with fresh air diminishes the virulency of infective matter. The minimum amount of cubic space per patient should be 2000 feet; a still more desirable amount is 2500 feet. The minimum amount of floor space should be 144 square feet, and if possible, 156 square feet. The minimum requirements are secured in a ward of the following dimensions, *viz.:* twenty-four feet in width, fourteen feet in height, with twelve feet of wall space per bed; and the larger requirements in one, twenty-six feet wide, fourteen feet high, with fourteen feet wall space per bed.

LIGHTING.

Efficient light is a *sine quâ non* of every hospital, but especially of isolation hospitals, by reason of the fact that light, and more particularly sunlight, is one of the best natural germicides. Window space should, there-

fore, have a distinct relation to total cubic space of a ward, and the proportion between the former and the latter should not be more than one square foot of window space to forty cubic feet of the latter, and not less than one to seventy. Unless special measures be taken for the conservation of heat, the ratio of one to fifty-five makes the heating of a ward difficult. This, however, may be overcome by having double window casements, or double glazed plate glass windows. In temporary wooden hospitals, even with a ratio of one to seventy, it is practically impossible to sustain adequate temperatures.

HEATING.

Heating is usually effected either (1) by hot-water pipes at ordinary pressure; (2) by open fires; or (3) by a combination of both. Where a hot-water system is to be installed, the heating engineer has to carefully calculate the extent of piping necessary. Hood, in his treatise on warming and ventilation, shows that one foot length of a four inch pipe, containing water at a temperature 125° Fahr. above that of the surrounding air, will elevate 222 cubic feet of air one degree of temperature per minute; that is, about 190 cubic feet for every superficial foot of surface of pipe. Thereupon, in order to calculate the necessary extent of piping required to heat any given confined space, he recommends that the total cubic space in feet be multiplied by the number of degrees of temperature desired, and that the product be divided by 190 into the time, reduced to minutes, within which the desired temperature is to be attained;

the answer will be the number of superficial feet of pipe required. In addition to this, however, careful estimation must be made for windows and open ceilings. A general rule, when a temperature of 60° Fahr. above that of the external air is wanted, is to provide one foot of piping for every two and a half feet of glass superficies.

VENTILATION.

In many hospitals, heating and ventilation are combined, whereas, in others, provision is only made for the entrance of fresh air at the outside temperature, and heating is effected by the means already spoken of. There can be no doubt that the best mode to attain efficient ventilation is to purify, warm, and impel fresh air into the wards of a hospital, since, by previous warming, the air can be introduced at a greater velocity with comfort and safety. Another mode is to first warm the incoming cold air by passing it over hot-water pipes and to exhaust the foul air by the ward chimneys, or by special exhaust flues built around or alongside the smoke flues, and by roof-ridge fixed ventilators; while a third mode is to permit the entering air to pass by special openings, as Sheringham valves or Tobin tubes, aided, if necessary, by cross window ventilation when required, and to leave the heating to the hot-water piping and the ward fires. The recent tendency in the building of new hospitals to combine a scheme of heating and ventilation is unquestionably in the right direction, and probably the Key system is the best at the present day. The essential features of this system are the purification, warming, and impulsion under

some degree of pressure of the air so treated into the different apartments of the hospital. The apparatus for filtering and washing of the air consists of thousands of cords of suitable material stretched on a frame which reaches from the top to the bottom of the incoming air chamber, and which fills the whole width of the chamber. These cords touch one another, and are interlaced with copper wire so as to give to the entering air a flat surface to impinge against. This screen is kept constantly moist by water trickling down the series of cords, and thus the rough fibres of the cords, together with the water, entirely free the air of sooty particles, and to some extent, of aerial microbes. Such a method of screening the air entirely prevents a foggy atmosphere within the wards, and we have seen on a day when a dense fog prevailed outside, the ward atmospheres of the Victoria Infirmary, Glasgow, where the system is in operation, perfectly clear. After the washed air passes through the screen, it next comes in contact with coils of piping containing steam by which it is warmed. Immediately behind these pipe coils are fans or propellers by which the warmed air is impelled into the cement-lined air ducts which pass into the hospital basement, and thence into the wards by special air shafts.

By means of subsidiary or ancillary pipe coils placed at various points of the air ducts, the air to any special ward, or to the operating theatre, may be raised in temperature as desired. The fresh air shaft enters each ward, close to the ceiling, and after serving the needs of the inmates, passes into the foul air shafts, which have their openings near the floor level; so that a person in the erect attitude receives the pure air before it might

be contaminated from patients lying in bed. The air enters the ward under some pressure, and therefore, itself being warmed, it forces downwards toward the exit shafts the respiratory impurities of the ward occupants. The windows are made not to open, and the swing doors are double, in order to minimise disturbance in the air current. Chemical and bacteriological experiments carried on continuously over a considerable period of time, amply demonstrate the greater purity of the ward air as compared with the outside atmosphere. Another advantage of this system, compared with others, is that in warm weather, the temperature of the ward atmosphere may be cooled. Thermometric experiments, too, carried on continuously, show a remarkable evenness of ward temperatures, a desideratum of the utmost importance in all diseases, but especially in those of the respiratory type. The system is presently being installed in the new Birmingham Infirmary. The diagram on p. 278 illustrates the arrangements for the purification, warming, and impulsion of air in this *plenum* system.

TYPICAL ISOLATION HOSPITALS.

The following may be taken as typical isolation hospitals on the large and small scale, for an urban and a rural community; and they have been selected because they are excellent types, and possess the most modern requirements, *viz.:* Ruchill Hospital, presently being constructed by the Corporation of Glasgow in addition to the present Belvidere Hospital; and the Dunfermline Combination Hospital.

The illustration on p. 268 will give the reader a bird's eye view of the general plan of Ruchill Hospital,

for the use of which we are indebted to the Convener of the Health Committee of the Glasgow Corporation.

Situated in the northern outskirts of the city, of easy access by road and rail, and planted upon a rising ground,

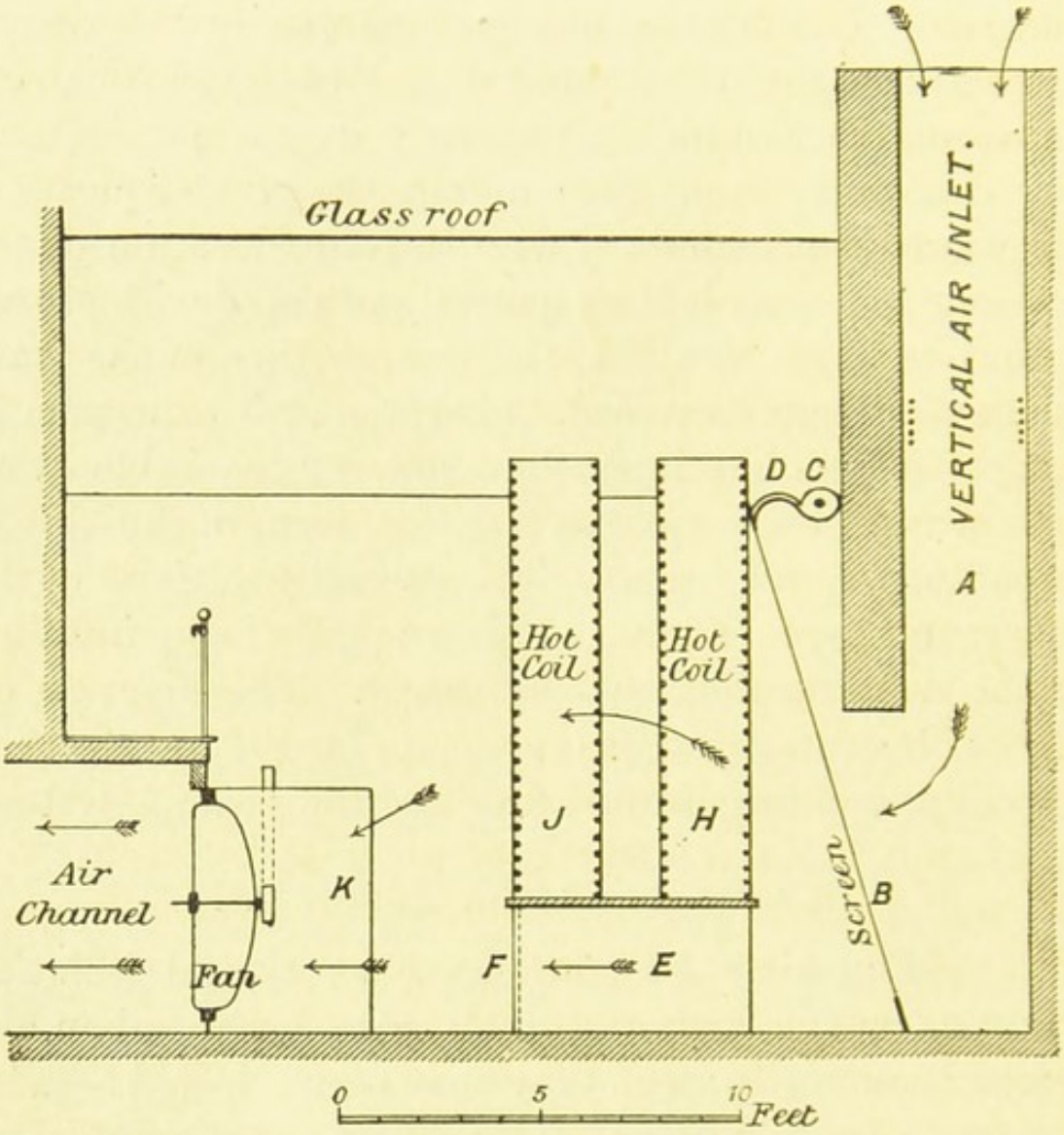


FIG. 66. The course of the air current is indicated by the arrows.

A, air inlet, into which steam-coil is introduced to warm air and thus prevent freezing of water on screen ; B, screen ; C, D, section of trough and feed-pipe to moisten fibres of screen ; E, F, passage for air in warm weather ; J, H, steam-coils ; K, fan channel.

it is intended to provide accommodation for over 400 beds.

It is composed of the following blocks, *viz.*: (1)

administrative; (2) isolation wards; (3) inquiry; (4) wash-houses and disinfecting; (5) kitchen and stores; (6) day-workers'; (7) clearing house and fire-engine station; (8) morgue; (9) boiler-house and workshops; (10) stables; (11) cottages for principal non-professional officials. The hospital has been arranged in entire conformity to the requirements of the Scottish Local Government Board.

The isolation pavilions number sixteen in all, twelve large and four small. At the sunny end of each, a balcony or verandah for convalescents is a prominent and novel feature. Each large pavilion embraces two acute and two convalescent wards, the former for ten beds each, the latter for five beds each. The dimensions of an acute ward are as follows: length, 66 feet; breadth, 22 feet; height, 15¾ feet; total superficies of floor, 1452 square feet; total cubic space, 23,100 cubic feet; window space, 391 square feet; ratio of window space to total cubic space, about 1 to 60.

The dimensions of a convalescent ward are exactly the same as for the small pavilion convalescent ward, as will be seen below. Each small pavilion contains two acute wards and two convalescent wards. The dimensions of each ward are as follows: length, 33 feet; breadth, 22 feet; height, 15¾ feet; total superficies of floor, 726 square feet; total cubic space, 11,550 cubic feet; window space (in acute ward), 187 square feet, and in convalescent ward, 255 square feet; ratio of window space to cubic space (in acute ward), 1 to 62, and (in convalescent ward), 1 to 45. The total number of beds in the hospital amounts to 408.

The ground floor plan of a small pavilion shows the

following accommodation, *viz.:* four wards with five beds each, two nurses' rooms, two pantries, two bath-rooms, two lavatories and water closets for patients, like accommodation for those on duty, two steep rooms for soiled linen, etc. The wards are disconnected from the annexes which contain the sanitary fittings by a hall having opposite door-ways into the outer air, and the nurses' rooms and pantries are situated between each pair of wards.

A like plan of a large pavilion shows a similar disposition of arrangements, but on a correspondingly larger scale.

All angles in ward walls are rounded off in Parian cement, so as to prevent lodgment of microbic dust. The heating of the wards is effected by hot-water pipes at ordinary pressure, aided by open central fires; and ventilation, by fixed roof-ridge cowls, hopper-sashed windows, and by concentric outlet air shafts round ward chimneys.

The hospital will be entirely devoted to the treatment of infective diseases other than small-pox, for the treatment of which ample provision already exists at Belvidere Hospital.

A very excellent type of a rural hospital is the Dunfermline Combination Isolation Hospital, which has been erected on a site of two and a half acres with a good fall for drainage, and has a southern exposure. The illustration on page facing this gives a clear idea of the disposition of the buildings, for the use of which we are indebted to the editor of the *Dunfermline Press*.

It consists of a central administrative building

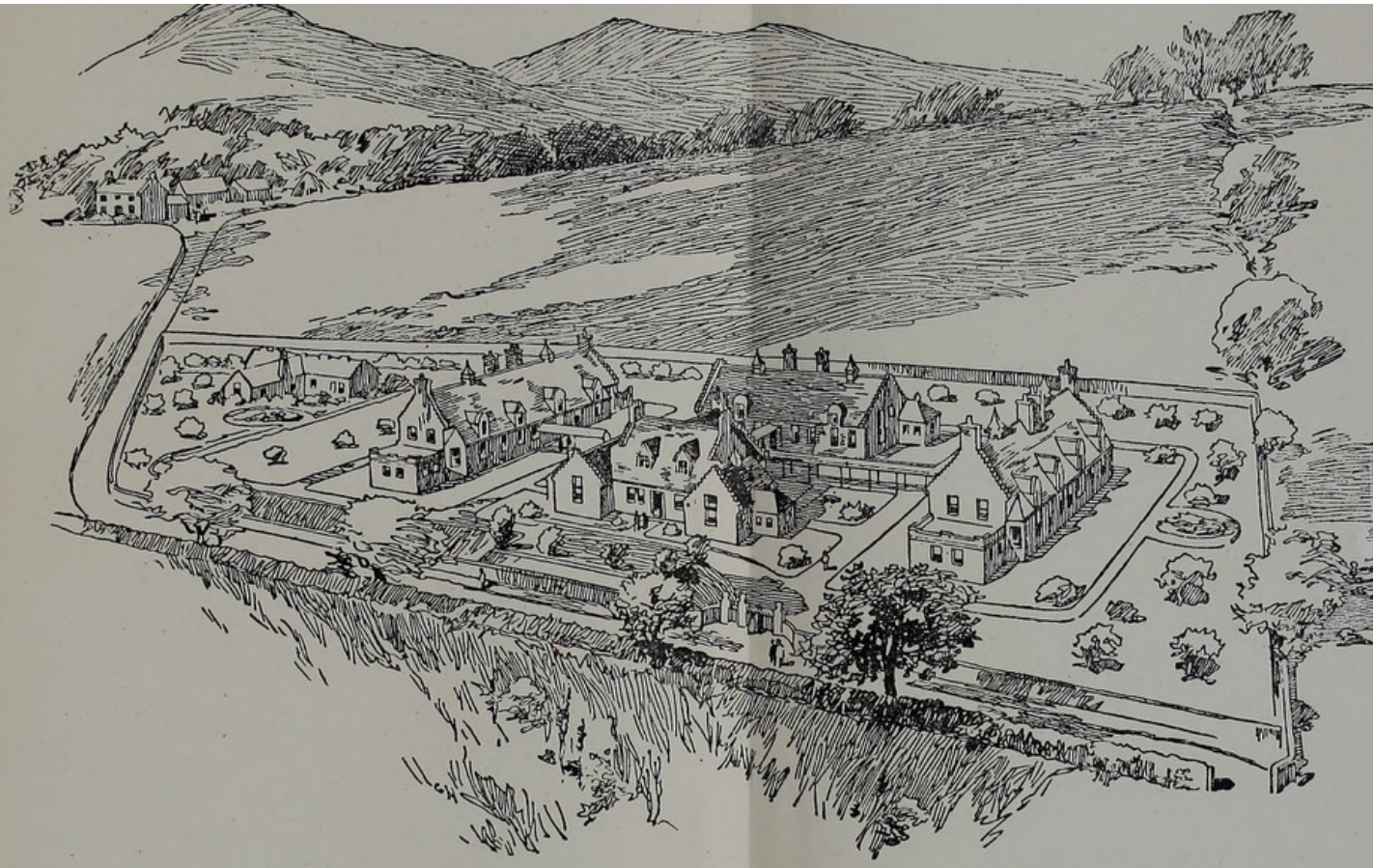


FIG. 67.

DUNFERMLINE COMBINATION ISOLATION HOSPITAL.

Offices. Western Pavilion. Northern Pavilion. Eastern Pavilion.

Probationary Ward. Administrative Block. Probationary Ward.

[To face pag

which is flanked by two semi-detached "quarantine" wards for the reception of doubtful cases. Behind this block, and on each side—west and east—is an isolation pavilion, which is distant from 40 to 60 feet from the administrative block, which communicates with each pavilion by means of open covered ways. The "offices" are placed in the extreme west angle of the site—shown in the diagram in the upper left corner—between which and the western pavilion sufficient space is left whereupon to build another pavilion, if such an extension be required. In the lower right angle of the site it is proposed to erect accommodation for the engineer, caretaker, and other resident officials.

A sanitary zone of 40 feet separates at all points the hospital buildings from the public road.

The fever pavilions are situated north and south. They are simple in design, being based largely on the plan of the Warrington Fever Hospital, and are so arranged that every window in each ward may receive the rays of the sun during several hours of a sunny day.

The administrative building placed on the southern side of the site contains the kitchen, scullery, larder, store-rooms, rooms for physician and matron on the ground floor, and three large bedrooms, with bath-room and napery stores, upstairs; while, in the basement, the air-warming chamber, air-propelling fan, and steam engine for the fan, are located. The quarantine or "probationary" wards, while they flank the former building, are wholly isolated from it and from each other. They are overlooked, however, by air-tight windows from the administrative building. They are

entered by separate door-ways outside of the administrative block. Each ward—one for each sex—measures 24 feet in length, 12 feet in breadth, and 14½ feet in height, and thus contains 4176 cubic feet of air space. Each is intended for two beds, so that each occupant has 2000 odd cubic feet air space, 12 feet wall space, and 144 superficial feet of floor space, allotted to him. Each isolation block contains a ward for males, and one for females. Each ward, on either side of the administrative block, has six beds, while those in the block behind, being smaller than the others, have only four beds; the latter are intended for convalescent patients when circumstances suit. In each of these wards the measurements provide the following spaces per bed, *viz.:* 2000 cubic feet of air space, 144 square feet of floor space, and 12 feet of wall space. The present total number of beds in the hospital is 36; the number of beds per acre is, therefore, about 14.

All the outer walls of the hospital wards are of hollow construction, the inner lining being of brick plastered with "adamant" plaster, the outer of stone, with an air space between of three inches. All the internal corners of walls, floor, and ceiling are rounded, so as to prevent lodgment of dust. Woodwork has been sparingly used because of its absorptive character, and had it not been objected to by the Local Government Board, the floor would have been laid in granolithic instead of wood.

The offices consist of wash-house, laundry, ambulance shed, mortuary, and a small disinfecting chamber for the use of sulphurous acid gas. Disinfection, however, by heat is more adequately provided for in a

separate apartment by a Washington-Lyon Disinfector of the type formerly described. The heating and ventilation of the whole hospital are combined in one scheme, *viz.*, by Key's system already described. The air of the administrative block is changed six times, and of the isolation pavilions, eight times per hour, night and day, and the system is guaranteed to supply air at an uniform temperature of 62° Fahr.

The drainage system and sanitary fittings have been designed by Messrs. Thomson & Wright, sanitary engineers. The drain pipes are laid in straight lines, are of as small size as possible, and are provided with manholes and inspection openings at all angles and junctions. The drains of each block of buildings are entirely disconnected from one another and from the main drain, while the main drain is ventilated by the exhaust power of the heated air of the chimney stalk at the offices, by which a current of fresh air with a velocity of 700 feet per minute is passed through.

It will, therefore, be apparent that the hospital combines all the important modern improvements in construction, with some points of novelty, and that in respect of ventilation and drainage arrangements it is in advance of many larger hospitals.

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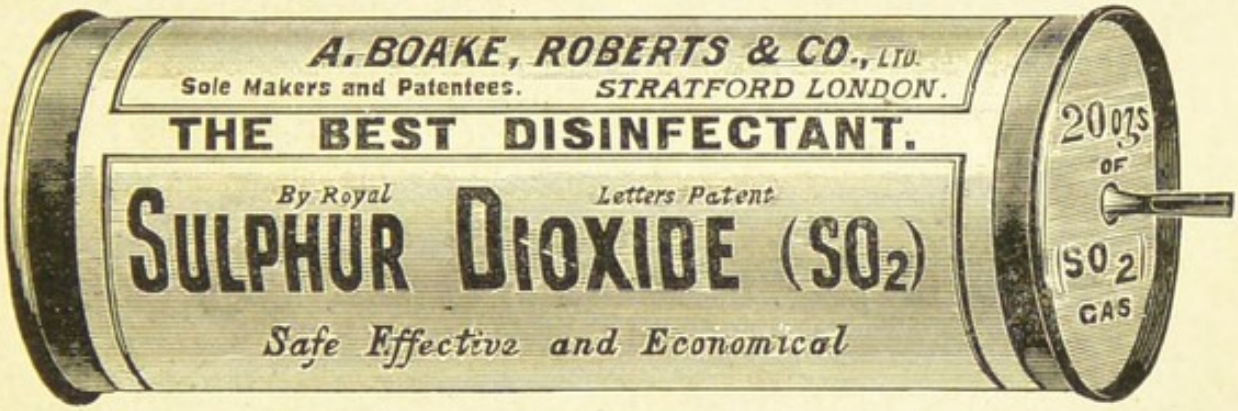
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