Handbook of public health / by John Orr.

Boyd-Orr, John Boyd Orr, Baron, 1880-
Royal College of Physicians of Edinburgh

Edinburgh : Livingstone, 1902.

LIVINGSTONES' MEDICAL HANDBOOKS.

Symington's Topographical Anatomy of the Child		£2:2/-
M'Lachlan's Applied Anatomy: Surgical, Medical, and Operative, 2 vols. (3rd Edition)		18/-
Wheeler's Practice of Medicine		10/6
Hughes' Nerves of the Human Body, with Plates		7/6
—— Manual of Surgical Anatomy	net	4/6
Gynecology: A Handbook for Students, *profusely Illustrated*		5/-
Husband's (H. Aubrey) Forensic Medicine and Public Health (6th Edition)	net	10/6
—— Practice of Medicine (5th Edition)	"	10/6
—— Pocket Prescriber (New Edition)	"	1/6
—— Examination of the Urine (3rd Edition)	"	1/-
Croom's Minor Gynecology (2nd Edition)		6/-
Examination Questions, Practice of Medicine, with Answers, Part 1 — GENERAL DISEASES. Part 2 — SKIN DISEASES. Part 3 — FEVERS	each, net	1/-
Craig's Materia Medica (5th Edition)		6/-
—— Posological Tables (New Edition)	net	1/-
Whitaker's The Brain and Spinal Cord, with Plates	"	5/-
—— Notes on Pathology—Vol. I. GENERAL	"	4/6
Martin's Yellow Fever	"	4/-
Masterman's Zoology	"	10/6
Orr's Handbook of Public Health	"	4/-
Poole's Vaccination Eruptions	"	4/6
Handbook of Diseases of the Skin, *Illustrated,*	"	2/6
Butcher's Tables of Materia Medica	"	1/6
Giffen's Materia Medica (Second Edition)	"	2/-
Kempe's Diseases of the Eye,	"	1/6
Wishart's Botanist's Vade Mecum,	"	2/-
—— Schedules of Plant Description,	"	6d.
Hughes' Motor Nerves		1/-
Webster's Puberty and the Change of Life	net	1/-
Pathology—*Catechism Series*—GENERAL & SPECIAL (two Sets), each	"	2/6
Anatomy—*Catechism Series*, each Part	"	1/-
1. Upper Extremity. 2. Lower Extremity. 3. Head and Neck. 4. Abdomen. 5. Thorax. 6. Bones and Joints.		
Botany— *Catechism Series*,	net	1/-
Chemistry— Do., Parts 1 & 2—each,	"	1/-
Forensic Medicine— Do.,	"	1/-
Materia Medica— Do., Parts 1 to 3—each,	"	1/-
Midwifery— Do., Parts 1 & 2—each,	"	1/-
Physiology— Do., Parts 1 to 8—each,	"	1/-
Public Health— Do., Parts 1 to 5—each,	"	1/-
Surgery— Do., Parts 1 to 7—each,	"	1/-
Toxicology— Do.,	"	1/-
Zoology— Do., Two Parts—each,	"	1/-
Surgical Anatomy and Operations.—Parts 1 & 2—each,	"	1/-
Johnstone's Botany Notes (4th Edition)	"	2/-
—— Zoology Notes	"	3/6
MEDICAL SCHOOL CALENDAR for SCOTLAND, by post		2/3

Full Catalogues of our Publications on application. 9.1

R.C.P. EDINBURGH LIBRARY

R28465M0236

With the Author's Compliments.

PUBLIC HEALTH.

HANDBOOK

OF

PUBLIC HEALTH

BY

JOHN ORR, M.D., F.R.C.P.E.
M.R.C.S. (ENG.)

ILLUSTRATED

EDINBURGH: E. & S. LIVINGSTONE

1902

PRINTED BY
E. & S. LIVINGSTONE
MELBOURNE PLACE
EDINBURGH

TO MY FRIEND AND TEACHER

DR J. O. AFFLECK

CONSULTING PHYSICIAN TO THE EDINBURGH
ROYAL INFIRMARY,
IN GRATEFUL RECOGNITION OF
MUCH KINDNESS.

PREFACE.

ALTHOUGH there are several excellent Text-books of Public Health, it seems to me that there is need for another. For the Medical Student preparing for his degree examination most of the Text-books are somewhat large, and the details entered into tend to render it difficult for him to extract the information which it is essential for him to be conversant with. The aim of the present small volume is to describe in as concise a manner as possible those matters relating to Public Health, which a medical student ought to know in order to fit him for his future duties as a Practitioner of Medicine.

I take the opportunity of thanking all who have given me their assistance in the preparation of this volume, and in particular Dr Hugh Marshall and Dr George Wilson.

I am indebted to Mr H. K. Lewis, London, for his courtesy in permitting me to use several diagrams, and to Messrs Boyle for the plates illustrative of their system of ventilation.

JOHN ORR.

1 Rillbank Crescent,
Edinburgh.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

LIST OF ILLUSTRATIONS.

PUBLIC HEALTH.

CHAPTER I.

SOIL.

PHYSICAL CONDITIONS OF THE SOIL IN THEIR RELATION TO HEALTH.

SOILS offer very considerable points of difference in their composition and arrangement, for we find some are very porous, while others are less open, and in some cases, as in rocks, they are exceedingly dense. The more open the soil is with the greater readiness will fluids, gaseous and liquid, be able to penetrate and find lodgment therein; and, accordingly, we find that most soils contain a considerable proportion of air, which is commonly known as GROUND AIR. Ground air occurs in all soils, except the hardest rocks, and is especially abundant in loose soil, where it may reach a proportion as high as 50 per cent. The air is mixed with a large volume of carbon dioxide (CO_2), and is moist from the presence of water. Effluvia from organic matters, ammonia, marsh gas and hydrogen sulphide are also occasionally present.

As a general rule the amount of *Oxygen* in ground air is inversely proportional to the amount of carbonic acid gas, and it is found that the quantity of oxygen decreases as a deeper level of the soil is reached, till, at a depth of over 14 feet from the surface of the earth, the ground air is irrespirable and will not support combustion owing to its lack of oxygen.

The *Carbonic acid* present in ground air is derived from changes in organic matters, animal and vegetable, in the soil—changes which are most usually the result of the presence of micro-organisms. This carbonic acid varies in concentration from time to time according to the freedom, or otherwise, of the soil ventilation; for instance, when a fall of rain occurs the surface soil gets agglutinated and the spaces between the particles of earth become lost, being more or less occupied by rain-water; it is thus brought about that the carbonic acid gas cannot escape by the surface of the earth until, by the process of evaporation of the rain-water, or by the sinking of it into the deeper levels of the ground, the interstices between the earth particles are re-established.

Ground air in loose soil is in CONSTANT MOVEMENT, due to changes in the temperature of the soil, the fall of rain, and alterations in the level of the ground water. There are also additional factors which influence the movements of ground air as a result of conditions extraneous to the above mentioned, which may be called Natural causes. In inhabited localities ground air is liable to be drawn up into houses by reason of the air in houses being warmer than the ground air; the warm air tends to ascend and escape from the house, and to take its place the ground air rises up out of the subjacent soil. Should this ground air be particularly abundant in moisture or effluvia, it may constitute a source of ill-health or danger to the occupants of the house. For instance, many houses, in towns especially, are built on what is called "made-up" soil. "Made-up" soil consists of earth, ashes, refuse, such as rags, straw and all manner of debris, and is used by builders to fill up deficiences in the ground so as to level it. When houses are to be built on this, a sufficient time ought to elapse before building to secure that oxidation of the organic matter in it has proceeded very completely, and it should be tested by boring and found to be free from active decomposition. In addition to this precaution, to avoid these decomposition gases passing with the ground air into a house built on made-up soil, it is advantageous to have the basement laid with asphalt or concrete, and to establish thorough ventilation of the floors. Offensive gases escaping from leaking cesspools and coal gas from defective gaspipes have been known to be aspirated with ground air into a house and to produce disagreeable effects.

In malarious districts the "miasm" of malaria rises in the ground air, and in consequence it has been found beneficial to have the basement of houses raised a little above the surface of the ground.

WATER occurs in the soil under two conditions, viz., (1) as MOISTURE, and (2) as GROUND WATER.

Moisture is the term applied to the association in the soil of *water with air*: whereas the significance of the term *Ground water* is the occurrence of *water without admixture of air* in the soil. The function of the soil moisture is to keep the superficial levels of the soil damp, and it owes its existence to rainfall, to evaporation and capillary attraction from the surface of the deeper lying ground water, and to the rise and fall of the ground water, which, as it descends after a rise in its level, leaves damp the soil through which it has passed.

Ground water is often present in vast quantity and its level varies very greatly. Its upper surface is not necessarily horizontal by any means, but is often curved as the water falls towards its outlet, *e.g.*, in the sea or side of a valley. It may be hundreds of feet below the surface of the earth or merely two or three feet, and in marshy districts the upper level of the ground water may actually be coincident with the surface of the marshy ground. Ground water, like ground air, is in CONSTANT MOTION. The movement is slow and is dependent on rainfall, the influence of rivers, the sea and its tides, and the slope of the substratum on which it lies. It tends to move towards its natural outlet, and its rate may only average seven feet per day in certain districts, while in others it may travel faster. Changes in its level can be noticed and even measured by observing the variations of the level of water in wells.

In addition to gases and water found in soil, we have to refer to other constituents. These include animal and vegetable organic matters, micro-organisms (pathogenic and non-pathogenic) and mineral substances.

ANIMAL MATTERS arise from the constant deposit on and into the soil of excrementitious material, refuse, dead animals, &c., and these additions to the soil are particularly abundant in the vicinity of human habitation. These organic matters undergo putrefaction and evolve noxious odours, being decomposed into nitrogen-containing gases and salts, among which may be mentioned ammonia and its compounds, nitrates and nitrites. The gaseous decomposition products are partially diluted and partially oxidised by the air of the atmosphere and of the soil, while the solid and soluble decomposition products are washed into the ground to be dissolved by the moisture and ground water there. Debris more or less insoluble may remain on the surface of the ground or be carried mechanically by rain, &c., below the surface and become deposited on the particles of earth, being found at practically all levels of the soil, both superficial and deep. A great proportion of these decomposition products are utilised by vegetation, acting after the manner of manure purposely mixed into soil as pabulum for vegetable assimilation.

The conversion of complex organic materials into the simpler chemical forms like nitrates, is accomplished in the presence of oxygen by micro-organisms, more especially in the superficial layers of the soil, where both oxygen and micro-organisms are in most abundance. Pathogenic organisms can live readily in soil, their growth being secured by adequate moisture and heat, and the presence of the organic matter which adheres to the earth particles, or is dissolved in the moisture there. In the event of these essentials for organismal growth being inadequate or absent, or when antiseptic agents are thrown into the ground, then the growth of the organisms is arrested, and under certain conditions may be caused to cease altogether.

MINERAL SUBSTANCES abound in the soil and present great diversity of chemical and physical character. They are largely found to consist of silicates and aluminium compounds, chlorides, phosphates, carbonates, sulphates and sulphides, in combination with calcium, magnesium, iron, potash and soda.

THE GEOLOGICAL FORMATION of the soil has a special influence in determining the healthiness or unhealthiness of a given district, and especially when considered in conjunction with the natural physical formation of the locality. For instance, it is common to find in many districts that the deep substratum consists of hard granite rock which may be covered by a formation of sandy or gravelly soil. Water easily percolates from the surface of the ground down to this rocky substratum which bears it up. The slope of this rock being considerable, the ready flow of ground water along it is permitted, with the result that the soil of the district is well drained; accordingly, other things being equal, the locality is favourably situated with regard to one of the essentials for good health, viz., adequate drainage. Moreover, so easily is the rain water removed, the amount of water evaporated into the atmosphere is comparatively slight and therefore the air is dry. Clay, slate, limestone, sandstone and permeable chalk formations are healthy for similar reasons. Whenever the drainage in soil is bad or inadequate for any reason, such as when the fall of the ground water is insufficient, there is a great dampness of the soil and of the atmosphere by evaporation, and this is associated with a great prevalence of chronic rheumatism and catarrhal conditions of the respiratory and alimentary tracts. A marshy district possesses little or no soil drainage; abundance of aqueous vapour passes off by evaporation into the air, carrying with it considerable quantities of organic matter and, possibly, malarial parasites. Needless to say such a locality is extremely unhealthy.

The heat of the sun has an all important influence on the healthiness of a locality on account of its effect in raising the TEMPERATURE of the soil, and we find that this effect varies considerably in degree, according to the nature of the soil. Loose, open, sandy soil absorbs a very large amount of heat during the day, much more than clay or chalk or the organic deposit which forms on earth particles, and after nightfall parts with a considerable proportion of its heat to the air near the ground, so that when there is a great abundance of sand there may be great heat throughout the day, and at night the air may still remain very warm and stifling from the passage of heat again into the air. The radiation of heat from the soil is a quicker process than absorption of heat into it, and, therefore, soil after being heated occupies less time, as a rule, in losing its heat again than in gaining it. Water absorbs heat somewhat slowly but radiates it readily; hence it is a matter of common experience that the presence of much moisture in soil is liable to cause the locality to be cold.

The surface soil down to a depth of about 4 feet is most affected by the sun's rays and undergoes *daily variations* in temperature, and in consequence is warm during the day and colder at night; while on hot days it is warm and on cold days is of lower temperature: not only so, but on hot days the soil is hotter, and at night it is colder than the atmosphere. *Seasonal variations* of the soil-temperature occur, especially in the deeper strata, becoming inappreciable, however, at a depth of 40–50 feet. In the summer the lower strata are cooler, while in winter they are warmer than the atmosphere.

The growth of vegetation on the ground shields it from the sun's rays so that a notably smaller amount of heat reaches the earth ; at the same time it favours the escape of heat from the soil by evaporation, and in consequence soil covered by vegetation is both cooler and drier. Trees and large shrubs protect the earth from the sun and to some extent prevent evaporation from the surface vegetation, but they abstract much water from the soil and transmit it to the air by evaporation from the enormous extent of leaf surface which they possess. The air is therefore made cooler and more pleasant by the existence of trees, while at the same time the soil is drier. Dense vegetation on the other hand hinders free circulation of air, which becomes stagnant, vitiated with organic decomposition gases, and unhealthy in other respects, and such occurs where close thick brushwood covers a marshy locality. Trees have often a *protective* value, for should air currents be conveying malarial infection from a marshy district, a thick belt of trees may be of considerable importance, by intercepting the malaria laden air, in keeping the infection from a neighbouring non-malarious region. Though wind may in some cases disseminate diseases whose causative agents exist as spores or organisms, the free circulation of air is usually of high importance in determining the salubrity of a district. It is found that open and wind-swept plains are associated with pure air, with absence of effluvia and undue moisture in the atmosphere, and if in addition the drainage is good, such localities are healthy. Plains surrounded or enclosed by hills may, however, be unhealthy, because the water draining off the hills into the soil of the plains may not get away easily from the plains; consequently excessive growth of vegetation occurs, evaporation of the water into the air from the soaked ground renders the air unduly humid, and the conditions favourable for the occurrence of malaria are produced. The digging of trenches on the slope of the environing hills to carry off the excess of ground water, and thereby preventing it reaching the plain, is a remedy which has often been materially beneficial in rendering such plains more salubrious.

Deep ravines containing water and an abundant growth of vegetation, together with a considerable degree of decomposition of vegetable organic material, are dangerous to health. The air during the heat of the day undergoes expansion and becomes lighter, and passes in an upward direction towards the head of the ravine; at night it falls, having undergone cooling. Miasms originating in the vegetation-covered and moist soil are conveyed upward and readily affect dwellers at or near the outlets of these valleys. Places of this nature are accordingly to be avoided in selecting a site for a habitation. Positions of a good altitude are healthy because of the cool fresh air blowing; and even should marshes exist in these elevated positions the diminished atmospheric pressure facilitates quick evaporation, and will tend to lessen malarial infection by lowering the temperature at night. In addition, the coldness of the soil and atmosphere diminishes the extent of the fermentation and decomposition of the organic matters in the soil.

SOIL AND DISEASE.

We are now in a position to consider the role played by the various conditions of the soil in the production of disease. It has long been a matter of common knowledge that certain diseases tend to be caused, or at anyrate aggravated, by DAMPNESS of the soil and air. COMMON COLDS and CATARRHAL CONDITIONS of the respiratory passages and alimentary canal show a decided relationship to damp. Humidity, especially when excessive, lowers the temperature of the air to a considerable degree, and in districts where the soil is badly drained certain diseases are of undeniably frequent occurrence. Thus RHEUMATISM, in its chronic form, and GASTRO-ENTERIC CATARRH, particularly in young children and infants, are exceedingly frequent in those badly drained districts, and the frequency of their occurrence has been greatly decreased by the carrying out of certain sanitary measures, among which extensive and thorough systems of deep drainage have been the most important, and have secured the comparative dryness of the subsoil. Dr Newsholme believes that acute rheumatism is more frequent in localities where there has been a continued period of drought, and where the subsoil is dry and the ground water at a low level.

PHTHISIS also is particularly rife in districts whose deep drainage is imperfect. The disease is not, of course, originated by the dampness of the soil or air, because phthisis is due unmistakeably to a definite pathogenic organism, the Bacillus Tuberculosis. But damp acts by inducing catarrhal conditions of the respiratory organs, and continues to exert an evil influence by keeping up the catarrh. In the resulting inflammatory products the bacilli of Tubercle, probably present in greater or less quantity in the atmosphere of most inhabited places, find pabulum for their nutriment and development, and they speedily multiply in numbers after they obtain an entrance in the air inspired by the patient. Multiplying in numbers in the catarrhal exudation, they begin to produce further changes on their own account, aided to a great extent by the coldness and dampness of the inspired air, which continues to keep up the respiratory tract catarrh. Some observers are inclined to minimize the influence of cold and damp in predisposing to and aggravating phthisis, but the bulk of clinical experience seems to indicate that the role played by these factors acting in combination is an exceedingly important one.

Drainage of the subsoil has been of great service in causing a diminution in the phthisis mortality of districts—where the drainage has been carried out in a thorough manner, a reduction which has been as much as one-third in some instances.

MALARIAL FEVER is usually associated in its occurrence with marshes containing sluggish or stagnant water, rank rotting vegetation and want of free access of air currents. It also occurs in alluvial soils, and mud banks along the course of rivers, and particularly those formed most recently by the action of rivers or by the flow of water from higher ground. These alluvial soils are very rich in the amount of organic matter they contain and in consequence favour organismal growth. Outbreaks of malaria also occur after the soil of certain districts has been freshly turned over, such as may occur in the construction of new roads and in digging trenches or foundations for buildings. The malarial parasites, now known to be transmitted from man to man by the intermediary agency of certain kinds of mosquitos, may lie dormant for long in the dust or soil, whither they have been borne in the living or dead bodies of mosquitos.

The dust containing malarial organisms may also be blown by winds to distant parts, and in this relation we have already seen that the infection may be warded away from a community by the intervention of a thick plantation of trees in the path of the wind. It is a question whether odorous and antiseptic substances exhaled from the trees are to any extent additionally effective in arresting the progress of the malarial miasm. Probably the filtration of the malaria laden wind through the trees is the more important factor and perhaps is solely efficacious.

ENTERIC FEVER has a very important connection with telluric conditions. We find that dejecta carelessly thrown upon the soil may find their way in a practically unaltered state into wells providing the drinking water of a rural community; or the organic matter of dejecta may be almost entirely converted into nitrates and nitrites before reaching the well or ground water feeding the well. Should the bacilli of typhoid fever be in the soil already or be in the dejecta so finding access to drinking water, then they will accompany the organic matter or nitrates to the well water, will contaminate it, and rapidly propagate the disease among those making use of the well for drinking purposes. The dejecta from a single case of typhoid may in this manner affect a whole community.

Pettenkofer holds that the rise of ground water from any cause, *e.g.*, abundant rainfall, *followed by a speedy fall* in its level, is attended by a decided increase in the number of cases of typhoid fever. He found that the outbreak of enterica occurred after the ground water returned to its lowest level; and this observation has been confirmed by separate investigators in other instances. On the contrary, it has been clearly shown by other competent observers that the actual *rise of ground water* itself has been attended by a similar *increase* in the number of typhoid cases, and further, that the fall of ground water has been accompanied by a decreased spread of typhoid. These two views express two extremes of opinion, but in seeking to arrive at a conclusion one must take into account the fact that mere rise or fall of ground water will not of itself cause enteric fever. The special pathogenic organism of Eberth is without doubt an essential factor in the production of the disease, and unless it be present in considerable abundance in the soil, cases of typhoid will not occur. The true relation of the changes of level of the ground water to typhoid seems to be, that the moving water carries up with it organic matters which may also contain the specific micro-organisms; the organic matter and organisms are left high up in the soil and near the surface by the receding water, and subsequently are liable to contaminate wells faulty in their construction or out of repair. Or, the organic matter left in the upper strata of the soil affords pabulum for the development of typhoid bacilli, reaching the soil later or already existing there, and at a subsequent period the bacilli, now in great numbers, may gain access to drinking water and contaminate it. Again, it may be that infected ground air is forced by the rising ground water into leaking wells, or into houses, and in this manner the occurrence of typhoid outbreaks may be occasioned.

PLAGUE may be disseminated by the throwing on the soil of the dejecta from a patient suffering from plague. Under favourable conditions the bacilli of plague may gain access to the drinking water in wells, and thus spread the mischief. The bacilli are, however, of feeble vitality when in the earth, and the disease owes its extremely rapid spread to conditions additional tō this (see later).

CHOLERA in its occurrence is, according to Pettenkofer, dependent on soil and ground water relationships, similar to typhoid, but all authorities do not accept his views unreservedly. It is certainly a water borne disease, the spirilla gaining access to drinking water owing to defective sanitary arrangements allowing the dejecta of cholera patients to gain access in some way to the water supply. Perhaps spirilla from dried cholera evacuations on the soil may be carried by the wind. Coldness of the soil arrests the growth of the spirilla of cholera.

DIPHTHERIA is to some extent spread by the existence of certain soil conditions, whereby the Loëffler bacillus is enabled to retain its vitality and virulence. Heat, together with a sufficiency of organic matter and of moisture, enables the bacillus to preserve its activity, and ground air carrying with it these organisms may gain access into houses. Dr Newsholme has shown that epidemics of diphtheria follow a period of deficient rainfall, whereby the level of the ground water is low; and that conversely diphtheria is less prevalent in seasons of excessive rainfall.

TETANUS is a disease whose organism is definitely known to reside in the earth, and it finds an entrance into the body through abrasions and cuts of the skin surface.

ANTHRAX also is able to retain its vitality in soil for a considerable time, and cases have occurred where animals dying of splenic fever have been buried, and the anthrax bacilli have been known to give origin to cases of anthrax long afterwards in these localities.

YELLOW FEVER AND DYSENTERY.—With regard to these one may simply say that there is abundance of organic materials in the soil in the localities where these diseases are met with, and the organisms which have been regarded as pathognomonic of yellow fever and dysentery have been found there also; but as to what the exact relationships are between the soil conditions and outbreaks of these diseases, it is impossible to give a decided opinion in the present state of our knowledge.

CHAPTER II.

AIR,

AND ITS RELATIONS TO HEALTH AND DISEASE.

THE composition of the atmospheric air is, except in certain localities where adventitious gases and substances become added to it, practically uniform. It consists of a mixture of oxygen, the *sine qua non* of existence, and nitrogen, a gas which acts as a pure diluent, undiluted oxygen being unsuited for human respiration under ordinary circumstances. An allotropic modification of oxygen (O_2), called ozone (O_3), occurs in minute quantity in the atmosphere, and is relatively abundant where no human habitations exist—on mountains and near the sea. A small but almost constant amount of carbonic acid (CO_2) is also present, together with traces of organic substances, ammonia and water vapour. The following table gives a fair estimate of the relative quantities of the constituents which go to form the atmospheric air, whose composition is practically identical in all parts of the world:—

OXYGEN 20·810 per 100, *i.e.*, over 1 in 5.
NITROGEN 79·150 per 100, *i.e.*, nearly 4 in 5.
CARBONIC ANHYDRIDE (CO_2), ·04 per 100.
OTHER SUBSTANCES (including ozone, inorganic matters, organic matters, ammonia), traces.
WATER VAPOUR, variable.

In localities remote from towns, on mountains, and on the sea, the air reaches its maximum of purity. Wherever there is life, be it animal or vegetable, unceasing interchange occurs between the atmosphere and the living organisms, resulting in considerable alterations in the relative quantity of the atmospheric constituents. In this relation vegetation plays an important part, for, under the influence of sunlight and chlorophyll, plants can assimilate the carbon of the atmospheric carbonic anhydride, liberating free oxygen into the air and to some extent actually purifying it. During the night, however, plants exhale carbonic acid, though not to the same extent to which they absorb it during the day.

When vegetable matter is dead and is decomposing, which it does under the influence of heat and moisture, certain gases and substances are liberated into the atmosphere, of these the most important are marsh gas (CH_4), carbonic acid or anhydride (CO_2), and sulphuretted hydrogen (H_2S). These gases escape into the air and under favourable conditions, namely by diffusion and the action of winds, get thoroughly diluted and dissipated, and thereby are rendered innocuous. In addition, algæ, fungi and organisms such as the malarial organisms rise up into the air from the ground where such decomposition is taking place. Being definite structures these organisms are not necessarily rendered innocuous by escaping into the air; indeed on the contrary they may be disseminated by wind currents and carried to a distance, where they may exert their specific influence; and this is particularly the case with the malarial organism, which in this manner finds a ready means of carrying the disease from its original source to distant parts.

Animal organic matter is subject to similar decomposition changes with the evolution of gases into the atmosphere, where they are diluted and have their potentiality for evil considerably reduced or neutralised.

In towns these same changes occur in connection with the decomposition of dead animal and vegetable organic matters, and in addition there are other air vitiating agencies in operation caused by the respiration of the town population, the combustion of fuel for lighting and heating purposes, effluvia from manufactories, sewers, &c. Germs must also be mentioned as being particularly abundant in the air of towns, and that at certain times of the year, more especially during the hotter months. The impurities thus produced are in part gaseous, and in part consist of minute particles in suspension in the air, which from time to time get deposited in various places or are inhaled by the individuals breathing the atmosphere so vitiated.

VITIATION OF AIR.

1. EFFECT OF RESPIRATION ON AIR.—The first and most important effect induced by the process of respiration is that OXYGEN is absorbed into the blood from the air drawn into the lungs, and is taken up by the hæmoglobin of the blood circulating in the capillaries of the pulmonary air vesicles. Inspired air accordingly loses its oxygen. At the same time other changes occur in the air inspired, for we find that expired air contains certain effete substances of which the most important is CARBONIC ACID. The average amount of oxygen absorbed daily by a healthy man is about 26 ounces, and the average weight of carbon excreted by the lungs as carbonic acid is about 8 ounces. WATERY VAPOUR to the

amount of about 9 ounces is daily given off by the lungs (Rutherford). Variations in these amounts of course occur, depending on the amount of work done by the individual, the condition of activity of his skin and kidneys, &c. Air inspired and then expired is considerably HEATED during its passage over the highly vascular mucous membranes of the nose, pharynx, and respiratory apparatus proper, and has been shown to have risen from the temperature of the atmosphere at the time (say 60° F.) up to 94° F., or 96° F. A portion of this heat is derived from the blood circulating in the walls of the air vesicles. Moreover, the air in its course through the respiratory passages acquires from the mucous membranes a small but appreciable quantity of PUTRESCIBLE ORGANIC MATTER. This organic matter is suspended in the expired air; its amount is somewhat difficult to determine, but it bears a fairly constant relative proportion to the quantity of expired carbonic acid. So constant is the ratio of the one to the other that, in the estimation of these impurities in air, the amount of carbonic acid, which is easily measured, forms a sufficiently accurate index of the extent of vitiation by the putrescible organic matter.

Nitrogen passes into and out of the lungs during respiration without being materially altered in quantity.

A useful table gives the approximate figures of respiratory gaseous interchange as follows:—

	OXYGEN.	CARBONIC ACID (CO_2).
Inspired air,	20·80 per cent.	·04 per cent.
Expired air,	16·00 per cent.	4·38 per cent.
Difference,	4·8 per cent.	4·34 per cent.

The putrescible organic matter of expired air is so very offensive that it readily makes its presence manifest to the senses, and the degree of carbonic acid impurity corresponding to an offensive proportion of this organic matter is *by itself* quite respirable without appreciation that the air is of less than its normal purity. We find that when the amount of carbonic acid in an inhabited room gets over ·06 per cent. the air is unpleasant, not because of this excess of carbonic acid, but because of the quantity of organic matter simultaneously present and of which the carbonic acid is the index. Carbonic acid added to air (in the absence of putrescible organic matter) can be respired without bad effects when it amounts even to 2%; but its presence in a proportion higher than this becomes decidedly deleterious and gives rise to nausea, sickness, and vomiting with headache, and if in still greater abundance it will produce asphyxia. Such a fatal degree of carbonic acid impurity occurs in fermentation vats from which the carbonic acid has not yet been removed, and in the immediate vicinity of lime-kilns. Deaths have occurred among workmen who have fallen into such vats, and among tramps who have been attracted by the heat of lime-kilns and have slept out on the ground near one.

Up to the amount of ·06 per cent. of carbonic acid (+*putrescible organic matter*) impurity, air in a room is still within the limits of "purity," but when this limit is passed disagreeable sensations are experienced. We thus allow a margin of ·02 per cent. of carbonic anhydride in excess of the normal ·04 per cent. of carbonic anhydride* in ordinary atmospheric air when we are reckoning the suitability of air in a room for respiration

---

* The terms carbonic "acid" and carbonic "anhydride" in the text are used as alternative designations for carbon dioxide (CO_2).

purposes; so that when the air of an inhabited room shows a degree of carbonic acid impurity of say ·07 per cent., the disagreeable symptoms referred to above begin to occur. The indications of this disagreeable impurity are, nasty close smell, general discomfort, sickness, vertigo, headache and mental confusion, followed by muscular weakness and physical prostration. Prolonged and habitual breathing of such impure air tends to cause ill-health, anorexia, sickness, constant headache, sore throat, and boils; while, on account of the depression of vitality, certain diseases readily gain a hold on the individuals so deteriorated, diseases among which may be mentioned typhus fever, phthisis, and in children diarrhœa, bronchitis, and rickets.

These evil effects, it may be repeated, are mainly due to the putrescible organic matter present in the expired air, but it should not be forgotten that some of the unpleasant effects of air vitiated by breathing are due to the heat given out from the lungs with the air. When the air in an inhabited room gains an increment of 6° F. to the average healthy temperature of 60° or 65° F. it can still be said to be comfortable; but when it becomes raised to 75° or 80° F. it feels decidedly hot, and produces lassitude, headache, flushing of the face and perspiration, and a general feeling of stuffiness and discomfort which may end in fainting.

2. The gases generated by decomposition of vegetable organic matters have been already referred to. We must now indicate the VITIATION produced by ANIMAL ORGANIC MATTERS. In this relation the atmosphere receives impurity from the effluvia emanating from refuse heaps, cesspools and sewers, from debris and

dust produced by the traffic in streets, from horse-droppings, &c. Moreover, in certain localities and parts of the world human fæces are constantly deposited on the ground, from which effluvia may arise, and should these evacuations be from the subjects of cholera, typhoid fever, dysentery, plague, &c., it is not impossible that such emanations may be in large measure instrumental in propagating these diseases.

The gases occurring in SEWERS consist largely of foul-smelling combinations of carbon and ammonia, and this evil odour is greatly increased when active fermentation and decomposition are going on in the sewage. Sewer air arising from sewage not as yet undergoing fermentation, is of heavy sickly odour, and, if breathed even with considerable dilution with air, causes nausea, sickness, vomiting and fainting. In dilution, sewer air not undergoing decomposition may be almost odourless. When the contents of sewers are decomposing the gases evolved are of a disgusting, very offensive and sour smelling character. Decomposition changes are particularly liable to occur where there is inefficient sewer ventilation or much deposit in the sewage, owing to faulty construction of the sewer and impediment to its out-flow, and of course putrefaction is exceedingly frequent in stagnant cesspools.

Poisonous Alkaloids also are represented in the organic matters, and include those produced by the action of Bacteria in the organic matter of the sewage, and those which occur in non-decomposing fæces and urine, and have their origin in the normal metabolic processes of the tissues. The former class of alkaloids resulting from organismal growth are called *Ptomaines*, the latter *Leucomaines*.

Bacteria are present in the liquid and solid sewer contents in great abundance. They include in all cases non-pathogenic bacteria, and not unfrequently pathogenic organisms, the latter according to the source of some of the various constituents of the sewage. Typhoid bacilli for instance can be detected when cases of that disease are occurring and whose dejecta are being passed into the cesspools or sewers receiving the house drainage. But it does not always follow, because there are many bacteria in sewage, that the sewer gas is to a corresponding extent contaminated with bacteria, for if the walls of the sewer are well constructed and smooth, if the gradient and out-flow of the sewer are good and adequate, and if there is no interruption to the steady flow of sewage, then the sewer contents pass along steadily and without commotion, carrying the bacteria suspended in the stream. Should, however, there be any eddying or splashing in the liquid, or should fermentation be active, gaseous bubbles are encouraged to rise from the surface of the sewage and burst into the sewer air, and as the gaseous bubbles break on the surface of the sewage the bacteria are freely disseminated into the sewer gas and thereby contaminate it. Thus we find the sewer air particularly full of bacteria when the sewer is faultily constructed or out of repair, whereby its walls present irregularities disturbing the steady, even flow of the liquid sewage; and also when the flow is sluggish or stagnant, as in times of drought where there is too little fluid in proportion to the total quantity of solid matters in the sewage, these solid matters get deposited and become actively decomposed. These gases laden with bacteria may in certain circumstances be fruitful causes of general ill-health and specific disease

Sewer gas which escapes into the open air is at once diluted and in part oxidised by admixture with the atmospheric air. Dilution with air and dissipation by wind currents will of course tend to greatly minimise and even fully antagonise its potentiality for ill. But should it escape into an enclosed space or into a house, such free dilution and dissipation become impossible, and it is under these circumstances that sewer air comes to constitute such a great danger to health. What these effects are we shall consider later, but we may here simply indicate that, when specifically contaminated, sewer gas may convey specific diseases to individuals. Typhoid fever, although not usually transmitted in this fashion, may, however, be caused by sewer gas containing the Eberth's bacillus being inhaled, and the organisms getting deposited on the saliva and thereafter conveyed to the intestinal canal.

The dead bodies of animals decaying in the open air, human excrementitious matter deposited on the ground, organic matter from grave-yards, &c., permeating the soil may evolve gases capable of polluting the air. Similar gases may arise from the surface of polluted rivers, especially where the flow is sluggish, owing to deficient fall to the sea, tidal variations, &c., or when the season has been particularly dry. Rivers polluted by organic matters are partially purified by oxidation, vegetable growth, fish, and by the subsidence and settling to the bottom of some of the impurities. Complete purification by those natural means can only be attained when the river is of great length, and in this country the water of organically polluted rivers is not purified until after it has reached the sea, because our rivers are so short.

3. Inside dwelling-houses the air is liable to be vitiated by the combustion products incidental to the methods of ARTIFICIAL LIGHTING AND HEATING. The chief illuminants employed are COAL GAS, PETROLEUM OIL, and ELECTRICITY. Of these, the latter may be said to be without effect on the atmosphere of rooms. For domestic purposes the light is produced by the electric current being passed along a filament of platinum wire enclosed in a glass globe, which is either devoid of air or is filled with nitrogen gas. The resistance offered to the passage of the electricity along the platinum wire causes the latter to become incandescent, and, there being no oxygen present in the globe, no combustion takes place. The light so produced is good and steady, the air in the apartment is not used up, and the amount of heat imparted to the air is a negligible quantity. No dust or dirt is produced by these incandescent lights, and their sole drawback is that at present the expense exceeds that of petroleum and coal gas.

PETROLEUM OILS are used to a considerable extent both in town and country, and the light produced is steady and bright. The danger of explosion is now greatly reduced by the many improvements which have been made in the construction of the lamps. These improvements are in the direction of ensuring more complete combustion of the oil by better methods of bringing air into contact with the flame, and in providing easy extinguishers, some of which are made to act automatically when the lamp by any accident is overturned. These petroleum oils possess different flash points, the flash point being that temperature at which the petroleum begins to give off inflammable vapour. The law provides that petroleum oils used in this country must not have a flash point lower than 73° F. (100° F. was the limit previous to 1879).

A lamp burning 300 gr. of petroleum oil per hour gives off 1 cubic foot of carbonic acid gas, besides other products of combustion, viz., carbonic oxide (CO), sulphur compounds, soot and heat.

COAL GAS consists of a mixture of marsh gas, hydrogen, carbonic oxide, acetylene and ethylene, a little carbonic acid and traces of other substances. Some gas corporations add a certain proportion of *water gas* to the coal gas. WATER GAS is a mixture of hydrogen and carbonic oxide (CO), is cheaply prepared, and is possessed of considerable heating power. It is easily produced by passing steam over incandescent carbon-containing material. Coal gas produces by its combustion the following substances—nitrogen, carbonic acid, carbonic oxide, sulphurous acid, a little ammonia, water vapour and heat; and 1 cubic foot of it produces by combustion nearly 2 cubic feet of carbonic acid or anhydride. Soot also results from the burning of gas, and its amount depends upon the completeness or otherwise of the combustion. This soot, resulting from the burning of coal gas and petroleum oils used as illuminants, passes off into the air of the room and becomes deposited on the walls and ceiling, and shows after a time on these places as discolorations and dirty marks on the paint and wall paper.

The carbonic oxide (CO) produced when the combustion of coal gas is imperfect (and occurring to a small extent in ordinary coal gas and to a great extent, namely over 30 per cent., in water gas) is possessed of highly poisonous properties. Less than 1 per cent. added to the air of a room has been known to cause a fatal result. The reason why it is specially dangerous is that when respired it gains ready access to the blood and not only displaces the oxygen of oxyhæmoglobin (HbO_2) from its combination with hæmoglobin, but forms a new compound ($HbCO$). This combination is a very stable one, and can only with difficulty be broken up. Artificial respiration, and the transfusion of blood and saline solution are the agencies made use of in cases of poisoning with this gas. On account of the large proportion of carbonic oxide in water gas, the use of the latter in admixture with coal gas is attended with some danger, because carbonic oxide is practically odourless, and should an escape occur it is not so quickly detected as an escape of coal gas is, and it is far more lethal. Coal gas, then, when burned in a room as an illuminant sets free into the air of the room a considerable quantity of vitiating substances, and it has been estimated that an ordinary gas jet will vitiate the atmosphere more than the respiration of two adults.

Accidental escape of coal gas is an occurrence liable to happen occasionally from carelessness or defect in the pipes. A considerable escape readily makes its presence known by its characteristic smell, but minor escapes are not so readily detected in this manner, nor is the attention so easily attracted to the escape of coal gas mixed with much water gas. The escape of a large quantity of gas, occurring as it often does during the night, is liable to cause asphyxia. A small escape of gas may pass unnoticed for a time, but ultimately produces an effect on the general health, in the way of feelings of lassitude, headache and sore throat.

The various *gas burners* in common use differ not only in regard to their lighting power, but also in the proportions of unconsumed carbon and heat which they give off. The usual burners used are the *fish-tail* and *bats-wing* patterns, which have a flat flame with an expanded yellow luminous portion at the upper region of the flame. Much more luminous but more trying to the eyes and at the same time evolving more heat is the *Wellsbach burner.* This consists of a small bunsen flame, the heat of which renders incandescent a mantle composed of asbestos gauze and sulphide of zirconium. The mantle is surrounded by a glass funnel. This burner is in extensive use, and consumes little gas, comparatively speaking, and is most luminous. The mantle, however, is extremely brittle and readily breaks, and for this reason the greatest care must be employed in using it, else it becomes a very expensive illuminating agent. The *Argand burner* consists of a circular piece of porcelain whose rim is perforated by small apertures; air passes up the centre of the ring of porcelain; the gas escapes at the little apertures, and when lighted the flame is surrounded by a glass funnel. The flame is circular, is bright and economical, but a good deal of heat and dirt are produced by it.

All these burners permit the products of combustion to escape freely into the room, but this is obviated in the *Siemen's regenerative burner,* in which the products are all removed by a special ventilator; the light given by this burner is good.

THE COMBUSTION OF FUEL for the purpose of heating rooms is of much importance in relation to the ventilation of dwelling houses. The products of combustion being removed up the chimney do not vitiate the air, although open coal fires are liable to produce a good deal of dust, the amount of which depends upon the kind of coal employed, and this dust makes the room dirty if it does not vitiate its atmosphere. The fuel burnt, however, requires oxygen, and consequently the air is attracted towards the fire in large amount, and to replenish this loss of air, fresh air is drawn into the room by every possible means of entrance. It is reckoned that 1 lb. of coal requires over 240 cubic feet of air for its complete combustion (Parkes).

Artificial heat in rooms becomes a necessity in climates where the temperature is not by natural means at or about 55 to 60° F.

The usual method of obtaining this artificial heat is by the use of open fires which supply heat by RADIATION, that is to say, by the heat passing from warmer bodies to colder ones through the air, which is not itself heated. Most of the heat generated in open fires passes with the combustion products up the chimney, but a certain proportion of it radiates out into the room and warms the occupants. Of course all parts of the room are not equally heated, for the amount of heat given out by radiation has been found to be inversely as the square of the distance of the object to be heated from the fire. Thus an object 4 feet distant from the fire will receive $\frac{1}{16}$ the amount of heat of an object 1 foot from the fire. In order to get as much heat as possible thrown into the room with the least consumption of fuel, grates have been constructed of late years with certain improvements. The old iron and steel grates with wide chimneys and open firebars are now discarded in favour of grates having as little metal in their construction as possible. The fire places are constructed with fire-clay backs and sides built in with brickwork, and at the sides of the grate the brickwork is faced with glazed tiles; the firebars in front are vertical and set fairly close together, while the space between the front of the bottom of the fire and the hearth is closed by a movable plate so as to diminish and regulate the supply of air to the bottom of the fire and thereby the rapidity of combustion. Moreover, the fire-clay back is sloped forward and upward from the back of the fireplace towards the chimney throat which is narrowed before opening into the wider chimney above (Fig. 1, B). Such grates modelled on the plan of the Marlborough or Grosvenor "interior" are very economical of fuel and at the same time undoubtedly give a very much greater heat than the old metal grates.

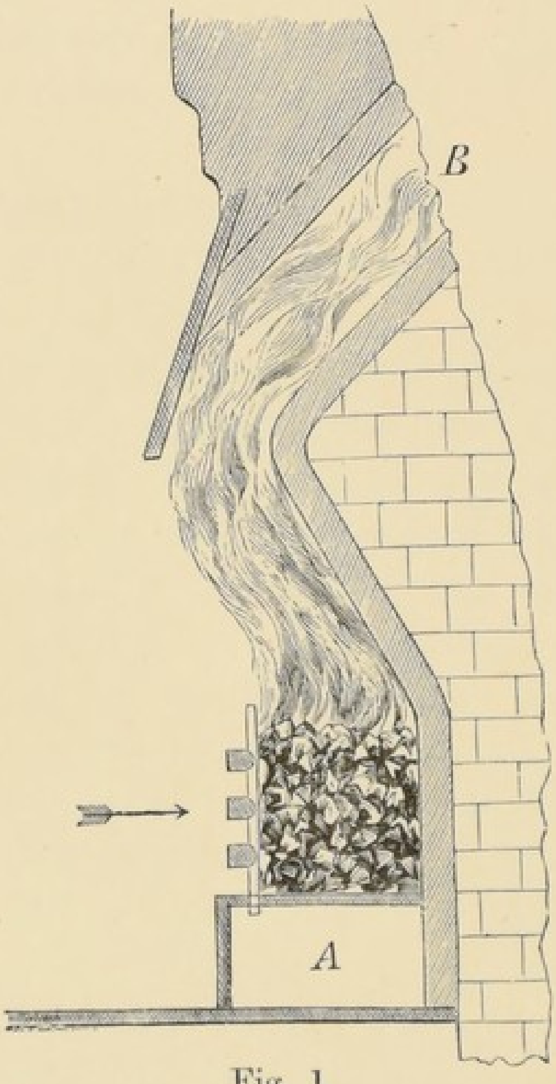


Fig. 1.

In Galton's hot air grate, the fresh air for the ventilation of the room is led in at the back of the grate and so heated before being admitted to the room at a higher level between the fireplace and the ceiling.

OPEN GAS FIRES are often employed on account of their convenience and their cleanliness. The coal gas is led to a row of Bunsen burners, the flames of which play on a surface of cast-iron work or on asbestos lumps and heat these up to a high temperature. These gas fires give out a good heat and the products of combustion are conveyed up the chimney as in the ordinary open coal fire. Water gas would be specially appropriate for use in this way on account of the great heat its combustion produces, but the dangers attendant on its escape into rooms are excessive as we have already seen.

STOVES, HOT WATER and STEAM PIPES are frequently made use of for warming rooms, warehouses, &c., and effect this purpose by heating the air which comes in contact with them. The heated air rises in virtue of its expansion and diminished specific gravity, and cold air descending to take the place of the heated air becomes warmed in its turn. The air is thus heated by CONDUCTION and CONVECTION — "conduction" meaning the conveyance of warmth from one air particle to another, "convection" being the conveyance of heat resulting from the ascension of heated air into the upper parts of the room, and causing the descent of colder air which in its turn gets warmed and in its turn ascends.

The warming of the room is economically carried out in this manner, but the air is very liable to feel dry, as with the increase of temperature of the air its relative humidity decreases, and more moisture is required to keep the relative humidity at the same level; so that if more moisture is not added to the air, the air which has gained in temperature will appear to the senses to be drier. By placing a small vessel containing water on the stove or hot pipes a sufficient amount of water is vaporised into the air and the air is kept comfortable. An unpleasant feature of stoves, &c., is an objectionable smell they give rise to, and which is probably due to the charring of organic matters in the air. This cannot be avoided in any way however. It has also been suggested that the smell is in part due to the production of a little carbonic oxide gas in the air owing to the action of the heat on the cast-iron work of the stove. Stoves lined with fire-clay are free from this production of carbonic oxide.

For the heating of factories, &c., STEAM is easily obtained from the boilers supplying the machinery and is a satisfactory and economical method of warming the establishment.

Hot water is utilised for heating purposes under two systems, viz., the High and the Low Pressure systems. PERKIN'S HIGH PRESSURE SYSTEM is carried out by means of thick walled and narrow iron pipes which pass directly through a furnace, are carried throughout the building which they are warming, and return to the furnace. The water in these pipes can be raised to a temperature of over 300° F. In the LOW PRESSURE SYSTEM the water is heated in a boiler, passes along wide iron pipes through the building and returns to the boiler. An escape pipe is carried from the top of this system to the outer air to permit the escape of the superfluous steam. The water circulates in the pipes at a temperature ranging about 200° F.

For the purpose of hot water pipe heating, the water ought to be as soft as possible, as incrustation with lime tends to diminish or actually occlude the calibre of the pipes, and may lead to the pipes bursting. Further, if the supply pipe to the boiler be occluded by this incrustation or by freezing, a similar result may occur, though the latter cause can be obviated by the use of a hot water cistern supplying the boiler.

4. Besides the impurities tending to vitiate the atmosphere from respiration, illumination, &c., it is necessary to refer to the possibility of harm which may arise from the presence of DUST suspended in the atmosphere of a room, or lying in collections about its walls, furniture, &c. Dust may be highly detrimental to health, and it is derived from many sources. It is blown about in the streets of towns, is carried into dwelling-houses by open windows and doors, is brushed off the clothes, &c., of the occupants of the house. Part of it is derived from the combustion of fuel in open grates. Mixing with the atmosphere of a room, it tends to find a lodgment in all the corners of it, on cornices, on furniture and curtains, on rough surfaced wall paper, carpets, &c. Its presence is unavoidable and it may be deleterious to health, but its potentiality for evil can be greatly reduced by systematic and careful cleanliness whereby no dust is permitted to find more than a very temporary lodgment. The furniture should be as simple as possible, carpets should only be used where they cannot be dispensed with, polished floors covered with mats being healthiest in bedrooms, or floors covered with linoleum or cork carpets; the walls should be oil painted, or covered with a smooth paper afterwards varnished over, and care should be taken that no old paper is left on the walls underneath a new paper. Oil painted walls are particularly healthy because they can be washed with soap and water from time to time and their smooth surface

does not collect dust. The size and paste used by the painters ought to be perfectly freshly prepared.

Dust is not only harmful because of its presence as a foreign body in air, but it may be specially deleterious by having associated with it the germs of disease, such as those of Phthisis, Erysipelas, &c.

5. Vitiation of the air by MANUFACTORIES, TRADES, &c. In the vicinity of large works, and especially near certain works, it is common for the atmosphere to be greatly contaminated. Dense volumes of smoke are emitted from the furnace chimneys, conveying into the air mechanical and gaseous impurities resulting from the fuel combustion. As the chimneys are high, the smoke is carried far and wide and the soot is distributed over a wide area, while the gases are thoroughly diluted and diffused by the air. GASWORKS emit unpleasant smells from the various derivatives of coal distillation and which constitute some of the impurities of coal gas. The odour is penetrating, and slightly acrid, irritating the nasal and pharyngeal mucous membranes, and renders the neighbourhood of gasworks a place to be avoided. Large gasworks in towns are not infrequently situated in the centre of a poor and crowded population, and the constant impregnation of the air with the gaseous emanations tends to cause diminished appetite, feelings of sickness, and, by lowering vitality, is liable in an indirect manner to lead to ill-health.

Hydrochloric acid vapour is evolved from *Chemical and Alkali works,* owing to imperfections in the arrangements used for preventing its escape into the atmosphere. The volatilised hydrochloric acid becomes dissolved in the moisture in the air and falling on the soil tends to destroy vegetation in fields, &c., in the neighbourhood of the works.

Slaughter-houses constitute a source of much annoyance to persons who dwell near them. The odours arising and issuing from them are very far from pleasant, and in the air in their vicinity large quantities of hair, debris, &c., can be detected by microscopic examination. It would be difficult to assert that the odours by themselves are a direct cause of disease, but it can hardly be doubted that they predispose to ill-health on account of the nausea, disgust and anorexia produced by the continued breathing of the malodorous air.

Many *indoor trades and industries* are particularly injurious to the employés engaged in them, on account of the air being contaminated in a special manner according to the nature of the industry. The absence of adequate and efficient means of ventilation in a workroom is alone an important cause of ill-health, and may serve to predispose to phthisis; this is particularly the case in the case of clerks, bookbinders, &c., who are confined in close rooms all day, where often gas is the chief illuminant, and the air comes very decidedly below the requisite standard of purity.

When, in addition to the impurities accruing from respiration or illumination, or both, there is added the "trade impurities" then the effects may become very marked and serious. The fine dust given off into the air in cotton factories, in wool-sorting establishments, and in cloth and shoddy mills, causes *bronchitis* among the operatives, and woolsorters are exposed to the additional risk of *anthrax*.

Lead poisoning is liable to occur among potters, painters, printers, and plumbers.

Workers in brass frequently suffer from what is called *brassfounder's ague*, so called because it is associated with shivering and fever, nausea, vomiting, diarrhœa, and bronchitis. These effects are due to the inhalation of the copper and zinc particles which constitute brass, and seem to occur in the apprentices and younger hands most severely, although they may also be manifested in the older mechanics. The symptoms can be alleviated by drinking milk freely.

Wall paper manufacturers and makers of artificial flowers are liable to *arsenical poisoning*, and amalgam workers and mirror-makers are prone to suffer from *mercurial* poisoning.

In rubber factories *bisulphide of carbon* vapour is inhaled by the workers and is the cause of serious loss of health. Its effect is to produce sickness, nausea, headache, drowsiness, with unrefreshing sleep at night. In addition, it has a direct *toxic* effect on the nerves and nerve centres, producing staggering gait, loss of knee jerks and signs of neuritis resembling the alcoholic type: amblyopia and even amaurosis occur, or else limited field of vision. The cause of the eye symptoms is regarded by some as being due to actual optic neuritis, but the cases often present more resemblance to toxic amblyopia, similar to that due to tobacco. Occasionally epileptiform seizures occur, and vertigo is not infrequent.

Potassium bichromate workers are prone to suffer from necrosis of the nasal cartilage with concomitant ulceration of the nasal mucous membrane.

Match-makers used formerly to suffer extensively from *phosphorus poisoning* ("Phossy-jaw") in which the lower jaw undergoes necrosis. These patients suffer from dental caries, and Stockman has shown that the necrosis is associated with the presence of tubercle bacilli. The occurrence of phosphorus necrosis has been greatly diminished by providing adequate ventilation and removal of contaminating matters from the atmosphere of the work-rooms, and by the introduction of safety matches, for the manufacture of which amorphous non-poisonous phosphorus is used.

MICRO-ORGANISMS IN AIR.

In most samples of air abundant evidence of organisms can be found, and they include bacteria, and the spores of fungi, moulds, &c. They are detected by drawing air through a tube or cylinder whose inner wall has been provided with a coating of nutrient medium. These spores speedily form colonies under suitable temperature conditions, and the more foul the air is from respiration and other causes, the more bacteria are found to be present in the sample of air.

Pathogenic bacteria and bacilli are found in the air of hospital wards, and staphylococci and streptococci have been frequently demonstrated. In the air and dust and on the wall-paper, &c., of a room occupied by a phthisical patient tubercle bacilli can be demonstrated without great difficulty.

In hospitals it is usual to find that air which contains staphylococci and streptococci can also be shown to contain an abundance of pus and epithelial cells.

INFLUENCES tending to REMEDY THE VITIATION OF AIR, which is incidental to life, are very numerous. Healthy life is only possible when there is a periodic removal of the vitiating gases and substances and a free supply of fresh air. In the open air this is speedily brought about by the operation of the law regulating the *diffusion of gases*, by *winds*, the downfall of *rain*, changes of *temperature, sunlight*, and *vegetable growth*. Inside houses interchange of fresh for vitiated air occurs by the diffusion of gases and changes of temperature, the heated expired air rising upwards and seeking an outlet, while cold fresh air comes in to occupy its place: by winds driving pure air into and through the house and acting as extractors by aspiration of the foul air from it.

These natural means of air removal and renewal are largely utilised in the ventilation of houses, and are by certain mechanical contrivances rendered serviceable under the varying atmospheric conditions, as will be shown later.

The action of the SUN in assisting in the purification of air is readily appreciated in the absence of its salutary effects, for it is a common experience that the want of sunshine favours damp and renders the air more chilly, and, in addition, favours decomposition and the liberation of foul gases. It is well known that sunlight has a prejudicial influence on the growth of many kinds of micro-organisms, which not only may cease to grow when exposed to the sun but may actually die. Moreover, sunlight, besides obviating the above mentioned insanitary conditions, exercises another important effect on the health of a community. It tends to enliven and brighten the individual, making him feel more vigorous, while its absence often has the opposite effect, rendering him depressed in spirits, lowered in energy and vitality, and therefore diminished in his resistive power to disease. The beneficial action of the sun on the hæmoglobin of the blood can be abundantly observed in the study of the treatment of Chlorosis, sufferers from which readily begin to improve when placed under favourable conditions as regards sunlight, while at the same time use is made of other suitable therapeutic agents. The sun's rays also produce a considerable degree of warmth by heat radiating out from the soil.

BREEZES AND WINDS are largely due to the action of the sun, whose heat warms the air in certain regions and causes it to expand and ascend in consequence: colder air then rushes along to occupy the space thus vacated, with the result that a wind-current is produced by this motion of the air. In the production of winds the sun is aided by the different rate of motion of the earth's surface at the different latitudes, the earth moving fastest at the equator and with diminishing rapidity as the North and South poles are approached.

RAINS purify the atmosphere mechanically by washing down the suspended particles in the air and dissolving some of the gases it comes in contact with. Moisture is continually being evaporated from the surface of the earth, and rises up into the air. This is due to the fact that the warmer air is, the more moisture it can and does actually take up whenever opportunity affords. That is to say, the humidity of the air is greater at higher than at lower temperatures. When air has taken up all the moisture it can, it is said to be SATURATED.

RELATIVE HUMIDITY is the term used when we wish to compare the amount of moisture in a given sample of air at a given time and temperature with that amount of moisture it could contain if saturated. Thus the amount of moisture which would cause relative humidity at a certain temperature would at a *lower* temperature cause saturation. When the temperature of the air descends to a point at which the air is saturated by the amount of moisture already in it the temperature is called the DEW-POINT. The relative humidity of the air is ascertained (by means of tables) from the readings indicated on the *dry* and *wet bulb thermometers*, the latter of which commonly gives a lower reading than the former. The bulb of the wet bulb thermometer is covered by a piece of muslin which is kept moist by having one end lying in a little vessel of rain water whence it draws up moisture by capillary attraction. So long as the air is not saturated with aqueous vapour so long will it take up moisture from the wet muslin, and as the process of evaporation on the surface of the bulb causes loss of heat, the wet bulb thermometer accordingly reads lower than the dry bulb thermometer. When both dry and wet bulbs record the same temperature then the air is saturated with moisture, and the temperature recorded is the dew-point.

When air, whose degree of humidity is such as to render it pleasant to breathe, gets heated, it appears to have become too dry, owing to its relative humidity having been lowered by the increase of its temperature. When, on the other hand, air with a certain degree of humidity gets cooled, *e.g.*, by contact with a mountain, its moisture reaches saturation point, and, if further cooled, it deposits its moisture. The moisture is deposited on solid particles as *dew*, and in the air as *mist*, *rain*, or *snow* according to the state of the temperature. *Fog* differs from mist in that it is usually the effect of the admixture of cold air with hot over-moist air, and is particularly dense when there is much solid matter in suspension in the air, the particles of moisture clinging to the solid particles.

The amount of rainfall is measured by an instrument called a *rain gauge*. This consists of a rain receiver placed on the ground in an open space, the rain being conducted into the receiver by a circular funnel whose upper edge must be quite horizontal, and whose receiving area is usually 50 square inches, or as recommended by the meteorological department the diameter of the rim is 8 inches. At stated intervals the rain collected is poured into a graduated glass measure marked off into divisions, each of which indicates a fall of 0·01 inch of rain. 1 inch of rain per acre = 22,622 gallons of water.

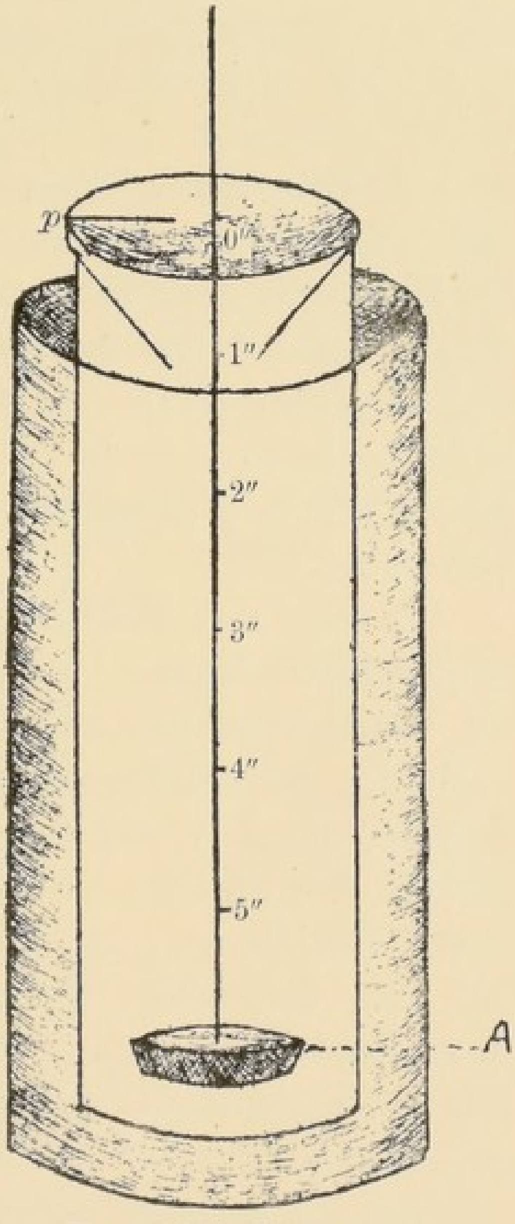


Fig. 2.—Rain Gauge.

Another and a very simple form of rain gauge consists of a zinc cylinder 2 feet long, and 2½ in. in diameter, having a brass rim at its upper, expanded end. The cylinder is placed in the ground inside another zinc cylinder or shield, and is so fixed that the brass rim is perfectly horizontal. Its diameter is 5 inches. Inside the cylinder is placed a float (Fig. 2 A) from which rises a strip of thin brass marked off at intervals. From the edge of the brass rim there projects a pointer (p), and as the rain falling into the cylinder causes the float to rise, the brass strip indicator rises also, and the pointer, placed at zero on the indicator, marks off the degree of ascent of the float. Every 4 inches marked off on the indicator = 1 inch rainfall.

Having indicated in what manner air is by natural means altered and purified, we can now turn to the consideration of the METHODS OF VENTILATION which must be carried out in dwelling-houses, large buildings, &c., to secure a pleasant and healthy atmosphere to the occupants.

We have seen that ordinary atmospheric air contains ·4 per 1000 volumes of carbonic anhydride (CO_2), and we found that an additional ·2 per 1000 volumes of carbonic anhydride was still tolerable for respiration, but that anything above a total of ·6 per 1000 of carbonic anhydride *in the presence of putrescible organic matter* was obnoxious and dangerous to the persons breathing the air. Supposing then that one person occupies a room containing, say, 1000 cubic feet of air, he gives out as the result of ordinary respiration ·6 cubic feet of carbonic anhydride* in the course of an hour. As the *additional* carbonic anhydride impurity in a room of 1000 cubic feet compatible with comfort and health is ·2 cubic feet, it follows that the exhalation of ·6 cubic feet of carbonic anhydride in the course of the hour is

---

* ·6 cubic feet is the amount of CO_2 exhaled by an *adult* every hour.

three times in excess of what the standard requires there should be. In consequence, to maintain the atmosphere at the requisite standard limit, the air in the room of 1000 cubic feet should be changed *thrice* in the course of the hour. Or, to put it in another way, 3000 cubic feet of fresh air would be required to reduce the ·6 cubic feet of added respiratory impurity to the ratio of ·2 per 1000, because ·6 per 3000 = ·2 per 1000.

The following formula will readily show what is conveyed by the above statement:—Let a = the carbonic anhydride impurity *added in an hour* to the air in the room, and let b = the limit of carbonic anhydride impurity per 1000 volumes consistent with comfort, then

$\frac{a}{b}$ = the number of times the air must be changed per hour to maintain a proper standard of purity.

Thus, when one person living in a room of 1000 cubic feet exhales ·6 cubic feet of carbonic anhydride per hour the air must be changed three times, because

$$\frac{a}{b} = \text{the number of times of renewal,}$$

$$i.e., \frac{\cdot 6}{\cdot 2} = 3,$$

and if the room be one of 1000 cubic feet, a total amount of 3000 cubic feet of fresh air has been admitted.

It must be borne in mind that more carbonic anhydride is given off by an individual when he is doing physical work; and, in calculating the renewal of air necessary for the adequate ventilation of workshops, due allowance must be made for the factor of the work and exertion of the occupants of the workshops.

Asssuming then that 3000 cubic feet of air per hour and per person is necessary under ordinary circumstances, a room of 1000 cubic feet will have to renew its air thrice every hour, a room of 500 cubic feet six times per hour, and so on. But when the necessary times of renewal come to exceed a certain number, say five times, per hour, *draughts* begin to be produced owing to the necessarily rapid admission and circulation of air, and they are apt to become very perceptible when the room is small and the air admitted is not warm. Draughts also occur when the air inlet is not at a higher level than the heads of the occupants of the room.

It is possible to avoid the occurrence of draughts and yet have a room thoroughly ventilated six times an hour by due attention to the following points, viz., 1. Let the inlet be placed above the level of the heads of the occupants of the room. 2. Let the incoming air be directed upwards towards the ceiling, where it gradually diffuses itself among the other air of the room, and gently falls to lower levels and is inspired. 3. Let the renewing air be warmed before it is admitted to the room. 4. Let there be a suitable outlet for the escape of the vitiated air.

The used air passes away largely by the fire-place and chimney, especially when a fire is burning; part of it also rises to the ceiling, and an exit provided near the cornice will readily remove much of it.

Allowance of Cubic Space.—Although no doubt it is very desirable that there should be 1000 cubic feet of space for each occupant of a room, this is not always feasible when several persons are occupying a room, and less has often to suffice. Accordingly we find that in common lodging houses, an average of 300 cubic feet per person, and in barracks 600 cubic feet per person are allowed; and these allowances, if not ideal, still are fairly satisfactory. It must not be forgotten, however, in relation to the cubic capacity of a room, that the requisite number of cubic feet may be contained in a certain room, by the walls of the room being more than usually high, and yet in such a room free and thorough renewal of air will not readily take place; and for this reason: the expired vitiated air being warmer than the purer and colder air near the ceiling rises upwards, comes in contact with the cool pure air, and becoming itself cooled, it falls down again to be once more respired by the occupants of the room. Moreover, the organic impurities tend to collect in the lower strata, when for any reason they are not at once removed with the vitiated air, and in consequence the impurity of the air in the vicinity of the occupants of the room is altogether out of proportion to the actual air capacity of the chamber. On the other hand, the ceiling must not be too low, else the air in the room will become very easily heated even near the low ceiling, and will be very unpleasant on account of the loss of its freshness and coolness. The height of the walls ought not to be less than 8 feet, and should not exceed 12 or 13 feet, in order to admit of the maintenance of a healthy purity of atmosphere.

The amount of *floorspace* allowed to each person in a room is of importance in relation to the vitiation of the air by respiration, &c. The essential amount per person is not always the same, as we have to consider in estimating the amount and the purpose for which the room in question is being employed. For instance, in an hospital ward, 90 to 100 square feet per person is allowed, whereas in common lodging houses, 30 square feet are considered adequate. Speaking generally, the amount ought in no case to fall below $\frac{1}{12}$ the total cubic capacity of the room.

To be healthy, a room ought to be provided with at least one window opening directly to the open air and reaching 7½ feet from the floor, and so constructed that both the top and bottom sashes can be opened. The area of the window should be $\frac{1}{10}$ that of the floor. In small dwelling houses, there is often a small interior room, used as a bedroom, which is usually provided with borrowed light and air from an adjacent apartment, and it opens either off the lobby or one of the other rooms. Free ventilation in a room of this kind is practically an impossibility, and when the room has no opening out into the lobby but is reached from an adjacent room, the air is always decidedly impure, and tends to be stuffy and hot.

Fresh air is always entering the rooms of a dwelling house, even when the usual apertures are all closed, by chinks at the sides of the windows, under the doors, along the skirtings, &c., and is discharged up the chimney whether a fire is burning there or not. By this unceasing circulation of air, a fairly good natural plan of ventilation is always in operation. It is not sufficient, however, particularly if the house is inhabited, when, in order to ensure thorough and complete ventilation, it is necessary to have recourse to more ample methods. Of these the action of PERFLATION OF WIND is of the greatest value. By opening the window of a room on that side from which the wind is blowing a goodly supply of air is at once driven into the room; and when in addition the door or, if it exists, a window on the opposite side of the room be left open, this action of the wind is greatly assisted. This means of ventilation is rather inclement, however, when the wind is high, or the outside temperature low, and is as a rule only utilised to rapidly change the air of an empty or disused room. The principle of *perflation* is made use of in ships, by the erection of a large cowl to face the wind: fresh air is thus received into it and is then conducted throughout the lower parts of the vessel, while the bad air is collected and led towards another cowl placed on deck, and so disposed that it faces away from the wind, which now acts as an abstracter of the vitiated air. Such a method is practically applied to the ventilation of a house by *Sylvester's plan,* whereby air collected in similar manner is heated, distributed to the various rooms, collected again after vitiation, and finally led to an exhaust-cowl placed on the roof of the house.

Various mechanical arrangements have been devised to ventilate rooms by the adoption of the principle of perflation, and these contrivances aim at securing an ample renewal and interchange of air, with the avoidance of draughts. It is accomplished by regulating the rate of ingress of the air, by admitting it into the room at a level higher than the heads of the occupants, by causing the fresh air to gently diffuse itself throughout the room, and in some cases by heating and even purifying it before allowing it to enter. Escape of the used-up air is provided for, either by making exits opening near the ceiling, or into the upper part of the chimney, while often the exit afforded by the fireplace and chimney alone is trusted to. Exit openings made into the chimney are guarded from reflux of smoke into the room by a set of suitably adjusted mica plates allowing gases to pass into, but not out of the chimney. Occasionally, however, these get defective and inoperative, and annoyance is caused by smoke coming into the apartment. The rattling of the mica plates is objected to by some, but in reality this is a very trifling inconvenience. Another way is to have the vitiated air escaping by a flue placed immediately beside the chimney, the heat of which is imparted to the air in the flue, causing it to become expanded, become lighter, and ascend, and so escape to the outside.

Various *extraction cowls* which utilise the aspiration of the wind

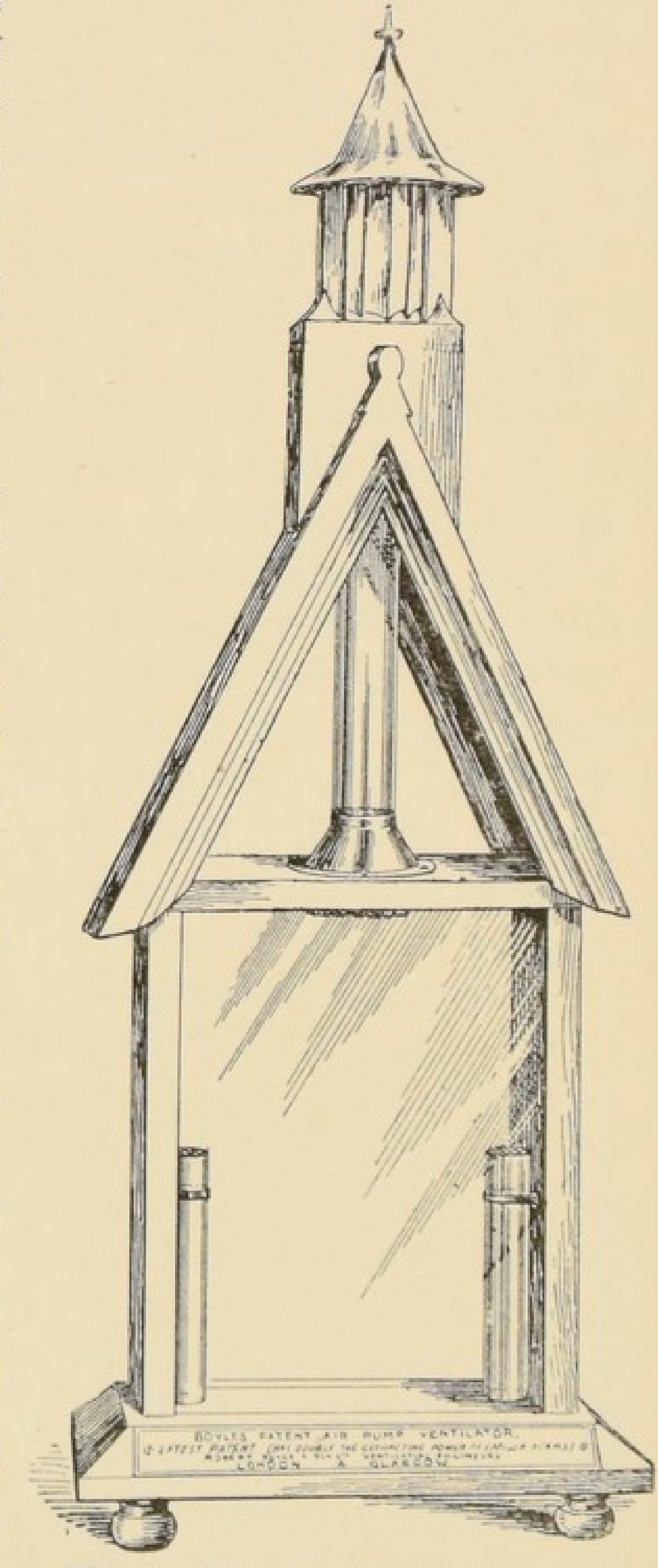


Fig. 3.—Diagram of Boyle's System.

to withdraw vitiated air from buildings have been devised. *Boyle's cowl* is highly spoken of, and forms part of a special system of ventilation, being used in conjunction with a special fresh air inlet arrangement. Boyle's system, shortly, consists of air inlets admitting air through the walls of the building, and sending it at a low velocity into the room in an upward direction towards the ceiling. The air can be previously purified and warmed or cooled as may be rendered necessary by the outside temperature. The exhaust or air-pump ventilator, fitted on the roof of the building, consists of an arrangement of metal plates placed at certain angles, enclosing a central chamber, to which the vitiated gases are conducted, and from which they are exhausted through a series of protected openings. An induced draught and a partial vacuum are produced by the working of this arrangement, while at the same time the atmospheric pressure in all weathers is removed from the top of the ventilating shaft, and there is thus attained a continuous upward current and free escape of vitiated air. The accompanying figure will at once illustrate the working of this ventilation system.

TOBIN'S TUBES are frequently employed, and consist of wooden casings placed at the sides of the room. Air passes into these through the lower part of the wall and escapes from them in an upward direction towards the ceiling, whence it gently falls to be breathed by the occupants of the room. The air may be purified in Tobin's tubes by passing through cotton wool, or by being deflected down as it comes through the wall on to the surface of a water tray.

SHERINGHAM'S VALVE.—In this arrangement the air inlet in the wall is covered by a perforated metal plate; the air passes through this inlet, and is directed upwards and into the room by a hinged valve, which can be raised or lowered at will.

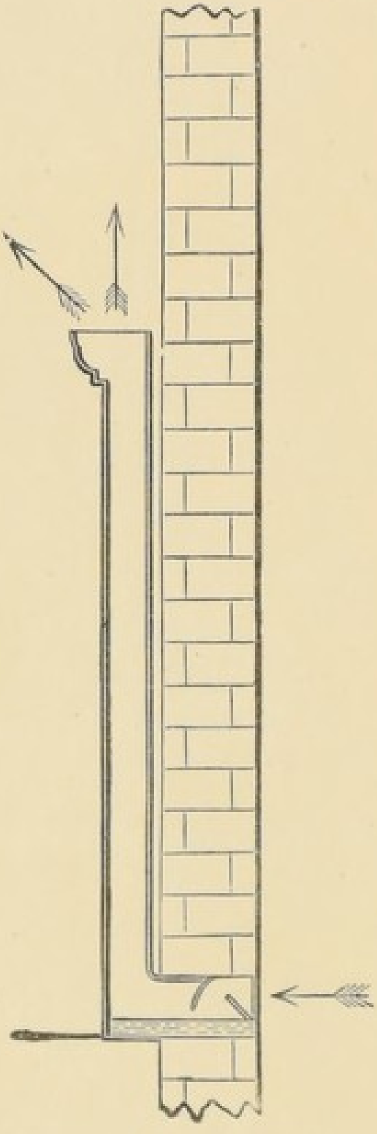


Fig. 4.
Tobin's Ventilating Tube.

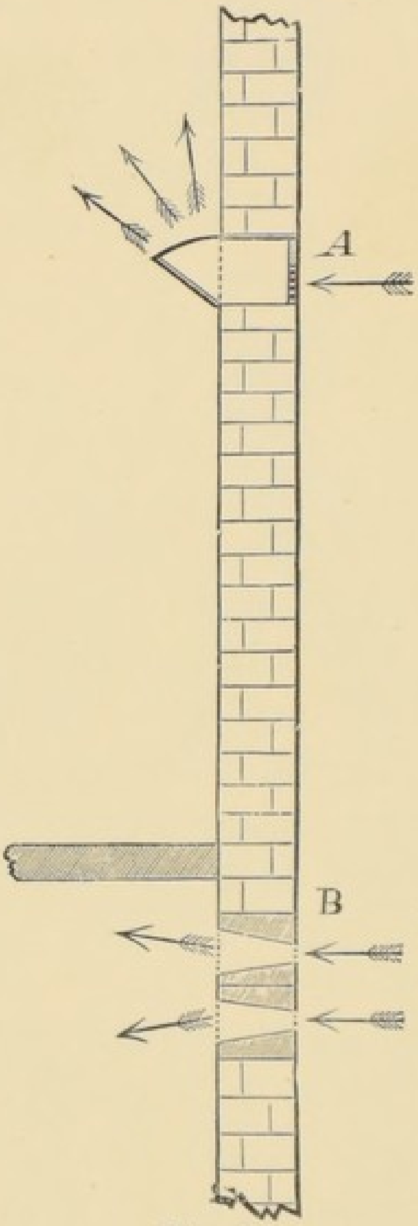


Fig. 5.
A, Sheringham's Valve.
B, Ellison's Conical Bricks.

ELLISON'S CONICAL BRICKS are let into the wall and are perforated. The perforations are unequal in diameter as they pass through the brick, the size of the outer aperture by which air is received being smaller than that on the inner side admitting the air into the room, so that the air is diffused better. The outer aperture is $\frac{1}{5}$ inch in diameter, the inner one being $1\frac{1}{4}$ inch.

On a smaller scale similar results may be achieved by the use of LOUVRED PANES, in which one of the window panes is formed of a series of imbricated, horizontal strips of glass, the upper edge of each strip overlapping the lower edge of the strip immediately above it, and each strip is so fitted as to be capable of being rotated so as to approximate close to, or diverge from its neighbour. In this manner air is admitted between the strips and diverted towards the ceiling, and when the wind is strong the strips can be easily approximated, so close, indeed, that no air may be allowed to enter at all.

Sometimes *double panes* are used, the outer pane being deficient in length below, the inner one deficient at its upper edge. The air accordingly enters at the lower free edge of the outer pane, passes up between the panes, and escapes into the room by the upper free edge of the inner pane (see Fig. 6).

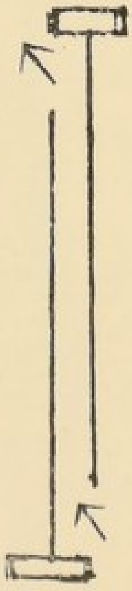


Fig. 6. Double Pane

A simple contrivance and one of considerable practical utility is that of HINCKES-BIRD. In this method the lower sash of the window is raised a few inches and a plain deal board is inserted to close the space thus created. At the junction of the two window sashes at the middle of the window there is now a space by which fresh air enters, and is, moreover, at once directed upwards toward the ceiling. This is an exceedingly simple and efficient method of thorough and rapid continuous ventilation, and has the additional advantage that it acts without creating a draught.

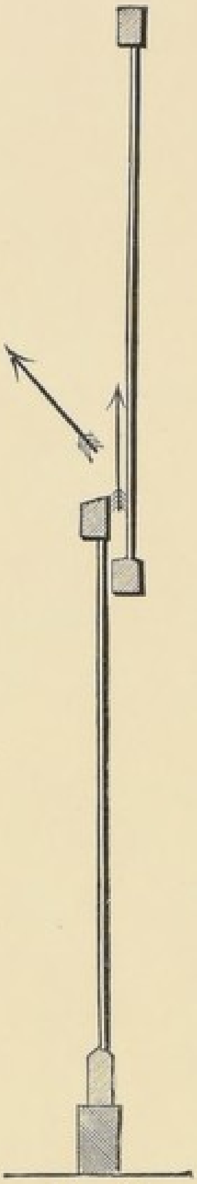


Fig. 7. Diagram of Hinckes-Bird's Method.

Under certain circumstances exits may become inlets, and conversely, as for instance, when the exit tube is too long, and the heated air gets cooled before it escapes and consequently descends into the room again. But generally speaking, this is not usual, and if adequate inlets and exits are present, a little attention will secure an efficient working of them.

McKinnel's Ventilator is composed of a double tube, placed in the ceiling of a room, or on the roof of the house, the inner tube being the longer and projecting above and below the ends of the outer tube. Air enters by the *outer* tube, and is directed along the ceiling for a certain distance by a flange on the end of the inner tube, before it is allowed to fall into the room. The vitiated air rises to escape by the inner tube, and to this end is assisted in some instances by a series of gas jets arranged under the inner tube. Such an apparatus can be employed advantageously for one-storeyed buildings and houses, but it has this drawback, that its working is often liable to be disturbed by a high wind blowing down the tubes, or by a strong fire burning in the grate, and converting all openings into the room into inlets, to supply a sufficiency of air for the combustion of the fire in the grate.

A useful application of the fact that an area of combustion draws air towards it is seen in the "*sunlight*" arrangement, whereby in large buildings a large number of gas jets are burned at the ceiling, and provided with a ventilating shaft placed above them for the escape of the resulting gases of combustion. Air is drawn up towards the burning gas jets and escapes up the ventilating shaft in connection with the jets, and consequently a valuable means is constantly in operation for the extraction of deleterious gases from the building, including of course the air vitiated by respiration.

In the ventilation of Mines the same principle is made use of and is found to be of much service. There are two main shafts, one of which is an inlet and the other an outlet shaft. At the bottom of the latter there burns a large fire, and towards it air is attracted from all parts of the mine. To occupy the place of the air thus removed from the workings of the mine, air is admitted to the mine by the inlet shaft, and by suitable arrangements, is caused to traverse all the parts of the mine before it is allowed to reach the furnace. The heated gases of combustion, tending to ascend, pass up the outlet shaft, and in this manner a very free circulation of air is maintained. The exhaustion of the foul air and combustion gases is in some cases aided by *rotatory fanners* placed at the top of the upcast shaft, and in other cases by the very efficient expulsive power of *blasts of steam* blown into the shaft.

Air is sometimes introduced into large buildings designed for the accommodation of many people by the method of PROPULSION, carried out by means of a gas or steam engine. The air is previously warmed or cooled, as the season of the year may render necessary, and can be delivered at any speed which may be required. In specially large buildings, such as the Houses of Parliament, special means of exit for the vitiated atmosphere are provided, other than ordinary fireplaces, &c., and the special method employed is often a large fire situated in the upper regions of the building, and towards which the extraction shafts lead the foul air.

AIR ANALYSIS.

The Quantitative Estimation of Carbonic Anhydride (CO_2). A fairly easy and ready, though not strictly accurate method is that of Dr Angus Smith, and is conducted by the observation of the behaviour of a certain amount (half an ounce) of lime water in bottles of different capacities.

If in a 15·5 oz. bottle of air the half-ounce of lime water shows *no turbidity*, less than 0·4 per 1000 CO_2 is present.

In a 10·5 oz. bottle, no turbidity, there is less than ·6 per 1000.

In a 8·5 oz. bottle, no turbidity, there is less than ·8 per 1000.

In a 6 oz. bottle, no turbidity, there is less than 1·0 per 1000.

The most usual *exact* method of determining the amount of carbonic acid present in air consists in absorbing the carbonic anhydride from a measured volume of air by means of baryta water, and finding the quantity of baryta thereby neutralised by titration with dilute standard acid—generally oxalic acid. As the alkalinity of the baryta water is reduced by the absorption by it of carbonic anhydride, it follows that it will require less oxalic acid to neutralise it after it has absorbed carbonic anhydride than it did previously. The oxalic acid solution is prepared so that 1 c.c. of it is equivalent in neutralising power to 0·1 c.c. carbonic anhydride. The baryta solution is so prepared as to be roughly equivalent to the acid, but does not require to be adjusted exactly, being standardised against the oxalic acid when in use.

The best "Indicator" is phenol-phthalein in 1 per cent. alcoholic solution. In alkaline solution this is rose-coloured, and is decolorised by acids. The smallest possible quantity of indicator should be used, just sufficient to distinctly tint the alkaline liquid.

There are various modifications of the method in use, all of which fall into two classes. In one, the air to be analysed is slowly aspirated through a measured volume of the baryta solution in suitable absorption vessels, such as Pettenkofer's tubes. The volume of air employed for the determination is obtained by measuring the quantity of water run out from the aspirator. After the air has been passed through it the baryta solution is poured into a clear dry bottle and allowed to stand till clear. The amount of acid needed to neutralise the baryta solution before and after this process gives the difference produced in alkalinity of the baryta by the carbonic anhydride in the air, and the difference of amount of oxalic acid used is proportional to the amount of carbonic anhydride present in the sample of air, and as it is known how much air has been used in the determination, a simple proportion sum will give the amount of carbonic acid as 1000 parts of air (see example).

In the second general method a bottle or flask of known capacity and provided with a suitable india-rubber stopper is filled with the air under examination, generally by blowing with a bellows. An accurately measured quantity of baryta solution is run in from a burette; the flask is then closed and allowed to stand for some time, with occasional agitation: thereafter the remaining baryta is titurated with the standard acid. The comparison of the baryta solution before and after the action gives the amount of carbonic anhydride in the sample of air, and a similar calculation is made as in the former method. For accurate work the volume of air must be corrected for temperature and pressure in the usual way.

The calculation will be understood from the following example:—

1 c.c. of standard solution oxalic acid=0·1 c.c. of CO_2.

1 c.c. of baryta solution=1·5 of acid (as found by a blank experiment).

Exact volume of sample of air=say, 2500 c.c.

Amount of baryta solution employed is 20 c.c.= 30 c.c. of acid (because 1 c.c. baryta=1·5 acid).

After exposure to CO_2 of air, 20 c.c. of baryta= 10 c.c. acid. 30 c.c.—10 c.c.=20 c.c.

$\therefore$ CO_2 in sample=20 × 0·1=2 c.c. $\because$ each c.c. of acid=0·1 c.c. of CO_2.

$\therefore$ By proportion sum 2500 : 1000 : : 12. Result 0·8 parts CO_2 per 1000.

The estimation of *nitrogenous organic matter* in air is carried out by drawing a known volume of air through distilled water, and making a quantitative analysis such as is described under water analysis.

CHAPTER III.

WATER SUPPLY.

THE original source from which man derives the water necessary for his existence is *Rain*. Falling on the surface of the earth the water constituting rain or snow is distributed in different ways according to the different conditions attending its fall. A portion of it is evaporated and is taken up into the atmosphere again. Another portion is absorbed into the soil, mixes with the earth, and is assimilated by plants and organisms, and animal life; while the rest, following the physical formation of the soil, gives origin to streams and lakes. Some of it, sinking deeply, forms collections of water borne up by layers of impermeable clay or rock, and in certain cases getting under these impenetrable strata swells the volume of the deep-seated water already there. For the time being apparently lost, this water seeks an outlet, and this outlet it finds in the sea; or a natural imperfection or rift in the impermeable stratum gives it a means of egress and access to the surface again.

Rain water is as pure or impure as the atmosphere through which it falls. If the air is pure so is the rain; should the air contain impurities the rain will share these. Dissolved in rain there are always some of the atmospheric gases, and we find oxygen and nitrogen in the relative proportion of 1 oxygen to 2 nitrogen. Carbonic anhydride in small amount is present. In the soil the rain water acquires new constituents, which naturally vary with the substances encountered by it in its travels through the soil. Aided by the carbonic acid dissolved in it, the water acts as a ready solvent for many chemical substances, particularly those met with in highly nitrogenous soils. It also takes up with comparative readiness inorganic substances, such as carbonates and sulphates of lime and magnesia. In dissolving the carbonates, water is dependent on the presence in it of carbonic acid, and so much is this the case, that loss of the carbonic acid means precipitation of the carbonates. These salts produce that quality in water which is called *Hardness.* Heat driving off carbonic acid entails loss by precipitation of a portion of the hardness which has thus been termed *Temporary,* as distinguished from that hardness called *Permanent,* which is uninfluenced by heat or dissipation of the dissolved carbonic acid and is constituted by salts dissolved by water alone.

Falling through the atmosphere of towns, rain acquires soot, dust particles, sulphurous and nitrous fumes and all manner of foreign bodies, including bacteria and fungi. The rain loses its purity, the atmosphere its impurity, and in this manner nature washes the atmosphere and renews the freshness of the air. Rain water may be collected as it falls and may be used direct for domestic and other purposes. For its collection the roofs of houses are utilised as rain receivers, as roofs are conveniently situated for the reception of the rain, and when covered by zinc, are impermeable. Should this not be convenient, however, the rain can be collected on large flat surfaces of concrete or cement, having a gentle slope, and from which the water is carried away by an outlet pipe to a reservoir. In districts where the rainfall is copious there is less evaporation of the fallen rain into the atmosphere again than in dry districts where there is less rainfall. Generally speaking, in reckoning the yield (by rainfall) of water per head of population in a given district, $\frac{1}{5}$ reduction must be allowed for this evaporation, that is to say $\frac{1}{5}$ of the total fall of rain is usually evaporated on an average. The average rainfall for the year, and the amount of roof space per head are the other factors, the knowledge of which enables an estimate to be made of the amount of water likely to be derived from direct rainfall. Rain water when collected into reservoirs should be stored as pure as possible, and accordingly the first rain water collected being subject to contamination by soot, debris, bird droppings, &c., is rejected and not stored.

Rain water naturally is very soft, having often less than half a degree of hardness. It is very liable to act on metals such as zinc and lead, and care must be observed in using it when there is a possibility of its having been for some time in contact with these metals, whether in cisterns or otherwise, such as in roof collection.

Other sources of water-supply are numerous and now come under consideration.

SPRINGS.

Of these there are two main kinds, called *land springs* and *main springs.* The former are shallow springs, while main springs are deep, and indeed the names shallow and deep seem to be more directly appropriate. The water of a shallow or land spring is derived from rain which has fallen in a circumscribed area or bed of gravel through which it has percolated till arrested by the subjacent impermeable stratum of clay. Prevented from sinking deeper the water travels more or less horizontally until it opens to the surface on the side of a hill or valley (see Fig. 8 S).

The water passing through the surface soil is very prone to be contaminated by organic matters of the same nature as those to which, as we shall see, shallow wells are exposed. Moreover, during hot weather the supply of water

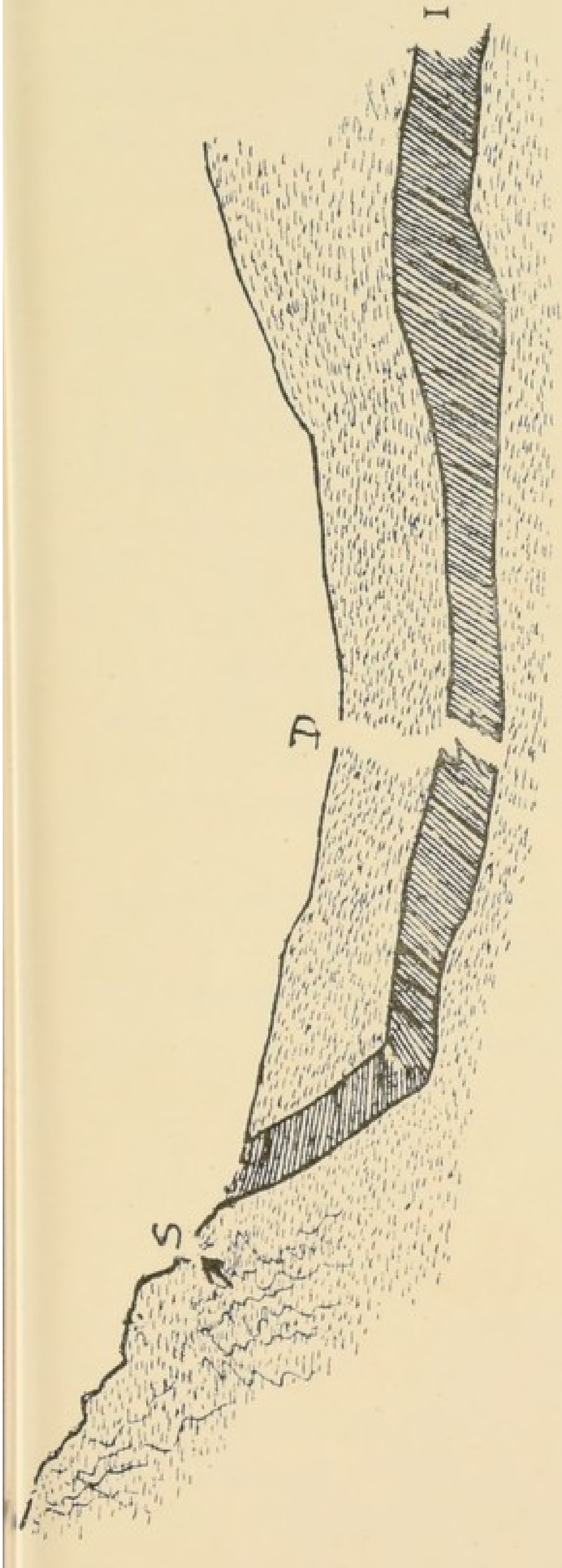


Fig. 8.—S, Orifice of Land Spring. D, Orifice of Main Spring. I, Impermeable Stratum.

from those land springs is liable to be intermittent on account of the decreased rainfall and the increased evaporation of water from the soil which takes place during these warm months.

MAIN OR DEEP SPRINGS have their origin in water which is lying in the strata *below the impermeable clay*, and in some cases the water comes from a long distance. It escapes from the lower strata through an imperfection or fissure at some part of the impermeable stratum of clay, and it ascends through the loose soil above the impermeable clay up to the surface. The water of deep springs is usually *hard, but free from organic matter* in its original state, although, as it traverses the loose superficial soil above the clay it may meet with impurities and become polluted. It is a reliable and good water, and its supply is constant in coolness and quantity.

Water is distributed from springs by collection and gravitation, or it can be pumped to its area of distribution by gas engine—an easy and inexpensive method—or by the action of a windmill.

WELLS.

Three varieties of wells are described, viz., shallow, deep, and artesian.

SHALLOW WELLS are sunk in the superficial soil overlying an impermeable stratum, and the water supplying them is similar in origin and course to the water which is found in land or shallow springs. This water is specially liable to contain impurities and as a matter of fact usually does contain impurities. The *surface waters* which feed the shallow wells are impure on account of the admixture with organic matters—vegetable organic matter in wells distant from human habitations, animal organic matter due to fæcal, urinary and other contamination in the neighbourhood of dwellings—and where the land near the well is under cultivation, manure will often get into and pollute the surface water, and secondarily the shallow well. The depth of the shallow well depends on the depth of the impermeable clay stratum from the surface of the ground. Usually a shallow well is under 50 feet in depth. The water contained in it is of course precisely the same as the surface water, and in consequence is very liable to be polluted by emanations from graveyards, cesspools and organic deposits, and contaminations of all sorts on the soil. A considerable variety of inorganic, nitrogenous and non-nitrogenous compounds is present, and on account of the latter the water of shallow wells is *hard,* while on account of the former it is, to the say the least, untrustworthy for human use. Water from such wells may be particularly clear, sparkling and inviting in appearance, but nevertheless when there is an excessive proportion of nitrogen in combination among the constituent elements of the water it is to be regarded as highly suspicious and even dangerous.

DEEP WELLS are those whose water is obtained by boring through the lower superficial soil down below the subjacent impermeable clay stratum and tapping the collections of water *lying under this impermeable stratum.* The water found there very often comes from a considerable distance, is cold, sparkling, and contains a large proportion of lime salts derived from the geological strata with which the water has been in contact. It is clearly similar to the water constituting deep springs, the water of the latter escaping to the surface by a *natural deficiency* in the impermeable clay, the means of escape of the water of a deep well being provided by a *boring* made artificially through the clay.

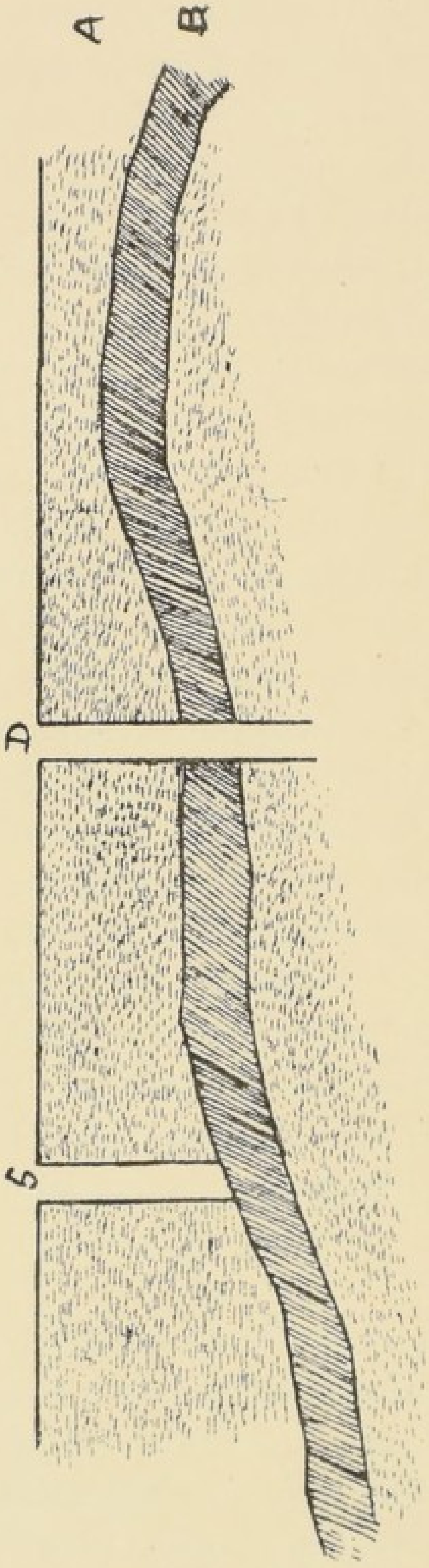


Fig. 9.—S, Shallow Well. D, Deep Well. A, Surface Soil. B, Impermeable Stratum.

THE ARTESIAN WELL is simply a variety of deep well, whose source of origin and water supply is at some considerable distance and at a higher level than the surface of the ground where the well is sunk. Consequently when the well is sunk, water rises readily into the boring in its natural tendency to reach its own level, and is practically inexhaustible in its abundance. The name "Artesian" is derived from the French province of Artois where these wells are much in use.

Deep wells must be of good construction and free from leakage, otherwise the impurities of the surface water may readily soak through any imperfections in the walls of the well as they pass upwards through the surface soil.

Should the impermeable stratum be so disposed as to slope up towards the surface of the earth, a deep well may be tapped by boring down through this impermeable stratum at a level comparatively near the surface, and it may actually occur that a deep well so reached may be really of less depth than an adjacent shallow well (vide Fig. 9).

Construction of Wells.—The sides of the well should be built with bricks and cement and surrounded with clay down to where the water leaves the impermeable stratum in order that surface water may not gain access to the well and pollute the water contained in it. It should project 12 inches above the surface of the ground and be provided with a cover fitting the top of the well. In other cases an iron tube perforated at its lower end is sunk to the foot of the well which is itself filled up with gravel and sand.

RIVER WATER.

The water of rivers is usually soft, but, being open to the easy acquisition of vegetable and animal organic impurities, has many of the elements of danger if it is desired to use it for human consumption. The danger is partly negatived by the action of oxygen and plants on the impurities in the water, but in this country rivers are not long enough to have all their organic impurities oxidised during their course towards the sea. When streams are utilised for the water supply of towns, water storage works are essential, provided with a dam to collect the water, and settling reservoirs and filter beds to purify it.

Peaty Waters are not usually injurious, although the dark colour of the water makes it look uninviting and unwholesome. Filtration of peaty water restores the water to a good clear colour. The water is soft and contains a good deal of vegetable organic matter, is acid in reaction from the presence of "humic acid," and its action on lead pipes is considerable.

Lakes contain the water which falls on hills, and in some cases derive their water from streams and rivers. The water is soft, and when the lake is large very pure and wholesome. Loch Katrine water is carried into Glasgow, and this abundant and pure water supply has proved of immense benefit to that city. When the water of a lake is used for the supply of a town, the lake is situated at a higher level than the highest part of the town to be supplied, and in addition the level of the lake is occasionally heightened artificially to secure that the lake will at all times contain an adequate and abundant amount of water in excess of the actual requirements, in order to provide against all possible contingencies such as prolonged periods of excessive drought and considerable enlargement of the town. By this system of supply by *gravitation* it is secured that the water rises without fail to the highest parts of the town, so that they may be provided with water in an adequate manner, equally with lower lying parts of the town.

Marshes are the recipients and containers of stagnant and highly dangerous water on account of the vast quantity of organic matter held in suspension and in solution by the water, matter which also is often in a decomposing state and evolving gases. In addition the water is full of organisms. Such water is eminently unsuitable for human needs and should be very carefully avoided.

Water to be used for the supply of a community is often collected in a suitable place, at a certain altitude, known as the GATHERING GROUND.

The water from Gathering Grounds is entirely dependent on the rainfall, and in order to form calculations as to the ability of them to constitute a proper and adequate water supply to a community, the factors to reckon from are chiefly the amount of the *smallest rainfall* and the *longest drought* which has been known to occur in the locality. The purest water will of course be found where the *least organic impurity* exists to contaminate it, viz., in *non-inhabited, barren, rocky districts.* The distribution of the water once it is collected should be by gravitation.

The water is collected from as near the surface of the ground as possible, and is conveyed along closed drains or in open ditches and channels. The latter, open channels and ditches, are not free from objection, and when possible their use should be avoided as they tend to become choked with weeds, and may be easily polluted or accidentally blocked, *e.g.*, by large stones falling into them, &c. Moreover, on account of their free exposure to the atmosphere they are liable to lose a large quantity of their water by evaporation in the warm summer months. The water then is brought preferably by closed drains to a natural basin or hollow, which, however, should be situated at a considerable height above the locality to be supplied, in order that gravitation may of itself deliver the water to its destination. The storage basin ought to be of such a size that it can accommodate enough water for a six month's supply, and large enough too to allow for increase in the size and consequent greater needs of the community it is designed for. Clay puddle forms the basis of the containing basin, which is built strong enough to prevent the egress of water and the possible ingress of water rats, and is faced with hard, dressed stonework; surrounding the top of the basin there is often laid down a finishing of grass turf.

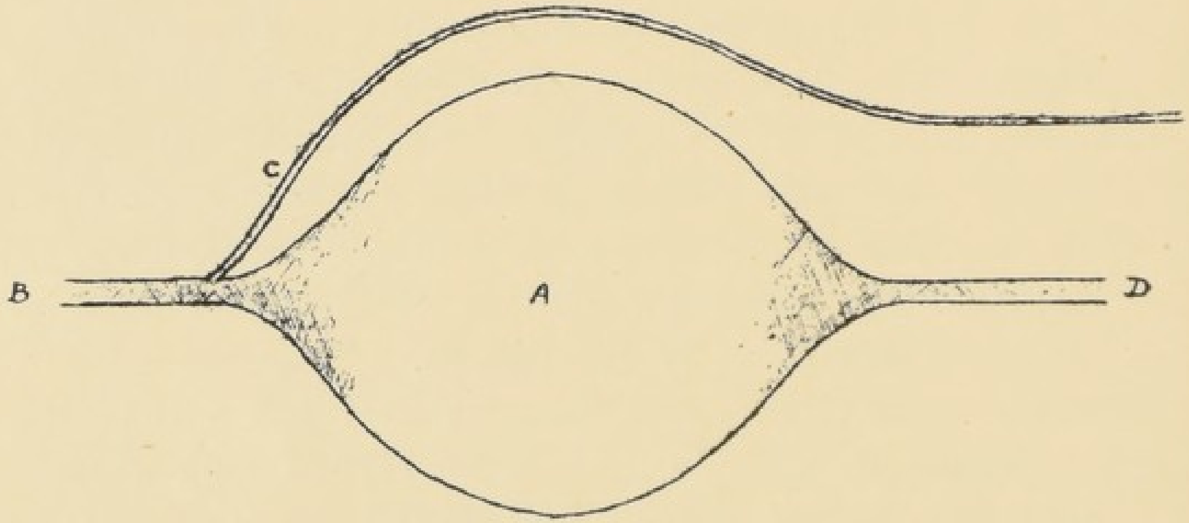


Fig. 10.—Scheme of Reservoir showing "By-wash" (C)

The reservoir when completed is provided with a by-channel (C Fig. 10), so that when the channels of supply (B) get dirty and full of mud and debris in times of flood, the water can thereby be diverted from the reservoir by the side channel or "by-wash," which opens into the natural water course below the level of and beyond the reservoir. In addition there is a cleansing pipe (B Fig. 11) carried from the lowest point of the reservoir itself into the water course below (see Fig. 11).

The exit or discharge pipe (A) of the reservoir is a tube placed at the bottom of the reservoir, and bent upwards, having several openings all of which are so protected that no debris such as leaves, bits of stick, &c., are admitted into them. It conducts the water from the reservoir toward the area of distribution, and is often called the aqueduct.

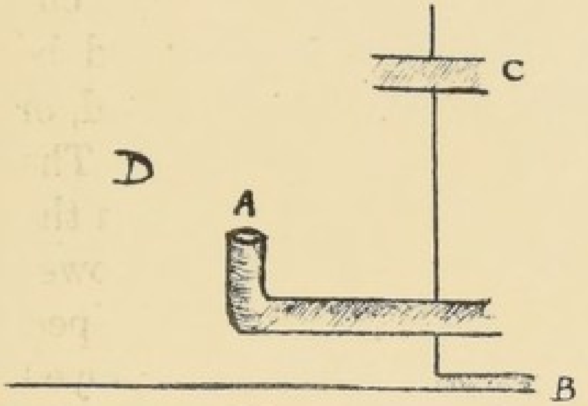


Fig. 11.
D, Reservoir. B, Cleansing Pipe.
A, Exit Pipe. C, Overflow.

The aqueduct is usually constructed of a series of iron pipes protected from the action of frost by being sunk three feet or thereby under the surface of the ground, and is provided at suitable intervals with arrangements to admit of the escape of air, the outflow of excess water, and at the same time to allow the execution of necessary repairs on the pipes. The pipe joints ought to be turned and bored, and, when considered necessary, the insides of these joints thoroughly secured by Portland cement.

The distribution mains receive the water from the aqueduct and are constructed of iron pipes covered on the inside with pitch or with the magnetic oxide of iron in order to prevent rusting—the pipe gains this magnetic oxide coating by being exposed when hot to the action of superheated steam passed along it (Barff's process). The joints between these iron pipes ought also to be secured by being turned and bored. When certain districts of a town require at certain times of the day an extra supply of water, a local reservoir may with advantage be added to the distribution system; this reservoir should be capable of holding about one day's supply of water for the district, and should be covered over to prevent it from being contaminated, or frozen in winter, and unduly heated in summer. The service mains pass along each side of the street, in the case of wide streets, a single pipe suffices in narrower streets, and from them issue the house service pipes, constructed usually of lead. Lead pipes are employed inside houses on account of their adaptability to the many turnings rendered necessary in bringing the pipes to the various rooms, &c., of a house.

New lead pipes are chemically acted upon by water and the soluble constituents of water. The lime salts of hard water form incrustations on the inside of the pipes, consisting of calcium and lead carbonate and sulphate: oxygen in the water forms an oxide of lead which is fairly readily washed or dissolved away, but which in the presence of calcium or sodium carbonate becomes converted into an insoluble compound and constitutes a *protective film* to the interior of the lead pipe. Small quantities of *silica* in the water are materially beneficial in diminishing the solvent action of water on lead pipes, and can be readily introduced into water not already containing a sufficiency of it by passing the water through sand, flints, and broken pieces of limestone. Soft, peaty water is particularly dangerous in its action on lead, an action which is accounted for by the presence in peaty water of organic vegetable acid constituents. Waters containing organic impurities, oxygen, nitrogenous inorganic salts like nitrates and nitrites, and chlorides, are all very active in their action on lead. Carbonic anhydride in water has a tendency to redissolve insoluble carbonates, and thus is liable to cause the removal of protective films which have already formed on the pipes. As of course there is great danger of lead poisoning arising when the pipes are corroded by the water passing along them, one must consider what are the remedies for so undesirable, and sometimes dangerous, a state of affairs. The remedies consist in adding an alkaline carbonate to the water, such for instance as sodium carbonate, or silica in small quantity. The water which has been lying in the house service pipes should be run off every morning, so avoiding the using of water possibly impregnated or at any rate contaminated with lead. Or the lead pipes may be lined in their interior with block tin, both metals being securely fixed together: the combination of metals can be fairly easily bent without the tin breaking or cracking. Iron pipes may be employed, but are not nearly so easily worked inside houses as leaden pipes which can be bent to any extent, practically, in order to suit the requirements of the household water supply arrangements. If iron be used there still is the difficulty of rusting of the pipes to contend with, especially when the water supply is on the intermittent system. This difficulty is met by coating the interior of the iron pipes with Angus Smith's varnish, or by the use of pipes subjected to Barff's magnetic oxide of iron process, or by lining the interior of the pipes with tin or glass. After all that has been said against them, however, leaden pipes are the most convenient and are most extensively used. It is uncertain whether the presence of organismal life in water has any influence on the solvent action of water on lead.

In addition to house-service pipes being given off from the service mains, hydrants are provided at various intervals along the mains for use in case of fires, and in some cities for cleaning the streets.

The water brought in this manner into a town is supplied to the inhabitants by one of two systems, respectively called the Intermittent and the Constant system.

In the INTERMITTENT SYSTEM the water is turned on for a certain number of hours daily, and the house service pipes contain water only during this period. To provide for the time when the water is turned off, *cisterns* are made use of in houses and tenements to store a supply of water.

When the CONSTANT SYSTEM is in operation, the water mains are full night and day, so that the house pipes are always supplied and no storage cisterns are needed; only small cisterns for boilers and water-closets are made use of in the houses.

The disadvantages of the Intermittent system, which is the one adopted when the water supply is not very abundant, are manifold. Thus, the necessity for large cisterns is a great drawback, for they are very liable to get dirty, and in the dwellings of the poor classes (and even in those of the better classes sometimes) there is often neglect in the matter of the cleaning out of the cisterns, wherein is collected all manner of dirt and debris, dead animals and vermin of every description, while occasionally water closet effluvia may reach them on account of faulty fittings. Disease may be readily disseminated by cisterns therefore. Moreover, water standing in cisterns soon looses its cool refreshing qualities and becomes flat, warm and unpalatable.

By the Constant system the water at the disposal of the community is at all times abundant, and the water is fresh, pure, sparkling and cool, and is always supplied directly off the mains.

Careful attention must be exercised, however, in one or two particulars in order to make the best and most economical use of the constant service. All the taps and fittings should be secure and tight so as to prevent undue waste by leakage. The taps which are the best are of the "screw down" variety. Each water-closet should be provided with a *special little cistern* of its own to flush it, because if it is flushed from the main, there is a danger that gases may escape back from the water-closet, along the W.C. supply pipe and reach the main, and thereby pollute the whole main service or a large part of it. Similarly, sewers ought not to be flushed directly from the water main.

On the occasion of the occurrence of a fire in a city, it is an extremely serious matter if the water supply is an intermittent one, as the time when the fire occurs may be the very time when the service is not in operation, and much valuable time may be lost ere the water can be turned into the service pipes to supply the hydrants.

An occurrence of very serious moment liable to happen in the intermittent system, and which greatly militates against its adoption, is this, that during the time when the supply is cut off there is a considerable tendency for leakage of objectionable and foul gases and liquids from the soil or from faulty sewers into the empty mains, and obviously much danger to the community may thereby arise. It is, however, the case that if the water mains be placed near sewers (and this should be always avoided) there is a danger in both intermittent and constant systems of foul air and liquid being drawn into the water mains, though under the former regime the risk is much greater.

When the use of cisterns is rendered essential by the existence of an intermittent water supply in a town, the storage cistern should be large enough to contain a full 24 hours' supply of water. It should be cleaned out at least every six months or oftener, and ought to have a close fitting cover. It must be well ventilated and is not to be used to flush the water-closet, and for this purpose a special cistern must be used. The overflow pipe should have no connection with the sewers, but may be allowed to open into the bath or kitchen sink, or be conducted to the outside of the house, and open free there.

Lead cisterns, when new, tend to cause lead poisoning from the solvent action of the water on the new lead, but when the protective coating has formed they are safe. Should the cistern be *scraped* in the process of cleaning, the clean lead will again favour the presence of some lead in the water. Cisterns must accordingly never be scraped.

Iron cisterns tend to get rusted, but galvanized iron ones are quite safe.

Zinc cisterns give off zinc to the water and are therefore open to objection.

Slate cisterns yield nothing to the water, but are liable to leak, while stoneware cisterns are perfectly safe, although they are very heavy and more expensive than the others.

Wood receptacles for the storage of water are very bad, because the wood rots and gives lodgment to worms, &c. They must never be employed.

To find the holding capacity of a cistern, the cubic capacity in feet of the cistern multiplied by 6·23 equals the number of gallons it can contain.

FILTRATION OF WATER.

When there are impurities in the original water selected as the source of supply to a community, it is necessary to adopt some means of filtration of the water. The filtration is carried out as follows:—

The FILTER BED consists of a reservoir, on the paved bottom of which are placed open jointed or perforated pipes to carry away at a slow rate the purified water. Immediately over the pipes is a layer of loose large gravel or pebbles, covered in turn by a layer of fine gravel, and, on the top of all, 3 feet of fine sand (with the occasional addition of some coarse sand). The water to be filtered is introduced to the filter bed at a slow speed until it reaches a depth never exceeding 1 to 2 feet, so that the filtration may be slow, and the amount of water per square foot allowed to percolate through in an hour is 1¾ to 3 gallons. The water is freed from its tangible impurities, its iron, and some of its hardness, while its organic matter is nitrified by the action of organisms, which are abundant in the superficial fine sand layer, and practically all the organisms existing in the water before filtration are removed. It is certain that all the pathogenic properties which have been present in the water are abstracted by the very adequate removal of bacteria which filtration carried out in this manner brings about.

The filter bed is liable to become clogged by the mechanical obstruction offered by the impurities removed from the water. It is consequently essential to have it cleansed from these impurities, and these are removed together with about ½ to 1 inch of the superficial layer of sand. A filter-bed which has been newly cleaned does not nitrify the organic matter so well, because the organisms which subserve this process are present in the layer of surface impurities which have been removed, and in consequence when they are absent, the nitrogenous matters for a time escape metamorphosis into nitrates, &c. In three days or thereby, however, after the filter bed has been cleansed, this defect is remedied. The presence of atmospheric oxygen in the filter bed is of undoubted value in aiding the oxidation of the organic matter dealt with by the filter-bed.

FILTRATION ON THE SMALL SCALE.

Filters for the purification of small quantities of water are of doubtful value when used for domestic and personal purposes. The reason of this is that the filters get quickly dirty, and are not thoroughly cleaned sufficiently frequently, and in some cases they become so saturated with organic matters and organisms that they may confer on the water they "filter" additional impurities to those already possessed by the water.

Animal Charcoal being very porous and containing much oxygen in its interstices, is an excellent oxidiser of organic matter, and for a time acts well. But speedily the charcoal becomes choked and ceases to have the slightest beneficial action on water passed through it. Moreover, it is never able to arrest organisms, and it yields calcium phosphate to the water coming in contact with it. Calcic phosphate is favourable to organismal growth, and at once we have a defect offering an additional and a serious objection to the use of charcoal as a means of purifying water.

Carferal is a mixture of charcoal, iron and clay, and is a useful filter for removing in a mechanical way any suspended matters in water. It can be cleaned by being subjected to a low red heat, and is more efficient than charcoal.

Spongy Iron is the active agent in Bischof's filter, and consists of roasted hæmatite. It mechanically removes suspended impurities, has a slight action on organic matter and nitrates which it converts into ammonia, and is possessed of a special action in removing much of the hardness from water. It must always be kept covered with water to prevent it from caking, and ought to be renewed once a year.

Magnetic Iron Carbide, formed by the heating together of sawdust and hæmatite, is also preferable to charcoal, but is not so much used as Bischof's filter.

Maignen's "Filtre Rapide" consists of a perforated porcelain cone over which is placed an asbestos cloth covered with a mixture of powdered charcoal and lime. It is a rapid and economical means of filtering water, from which it removes mechanical impurities and perhaps lead also, and has a slight action on organisms, but it can by no means be said to sterilise water.

The *Pasteur-Chamberland Filter* consists of one or more solid porous cylinders of porcelain, through whose pores the water is forced, either by the pressure in the service pipe from the main, or by being placed in the service pipe connected with a cistern, and 20 feet below the level of the cistern. The water forced through the pores is sterilised, being freed from all suspended impurities including organisms, but no action whatever is exerted on the matters it holds in solution.

Sponges and Asbestos have both been employed as filters. The former speedily become foul and inoperative; when the latter become foul, they are readily made fit for service again by being exposed to heat, which has no destructive effect whatever on asbestos.

Water which has been *boiled* is deprived of all organismal life and of temporary hardness, and in the throwing down of the latter, much organic matter is entangled and removed. Aeration is subsequently essential to render the water palatable, and this can readily be effected by passing the water through a sieve, or by pouring it backward and forward from one vessel to another.

Distillation permits of even sea water being utilised for drinking purposes, and the subsequent æration which is essential is carried out in the simple method already mentioned.

HARDNESS OF WATER.

What is termed the *hardness* of water is due to the ability of water to take up and dissolve a certain quantity of calcic carbonate, and the more carbonic anhydride there is present in the water, the more calcic carbonate can the water dissolve. Boiling entails the volatilisation of carbonic anhydride from water, when a part of the calcic carbonate becomes precipitated, and is deposited on the sides of the receptacle in which the water is boiled. This calcic carbonate thrown down constitutes what is called the temporary hardness of water, and shows itself as "fur" on the inside of kettles and boilers, &c.

When water is unduly hard it may be softened, and to accomplish this on the large scale the water is treated with a sufficiency of quick lime (calcic oxide) which combines with the free carbonic anhydride (CO_2) in the water and forms calcic carbonate and falls as a precipitate. This is accompanied in its descent by the calcic carbonate previously dissolved in the water by the free carbonic anhydride.

$$CaCO_3 + CO_2 + CaO = 2CaCO_3.$$

This is CLARK'S PROCESS, and the water so softened is often said to have undergone the process of "Clarking." 1 oz. of calcic oxide is added to every 100 gallons of water for each degree of temporary hardness present in the water. The precipitate is allowed to settle slowly, and in 12 hours the softened water is decanted. To avoid the delay entailed by the settling process, the *Porter-Clark* method filters the softened water by forcing it at high pressure through linen cloths.

Both processes, besides removing the temporary hardness, secure the entanglement of suspended and organic matters in the precipitate, an additional effect of some value. Of course by neither method is there any effect on the magnesium and calcic sulphate which constitute so large a proportion of the *permanent* hardness.

Alum is occasionally used and throws down a bulky precipitate of aluminium hydrate which entangles large quantities of suspended impurities and organic matters. It is particularly efficient in the presence of calcic carbonate, and in the precipitate calcic sulphate and aluminium hydrate are found.

ESSENTIALS OF A GOOD WATER SUPPLY.

1. The water selected must be of *good quality*, that is to say, it must be free from objectionable organic matter.

2. The *quantity* must be sufficient for the needs of the community in its present numbers, and should also be able to supply the increase in population likely to occur in the following 20 or 30 years.

3. It must be thoroughly purified and filtered, and rendered free from all adventitious substances.

4. The supply should be on the constant system. For this, of course, the quantity of water available is the all-important consideration, but it has been shown by some authorities that by the exercise of care on the part of the consumer, and by strict supervision by the water authorities to prevent waste and to see that the fittings are in good order and tight, the constant service need not require a larger amount of water than the intermittent service.

ESSENTIALS OF GOOD WATER.

The water should be colourless or nearly so, nor ought it to have any odour. No organic matter should be present in it, and certainly no organic matter of animal origin. Should organic matter be unavoidably present, then the amount of it must of necessity be small and of vegetable origin. With regard to hardness, the total permanent and temporary hardness must not be excessive, that is to say, not more than 4 or 5 degrees of permanent and 10 degrees of temporary hardness.

When water is too hard, then serious waste occurs in connection with the use of soap, every degree of hardness present representing the waste of 1 lb. of soap per 1000 gallons of water employed. Moreover, kettles and pots become readily furred, and accordingly more fuel is needed to carry out cooking operations. Certain gastric and intestinal symptoms are liable to occur when the water is too hard, in the way of enfeeblement of digestion and a tendency to diarrhœa. What the true relationship is, if any, between the occurrence of Goître and hardness of water, one cannot with any certainty say, but certainly the disease occurs often in districts where there is magnesian limestone. Nor can one affirm that hardness of water is a cause of Urinary Calculi, although there is some evidence in favour of the view that these have a relationship of cause and effect.

Water of a certain degree of hardness is much more palatable than soft water, and does not have the same affinity for acting on leaden pipes. Apart from the latter objection soft water is more useful and economical for cooking and washing than hard water.

The *quantity of water* necessary for a community may be tabulated as follows:—

	12—18	Gallons per head for	domestic and personal purposes.
	5—10	” ”	municipal purposes.
	5— 7	” ”	trade uses.
	3— 5	” ”	waste allowance.
Total	25—40	per head of population.	

In Edinburgh the official return of the water delivered during the month of November 1900 was 40·22 gallons per head per day.

RELATION OF DISEASE TO WATER.

There can be no doubt that certain diseases have a direct relationship to water and water supply, while others have a more or less indirect or doubtful relationship. The analysis of water and its appearance do not necessarily form an absolute index of the soundness or otherwise of water, for we find that sparkling clear water containing nitrates may look and taste pleasant and wholesome, but may also be full of typhoid organisms, while certain coloured waters such as peaty water may be quite safe and innocuous.

Disease may arise from either its inorganic or its organic constituents.

1. Inorganic Constituents.

Hardness when due to calcic carbonate is not deleterious. As we have seen, 7–10 degrees of temporary hardness per gallon occur in a good water, but a similar amount of permanent hardness is bad. It is bad on economic grounds, and it is deleterious to health on account of the gastro-enteric derangements which ensue on its regular consumption.

Goître too, it appears, may be produced by the drinking of excessively hard water, although there is reason for doubting this. Some observers indicate that it is possible that iron sulphide, which occasionally is found along with magnesium and calcium salts, may be the cause of goître.

Iron, when existent in water, has been noticed to cause headaches, lassitude, gastric discomfort and difficulty in the digestion of food, and constipation.

Lead.—Plumbism may be produced by individuals drinking water containing $\frac{1}{20}$th grain of lead salts per gallon. The symptoms complained of include constipation, colicy pains in the abdomen (enteralgia), headaches, high-coloured urine, followed later by severe encephalopathia, gouty manifestations, renal disease and its sequelæ, and paralysis of the extensor and supinator muscles of the forearm, the supinator longus excepted. It also produces a blue line along the gums, particularly when the teeth are carious and have been neglected. The occurrence of lead in water is due to the solvent action of water on the new lead pipes or cisterns—and the metal is specially liable to be taken up by waters which are soft, peaty, and contain some vegetable organic matters and of acid reaction due to the presence of "ulmic" or "humic acid."

2. Organic Constituents.

Vegetable Organic Matter in water imparts a yellowish discoloration to the water, but this is removed by filtration through sand and gravel, and the organic matter is oxidised by exposing it in reservoirs to the air. The presence of it in amounts not exceeding 2 grs. per gallon is not necessarily deleterious, but if it exceed this amount it is liable to cause *diarrhœa*. In malarious districts its presence in the water is also very frequently associated with the existence of the malarial parasites in the water.

Organic Matters of Animal Origin are, however, of much more serious moment. This impurity may reach drinking well-water from cesspools, from impurities in the surface soil, may be owing to sewage, &c., being passed directly into rivers, or sewer gases may contaminate the water in house cisterns; while, again, sewer gases or liquid filth may gain access to water mains, particularly, as we have seen, where the intermittent system of water supply is in use. Occurring with this organic matter will be found bacteria, whose nature may be pathogenic or non-pathogenic.

Cholera is a disease which is certainly spread by means of water. The dejecta of a patient may gain access to the soil by some means or other, as, for instance, by being deposited or thrown on the surface of the soil, or by sewage escaping from a leaking cesspool; thence the organisms and accompanying organic matters reach a well which may not be water-tight or which is supplied by surface water, when the well becomes contaminated, and the persons partaking of this water are prone to develop cholera. Such contamination was proved in the epidemic of cholera in London in 1854 in connection with the use of the *Broad Street Pump*, whose sparkling water caused it to be much in requisition, but which was on analysis found to be full of nitrogenous impurity traced to leakage from the drains of a neighbouring house wherein a patient was suffering from diarrhœa or actual cholera.

Typhoid Fever is another disease of contaminated water. In the water supply of infected districts there can be traced with fair ease the presence and also the origin of a certain amount of organic matter, but it is not always so easy to trace the Eberth bacillus. Water which has failed to yield evidence of the Eberth bacillus on bacteriological examination has not unfrequently been the undoubted cause of epidemics of typhoid fever. Whenever water used for drinking purposes is infected by the stools of a typhoid patient an outbreak of the disease is sure to occur among those who use the water. *Leaking cesspools* have often been the means of letting the disease into the soil and into the surface water, and *leaking wells* have as often received the contamination.

Defective Water-Closet Arrangements, where the W.C. is supplied from the common cistern, have been found to allow of infected sewer gases passing from the W.C. into the water of the cistern and have been the cause of spread of enteric.

Leaking from Sewers into Main Service Pipes has taken place, particularly under the intermittent service system, with serious results, and accordingly, as shown previously, the sewers and water mains must be kept as far apart as possible.

Diarrhœa occurs with frequency when organic pollution of non-specific nature is present in drinking water, and Dysentery is probably water-borne in many instances also.

Intestinal Parasites such as Tænia Solium, Tænia Mediocanellata, Bothriocephalus Latus, Oxyuris Vermicularis and Ascaris Lumbricoides are easily spread by the ova getting into water and then being imbibed. Filaria Sanguinis Hominis and the Guinea worm are also indebted to water for providing a means of spread for them.

ANALYSIS OF WATER.

It is often necessary to determine not only what substances are present in a given sample of water whose purity or impurity is under consideration, but also to find out what quantity of these substances is actually present. This must be carried out by a skilled analyst, and we shall here indicate the principles of the various methods without entering into the details of the analytical processes.

The *total solids* present in a given sample of water can be readily determined by evaporating a known quantity of the water to dryness, and weighing the total residue. The further application of heat to the residue volatilises what part of it is of volatile saline and organic nature, when, by weighing what remains—the inorganic portion—it is easy to find what amount of solid residue has been driven off by the heating.

Chlorides occur in water polluted by sewage owing to the presence of urine as one of the constituents of of the sewage. The amount of chlorine is estimated quantitatively by converting the chlorine into silver chloride by the addition of nitric acid and silver nitrate. The precipitate is collected, dried and weighed, and the amount of chlorine is determined when the weight of the silver chloride is known.

Nitrates and Nitrites may be determined in the solid residue left by the evaporation of a certain quantity of the water sample by reducing them by means of strips of aluminium foil in the presence of pure caustic soda. The nitrogen is converted into ammonia (NH_3), which is then distilled over and "Nesslerised" in the manner described below.

The determination of such small quantities of *ammonia* as have to be dealt with in water analysis is effected by means of Nessler's reagent. This reagent is prepared by dissolving 35 grammes of potassium iodide and 13 grammes of mercuric chloride in hot water, dropping the mercuric chloride into the potassium iodide solution till a slight persistent precipitate of mercuric iodide is obtained, and then adding 180 grammes of caustic potash, and diluting the whole up to 1 litre (1000 c.c.). With this solution ammonia gives a brown precipitate. If the quantity of ammonia is very minute the liquid assumes merely a yellowish-brown colour. For the purpose of quantitative analysis 50 c.c. of the ammonia containing solution is taken, and 2 c.c. of Nessler's reagent is added. The colour produced is then *compared with the colour produced by the addition of a known quantity of an ammonium salt* dissolved in water (usually ammonium chloride solution of such strength that 1 c.c. of it=0·1 milligramme of Ammonia).

In carrying out this process practically, half a litre, *i.e.*, 500 c.c., of the water sample is distilled in a glass apparatus, which must be kept scrupulously clean. The distillate is collected in glass cylinders in separate amounts of 50 c.c. each. Each of these separate 50 c.c. may be "Nesslerised" to determine the total quantity of ammonia which has passed over, and the sum of these results gives the total ammonia present in the sample water. As $\frac{3}{4}$ of the total ammonia on an average passes over in the first 50 c.c. distillate, a quick calculation (though not an accurate one) is possible from knowing the amount of ammonia in the first 50 c.c. distillate.

The *Albuminoid Ammonia Process* is employed to detect and estimate *nitrogenous organic matter* in water, and it is carried out in the following manner:—To the residue from the distillation in the previous process is added permanganate of potash and caustic potash, and the distillation is continued. The organic matter is oxidised and the nitrogen of it becomes converted into ammonia, which is then determined by "Nesslerising" the total distillate in quantities of 50 c.c. at a time.

To gain an approximate idea of the *total quantity* of *organic contamination* present in water, the *Permanganate Process* is employed. This method consists in determining the quantity of permanganate of potash solution of known strength reduced in acid solution by a given quantity of the water at 140° F. The standard solution of potassium permanganate is dropped from a burette into, say, 250 c.c. of the sample water and heated to 140° F. At first the colour of the permanganate solution is discharged, but when all the oxidisable matter in the sample is oxidised the pink colour of the added permanganate remains unaltered. The process is regarded as complete when the pink colour of the solution persists for 15 minutes or thereby, and the amount of permanganate solution used is then read off on the burette. The permanganate of potash solution is standardised so that each c.c. of it is equal to 0·1 milligramme of oxygen.

Example—

10 c.c. of Permanganate solution used for 250 c.c. sample water.
1 c.c. = 0·1 milligramme of oxygen.
∴ 1 milligramme per 250 c.c.
i.e. 1 part oxidisable matter per 250,000 parts of water.
i.e. 4 parts " " 1,000,000 "

Frankland's Process is one which can only be carried out by an expert. The method is as follows:—The dry residue from a known quantity of water is burned with cupric oxide (CuO) in a tube from which all the air has been removed. The resulting gases are collected, and the amount of carbonic anhydride (CO_2) and nitrogen so collected are determined by gas analysis methods.

CHAPTER IV.

DISPOSAL OF EXCRETA AND REFUSE.

THE subject proposed to be dealt with in this chapter is one of much importance, and the modern practical treatment of the problem of sewage removal has been attended with very gratifying results in the improvement which has occurred in the general health and comfort of the community. The introduction of improved conveniences of various kinds has brought about a diminution in disease in towns, and a corresponding decrease in the death-rate, and this conclusion is arrived at after allowing for the improvements which have undoubtedly been associated with the introduction into towns of good water supplies. When we inquire into the nature of the benefits which adequate systems of drainage have produced, we find that cholera epidemics have been greatly minimised in severity, enteric fever has been vastly reduced in frequency, diarrhœa due to simple gastro-enteric catarrh has in many districts and towns been decidedly modified in frequency and severity, while the occurrence of phthisis has been markedly influenced for the better. Drainage of the soil, too, has in certain districts been the means of removing malaria, and the occurrence of chronic rheumatism has to some extent been less prominent in once notoriously damp districts now made drier by drainage. For the effect of drainage has been to render the soil drier, to heighten the temperature both of the soil and of the air (for the water evaporating from the soil is powerful in lowering the temperature of soil and air), and in consequence houses have come to have drier and healthier foundations.

Similar effects have been observed in towns where efficient drainage has been secured for the soil, and, as in towns there is an enormous amount of varied added impurities in the soil, it will be easily understood that the removal of these impurities together with the surface waters is a matter of the first importance for the health of the inhabitants.

The production and tendency to accumulation of excreta and refuse consequent on the aggregation of many individuals in one centre are great, and the extent of which a study of the actual details will readily show. The accumulation of these by-products of human life would of course be exceedingly dangerous, apart altogether from the mere unpleasantness and inconvenience of such accumulation. Their removal accordingly is an essential of healthy living, and the best means to this end has occupied the attention and taxed the inventive skill of many sanitarians.

An adult male excretes daily an average of 4 oz. of solid fæcal matter, and 50 oz. of urine; females and children of course excrete less; and the average daily excretion of a mixed population has been estimated at 2½ oz. of fæces and 35–40 oz. of urine per head, constituting an average elimination of 150 grains of nitrogen per individual per day.

Fæcal matter when evacuated is acid in reaction, and may remain so for some time, particularly if it remains dry, as, for instance, in warm weather. When decomposition sets in and progresses, ammonia is given off. Urine, likewise, is acid when voided, and for a day or so may remain acid, but in the presence of heat it ferments and gives off ammonia from decomposition of the urea contained in it. The admixture of fæces and urine favours the more rapid decomposition of both, and the fæcal matter becomes converted into a decomposing and viscid mass evolving putrid and very offensive organic gases, marsh gas (CH_4), sulphuretted hydrogen (H_2S) and ammonia (NH_3), the two latter often in combination as ammonium sulphide.

Town refuse consists of street sweepings, horse droppings, offal, debris from fish shops, butchers' shops, slaughter houses, vegetable shops, byres and stables: ashes, refuse food, house waters and trade waste waters: and the whole constitutes a very heterogeneous, highly organic and decomposable mixture of substances.

It is evident that both the human excreta and waste and refuse matters must be steadily added to day by day, and that accordingly it is necessary to have some method of systematically dealing with those and disposing of them, in the interest of the comfort and well-being of the inhabitants. And to this end many schemes have been devised, of which some have been found to be of great value and practical utility.

The quantity of waste products in towns and other well-populated localities is enormous, and the fluid part of this is commonly carried off by a system of drainage pipes. The matters so removed consist of household refuse water and waste water, organic fluids from public urinals, rain water falling on the streets and carrying along with it horse droppings, dirt, &c., of all descriptions, filthy matters from cowsheds, stables, slaughter houses, and from manufactories. The character of the fluid conveyed away in these drain pipes is of a highly organic and offensive nature, and it is so pollute that the addition to it of human excreta could hardly render it more foul than it already is. In an unpurified state it is not allowed to be discharged into rivers on account of the great contamination it would cause there. When human excreta are admitted into the drains and sewers conveying away the refuse waters, the town is said to be drained on the WATER CARRIAGE SYSTEM or WET METHOD. It is the best possible method, is cleanly, very effective, and less expensive than other methods on account of the saving in scavenging.

This method can not always be carried out, and in some towns and country places fæces and urine are disposed of in another manner, called the CONSERVANCY or DRY METHOD. The dry method is adopted in those localities in which the fall to the outlet of the drain is inadequate, and where the means of disposal of the sewage at the outlet is attended with difficulty. Moreover, from a commercial point of view there is something to be said in favour of the adoption of the conservancy method because of the manurial value of the fæces and urine; and, in order to prevent decomposition of the excreta, whereby much of the profitable nitrogen is dissipated as ammonia, various plans have been suggested to prevent admixture of the fæces with the urine. It cannot be said, however, that these plans have met with a great measure of success; nor can one advocate with any confidence any form of the dry method principle as better than the water carriage system, supposing the latter to be equally practicable, and in spite of the fact that the manurial value of the excreta is gained by the dry method.

When the excrementitious matters are to be employed for manurial purposes they are collected and treated with sulphuric acid in order to convert the volatile ammonia into the stable ammonium sulphate $(NH_4)_2\ SO_4$. Drawn into an air-tight tank the fluid is allowed to settle, when the thicker portion falls to the bottom. The supernatent fluid is then drawn off, evaporated down, and, when concentrated, is mixed with the settled-down portion of the excreta, and the whole is dried down to a powder known as *poudrette*. All the odorous gases evolved in this process are led to the furnace and burned there, so that, if the process is properly carried out no nuisance ought to occur in the vicinity of such manure works. The money value of poudrette varies according to its manurial value as determined by analysis. It averages 80 to 90 shillings per ton.

Before entering into the consideration of the various methods by which the conservancy system is actually carried into practical operation, we may here shortly refer to the means adopted for the REMOVAL OF DRY HOUSE REFUSE.

House refuse consists of scraps of food, vegetable debris, ashes, and miscellaneous materials, which are partly organic and decomposable and partly inorganic. It is extremely undesirable that any delay should occur in the removal of this rubbish from the neighbourhood of houses, and where it is possible a *daily removal* should be carried into operation. In that case the refuse is simply placed in wooden buckets or pails and these are emptied into dust-carts which make a round every 24 hours. When it is not possible to have so frequent a removal as this, then the next best thing is to collect the refuse into galvanised iron pails provided with covers, in order to keep the rain from entering among the refuse and favouring the occurrence of decomposition with the resulting evil odours thereof. It need hardly be said that, for a similar reason, no liquid slops or water of any description should be thrown into these pails. In no case should the refuse be collected less frequently than twice weekly. It is removed in dust-carts provided with hinged covers to prevent the wind blowing dirt and papers, &c., out of the carts into the streets, and is brought to a central depot to be dealt with and finally disposed of. *Destructors* are in frequent use for getting rid of this refuse by burning it up in a very complete and satisfactory manner. They should be placed in a locality as far removed from dwellings as possible, because of the odours which are liable to arise and be a source of annoyance.

In some cases the refuse is sorted by mechanical means: the cinders and small coals—commonly termed "breeze"—are separated and used as part of the fuel for the furnace required for the sorting machinery; while bones, glass bottles, &c., known as "hard core," are collected from the refuse and sold. Paper and rags are separated and converted into paper, and organic matters called "soft core" are turned into manure. This sorting process, as will be readily imagined, is a decidedly disgusting one.

When the refuse is not treated in either of these ways it can be used to fill up excavations or to level up inequalities in land for building purposes; due care must be taken, however, that the actual building does not take place until decomposition has entirely ceased in the collection of rubbish, and the levelled ground has sunk as much as it will.

VARIETIES OF THE CONSERVANCY METHOD.

1. *Privies* were very extensively used at one time, and were very faulty in their construction and arrangement, for they were placed quite near houses, were often freely exposed to the air and so admitted rain, and were of course unhealthy in consequence of the resulting putrefaction in the contents of the receptacle, while, on account of their smell, they were disgusting to a degree. In recent times they are still in use in certain districts but under altered conditions, and are constructed subject to certain laws of the Local Government Board, whereby it has been attempted to remove some of their more glaring defects. It is now made essential by these laws that a privy shall be distant at least 6 feet from any other building; 40 feet from any well or water used for drinking purposes; shall have a separate means of access other than that through the house, whereby the privy

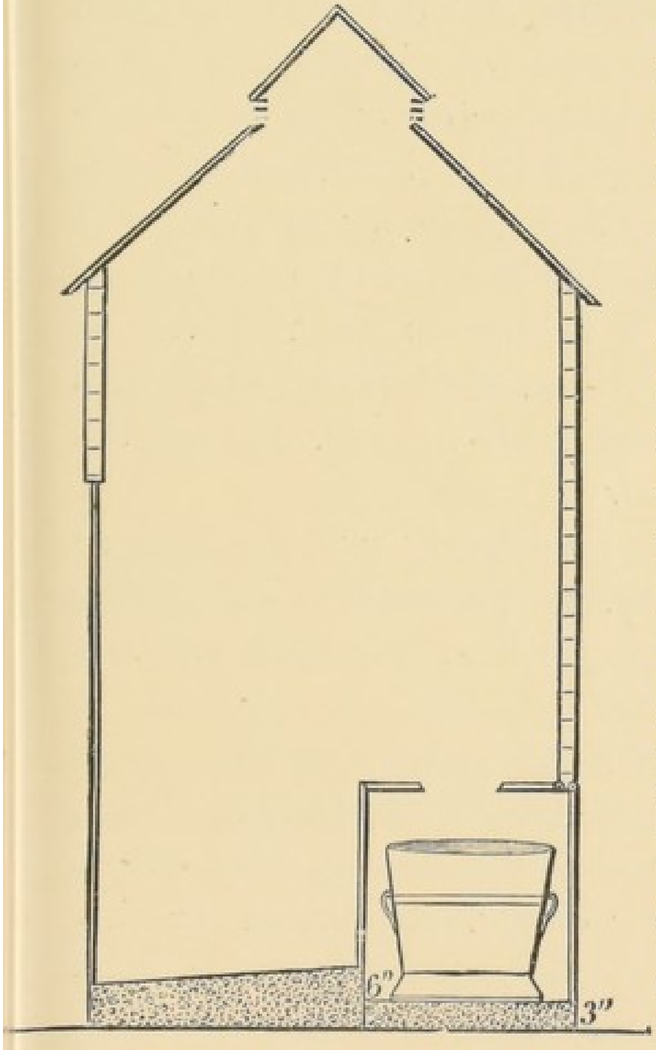


Fig. 12.—Diagram of Privy.

may be cleaned out without the scavenger having to pass through the house. Rain must be kept out by the provision of a good roof, and ventilation must be secured by openings placed as near the top of the privy as possible. The floor of the privy is 6 inches above the ground level outside, and has a slope of 1 in 24 towards the door, and is either laid with tiles or paved. The capacity of the receptacle for the excreta must not exceed 8 cubic feet, so as to ensure that it is changed often enough; the floor of the receptacle itself is 3 inches above the ground, and is constructed of impermeable material such as asphalt or 9-inch brickwork set in cement. The access to the receptacle for cleaning out purposes (and removal must be effected at least once a week) should be easy, and to facilitate ready removal the seat should be hinged. Ashes, cinders, or quantities of dried earth are to be used freely in order to keep the contents of the receptacle dry.

Attention to these rules renders the use of privies at any rate free from danger, as percolation of organic matters into the surrounding soil or adjacent water is obviated.

2. *Goux System.*—Under this system pails are used, which are lined with some organic substance to absorb the urine and keep the fæces dry, and vegetable debris such as ferns, straw, hay or chaff is employed for this purpose, along with some deodorant, *e.g.*, soot or charcoal. The pail is constructed of iron or tarred oak, is placed under a seat which is hinged to facilitate ready removal of the pail, and the capacity of the latter does not exceed 8 cubic feet. A closely fitting lid is provided for the pail, in order that when the scavenger removes it (once or twice every week this should be done) no

escape of foul air is permitted. The house cinders and ashes can be utilised to keep the contents of the pail dry, the fine ashes being added to the pail each time it is used by means of a hand scoop or by a mechanical arrangement placed above the seat. The less ashes used the better if the pail contents are to be employed for manurial purposes.

3. *Moule's System.*—The value of the use of *dried earth* as a deodorising agent was urged by the Rev. Henry Moule, whose system is based on this action of dried earth. The excreta are deposited into a pail; a hopper full of dried earth is placed above the seat, and, on a plug being pulled up, a certain quantity of the dried earth is allowed to fall on the excreta. For fæces the amount of earth used is 1½ lbs., and for urine 3 lbs. on each occasion. All smell is removed, and a peculiar combination of earth and fæces is formed free from odour. Subsequently the fæcal matter becomes disintegrated until, ultimately, it is quite unrecognisable. After being dried this combination can be utilised again and even a third time. The best earths to employ for this purpose are rich vegetable mould and dry clay, sandy soil being the least efficacious of all. The manurial value of the earth, even after being repeatedly used and dried, is slight, because a large amount of the nitrogen disappears in the form of ammonia. *Dryness* is an essential in carrying out this method, and only finely sifted earth must be used. No slop water should under any circumstances be added to the pails.

The method is not applicable to towns, but is of decided value in certain large institutions such as asylums situated in districts not admitting readily of the adoption of the water carriage system.

4. *Morell's Riddled Ash Closet* consists of a *small* fixed receptacle, small so as to necessitate frequent emptying of the contents. The ashes used are automatically sifted, so that only the fine ash is distributed over the fæces, the cinders being kept back and utilised as fuel.

CESSPOOLS.

Cesspools are still in use in many country places where no adequate means of drainage exists, and into them are conveyed the fæces, urine, and house waters by the soil-pipes and waste water pipes of the house. They are wrong in principle, because they do not aim at the immediate and complete removal of all excrementitious matters from the vicinity of the dwelling house, but, on the contrary, form a collection of these highly dangerous organic materials to be removed at a later date. In former times cesspools were badly built and were rarely or never mended, and leakage into the soil was the usual thing. They were seldom cleaned, and, in fact, not unfrequently their very existence was forgotten, till the outbreak of disease was the means of recalling the fact that there were arrangements of this nature near the house.

When, for any special reason, they have to be constructed now, they must fulfil the following requirements laid down by the Local Government Board, viz., that a cesspool must be 50 feet away from any building, and 100 feet distant from a well or drinking water. *Where sewers exist the cesspool must have no connection therewith;* and it must be constructed in walls and floor of brickwork set in cement, covered on the inside with cement, while around and below the brickwork there ought to be 9 inches of puddled clay. The top and bottom must be arched, the top being ventilated and provided with a manhole. The depth should not exceed 7 feet.

It is necessary to have the cesspool emptied from time to time. For this purpose hand labour is very laborious and disgusting in the extreme. In Paris the cesspools are emptied by pneumatic pressure. The receiver, which is an air-tight cart, has all its air removed by an air pump. A flexible tube connected with this chamber is thrust into the cesspool, and sucks up the cesspool contents into the vacuum of the cart. The contents are in this manner easily extracted from the cesspool and carried away.

In the *Liernur* system, which is in use in some towns in Holland, the fæces are conducted from the closets into iron tanks, situated under the streets, by means of iron pipes. By the action of steam suction pumps the fæces are drawn along to a central depôt and there converted into poudrette. The great objection to this system is the large initial expense, and the liability to blocking of the pipes. Moreover, the closets are liable to become rather odorous in course of time, and water is poured down to try to stop the smell; but this means of attempting to remove the smell is merely instrumental in deranging the proper working of the suction apparatus. This system cannot be commended in view of its expense and inherent defects.

WATER-CARRIAGE SYSTEM.

The WATER-CARRIAGE SYSTEM, or WET METHOD, is the means of sewage disposal which should nowadays always be made use of wherever it is at all practicable.

As has already been stated, the increased degree of impurity consequent on the addition of liquid and solid excreta to the contents of sewers is really comparatively slight, and the advantages in cleanliness, comfort, convenience, and health are on the other hand very great as compared with the conservancy method. The wet method is carried out by means of *water-closets* in houses, *house drains*, and the connection of these with the *town sewers*. As compared with the expense incurred in connection with the dry method, the initial outlay on water-closets, drains, &c., is much greater; moreover, a considerable amount of water is necessary to flush the water-closets and drains in order to efficiently carry away the excreta, and accordingly a portion of the water brought into the house for "household purposes" has to be specially set aside for this purpose. The excrementitious matter is of course rendered very much less valuable as an article of commerce on account of the decrease in its manurial properties from the addition of so much water, but it can nevertheless be put to use for agricultural purposes under certain conditions which we shall consider later.

In those towns where old sewers still exist, sewers which were adapted for soil drainage and the removal of storm water and house waste waters, it has been found advisable to remove the excreta by separate impermeable sewer pipes, the house waste waters and the excrementitious matters being dealt with by one distinct set of pipes, and the storm, surface, and soil waters by other pipes, the one set not communicating with the other. This has been called the *separate system*. As we shall have occasion to point out, under the *combined system*, one set of pipes subserves the removal of all the waste and excrementitious substances and liquids from the house, along with the rain and storm waters.

REMOVAL OF HOUSE WASTE WATERS.

In "non-water-closet" towns these waters are carried off by a system of drains and sewers which ought to be constructed in manner similar to the system employed for the removal of house waters plus human excreta. In small communities, and single large houses, the house waters may be removed by pipes and conveyed into a cesspool, or ditch, or stream, and in all these cases pollution of the soil or stream unavoidably occurs to a considerable though of course variable extent. Where it is possible, and particularly if there should be a slope in the land downwards from the house, the waste waters can be utilised for the benefit of the land by *sub-irrigation*, and the purified effluent can afterwards be allowed with impunity to pass into a neighbouring and conveniently situated stream. The pipes which receive the waste water from the house are put into the ground 1 foot or thereby below the surface, are laid end to end, and not jointed together, but are protected on the upper aspect of their open ends from the ingress of dirt and earth by covers made of portions of pipes split lengthwise. The effluent passes away into a stream at a lower level, while the organic matter removed from the water fertilises the soil,

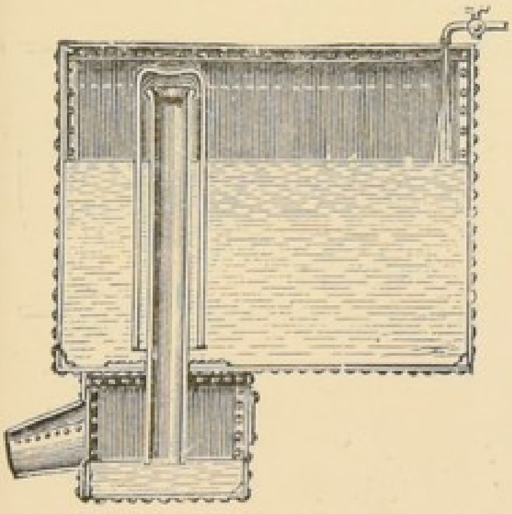


Fig. 13.—Field's Flush Tank.

and is absorbed by the roots of vegetation growing on the surface of the ground. To prevent blocking of this system, a flush tank like a Field's annular siphon flush tank will be found beneficial, placed between the house pipes and the system of open jointed irrigation pipes. Field's flush tank empties itself automatically every time the tank is filled by the tap figured in the upper right hand corner of the diagram: the regulation of the number of times per hour the tank automatically empties itself is thus controlled by the rate at which water is allowed to enter the tank by this tap.

ARRANGEMENTS FOR CARRYING OUT THE WATER-CARRIAGE SYSTEM.

WATER-CLOSETS.

The variety of principle and method of construction of water-closets is very great, but it will suffice for our purpose if we mention some of the forms which have been in most common use, and indicate those which are now considered to be the most generally serviceable and free from fault.

The PAN-CLOSET is one which is very frequently found in houses even at the present day, and is only now being replaced by better forms of water-closet. It consists of an earthenware *basin*, conical in shape, and covered in below by a *metal pan*. The metal pan can be caused to fall, by the pulling up of a plug, into an iron chamber situated below the basin, a chamber which is

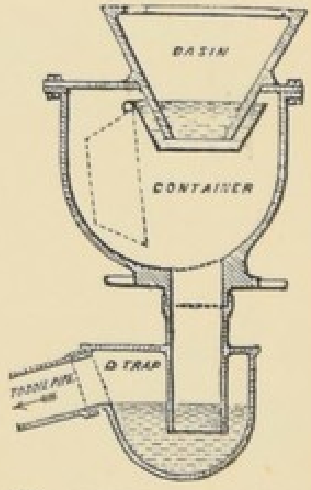


Fig. 14. Pan Closet.

technically known as the *container*. The basin, when closed below by the pan, contains a certain amount of water, and after the excreta fall into the basin the plug is pulled up and the water with the excreta is precipitated into the container. From the container a short pipe leads into a D trap, connected in its turn, by means of a pipe called the *soil pipe*, with the sewer, and so the arrangement of this water-closet is completed. The container may sometimes be found ventilated by a pipe passing directly from it to the open air, but in spite of this safeguard foul air tends to escape up into the basin from the container whenever the plug is pulled up, on account of the fact that the container gets coated with fæces and becomes very foul, while the D trap always contains a certain quantity of malodorous water. Defects in the mechanical arrangements of the pan-closet are liable to occur, and the D trap occasionally gets perforated by the action of the liquid contents in it, so that the pan-closet is far from being an ideal or safe closet.

The VALVE-CLOSET is like the pan-closet in its construction, but omits the container. A hinged water-tight valve worked by a handle fits the bottom of the basin, and opening downwards swings back into a small iron box made just large enough to accommodate it. From this iron box there passes away a tube leading into a syphon trap, and thence to the soil pipe which leads

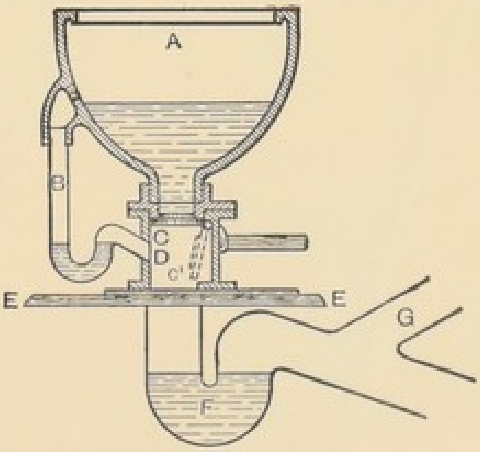


Fig. 15.—Valve Closet.

to the sewer. An overflow pipe (B Fig. 15), leading from the basin and provided with a syphon bend, opens into the pipe immediately below the valve; and the valve box is ventilated by a pipe which is conducted directly to the open air through the wall of the house.

Under the water-closet in each of these varieties there is constructed a tray made of lead and called the *safe* (E Fig. 15). Its purpose is to obviate any soaking from overflow, &c., into the roof of the room below. The safe is itself drained by a pipe either leading to the soil pipe, or better, being carried through the wall into the open air, where its external opening is guarded by a flapper from the action of wind blowing upon it.

The danger of the valve closet consists in the tendency to leakage of the valve, whereby escape of foul air into the basin may be permitted to occur, and from which the leak allows the water to dribble away, till the basin may become quite dry and empty of water, with the result that gases will readily ascend from below into the basin.

Water-closets which do not require movable mechanical contrivances to keep water in the basin are the most desirable, as they have no tendency to get out of order. There are several such, and among them are the following:—

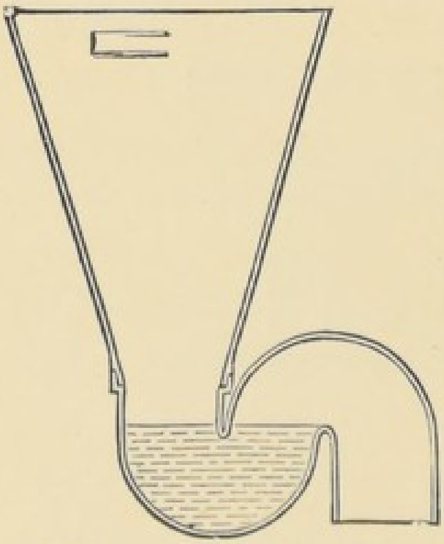


Fig. 16.—Long Hopper.

The **Long Hopper**.—This form of water-closet is constructed in the form of a long conical earthenware basin supplied below with an S-shaped syphon bend, which contains sufficient water to prevent passage of air from the exit pipe back to the basin. The cone of the basin is long, and herein lies a drawback as the basin is very likely to become soiled by fæces and not unfrequently the water does not succeed in flushing the trap completely, so that excreta are left behind in the basin.

The Short Hopper is an excellent form, and possesses a shorter cone, and in addition has its basin constructed with a *vertical* back. It is easily flushed, keeps very clean, and permits of no accumulation of air anywhere about, while overflow is impossible.

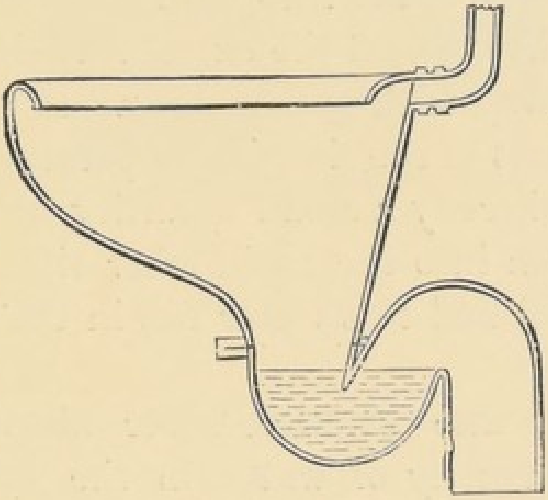
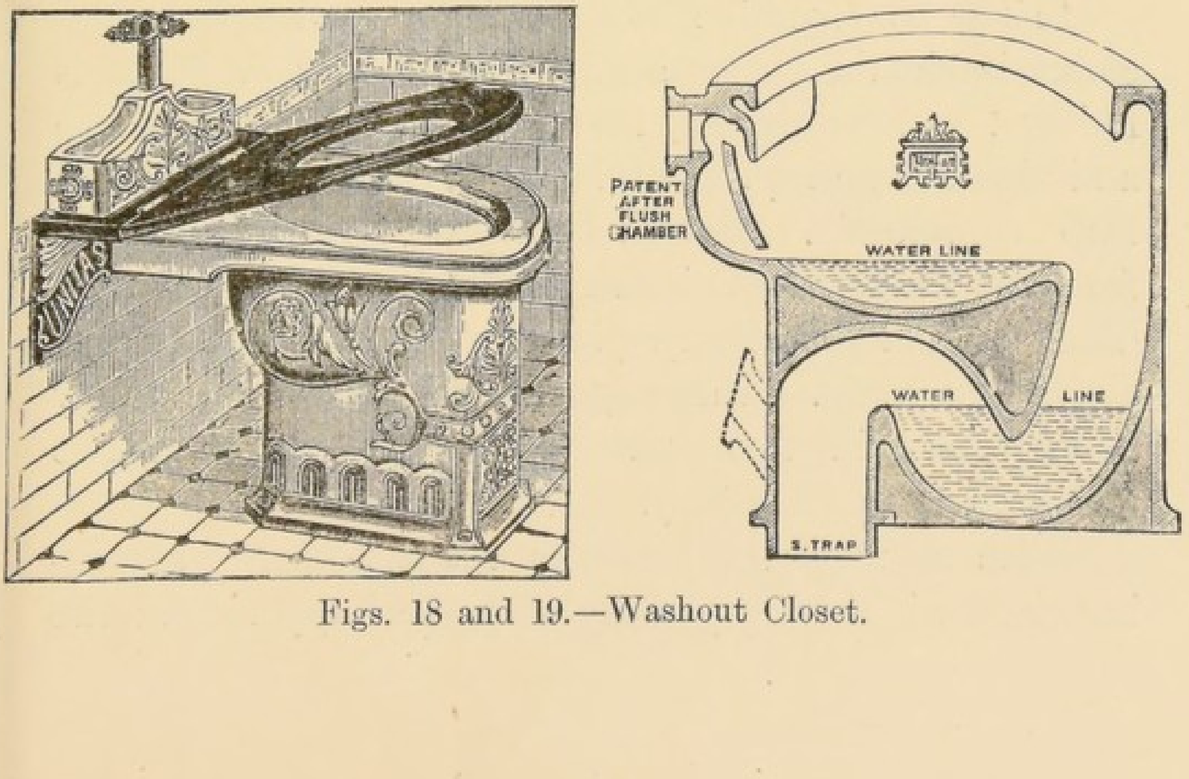


Fig. 17.—Short Hopper.

The Washout Closet is a fairly good form and is much in use, though scarcely so good as the short



Figs. 18 and 19.—Washout Closet.

hopper. In its construction there is a dip in the basin whereby a little water is always retained in the basin. The water flushing it conveys the excreta and water in the basin away, and if strong enough in force the flush carries the whole contents past the syphon trap. It is here, however, that fouling of the sides of the closet tends to occur, as the flush drives the excreta against the sides of the trap with some degree of force. Occasionally, too, all the excrementitious matters are not carried away with one flushing. A small chamber at the lower part of the flushing apparatus provides an "after-flush," whereby a small quantity of water is allowed slowly to run into the basin after the excreta have been carried off, and this water lies in the dip of the basin.

The PLUG CLOSET aims at maintaining a larger quantity of water in the basin by means of a plug placed in the connection between the basin and the syphon bend. The objection to this arrangement, however, is that fouling by excreta and the accidental lodging of paper, &c., may disorder the action of the plug.

In the construction of an efficient and safe water-closet it should be seen that the number of joints is reduced to a minimum, that the rush of water is free and vigorous and quite sufficient to clear the basin and trap completely. For this purpose the supply pipe from the water-closet cistern should be 1¼–1½ inches in diameter and the cistern placed at a height of 4 feet above the basin. Three gallons of water are usually enough, and in the short hopper no more than two gallons may be necessary.

With some of these closets a water-waste preventing cistern is used, especially with the hoppers and the wash-out closets. The working of the cistern can be seen by reference to the accompanying diagram. The syphon is put into action by pulling the handle attached to the chain, when the cistern at once completely empties itself, and the syphon cannot be again put into action until the cistern has become refilled with water.

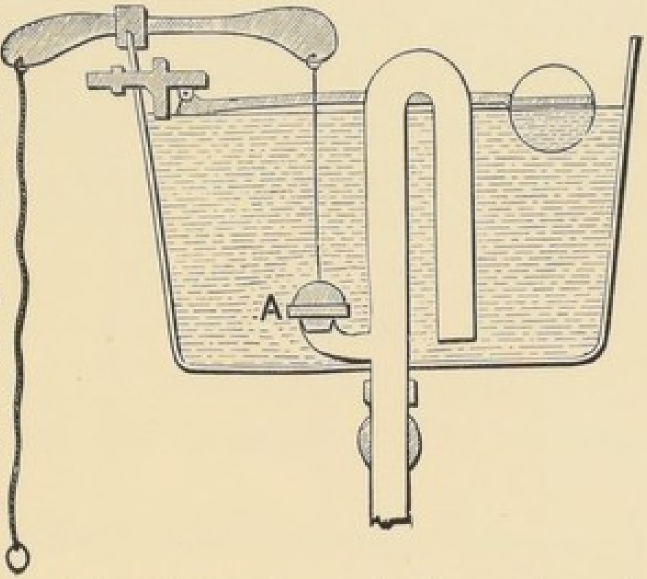


Fig. 20.—Water-waste Preventer.

Water-closets ought never to be situated in the interior of a house, but should adjoin one of the outside walls or be constructed in a special portion of the house which juts out from the rest of the building. The ventilation ought to be easy and free, and the closet fitted with a window opening to the outside, and measuring at the very least 2 feet by 1 foot. Continuous ventilation can be ensured by the use of air bricks or ventilating shaft. Ventilation of a water-closet into the lobby of a house or into a common stair in tenements should never be allowed.

For the requirements of a large establishment, as a factory or school, &c., it is customary to employ the TROUGH CLOSET. This is constructed of iron or earthenware in the form of a long trough divided off by several partitions, and it is inclined downwards to a slight extent in the direction of its outlet, guarding which there is a small weir which secures the retention of a certain quantity of water in the trough at all times. The soil pipe from the trough is protected by a syphon bend. The closet can be periodically flushed in an automatic manner by a Field's syphon tank, and when used in the dwelling houses of the poorer classes, where each small dwelling house is not provided with its own water-closet, the trough closet can be flushed with the household waste-waters. Inspection and disinfection of these trough closets can be easily carried out thoroughly, particularly during outbreaks of infectious disease.

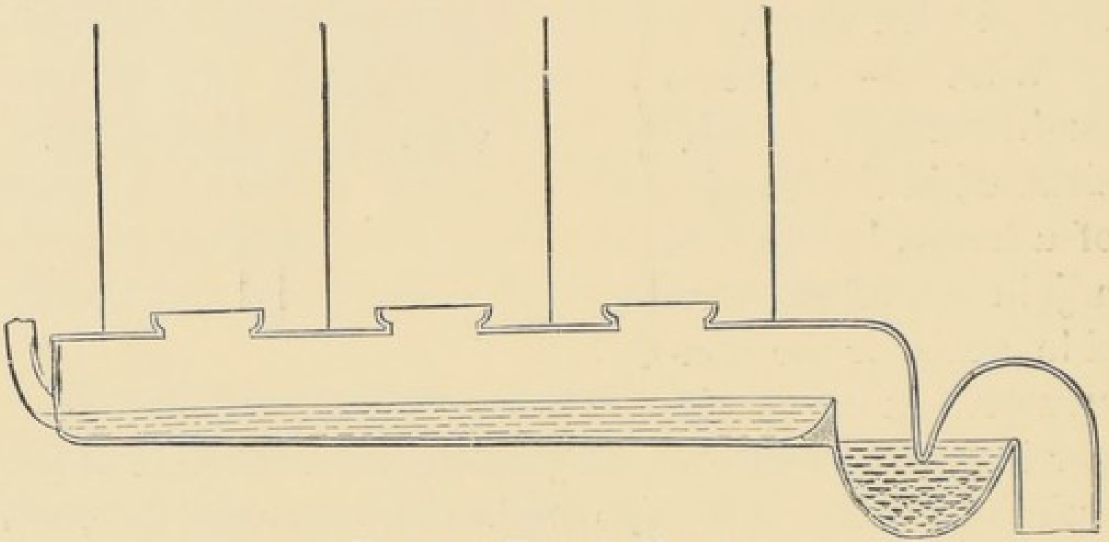


Fig. 21.—Trough Closet.

URINALS should be made of materials which do not lend themselves to corrosion, and either slate or stoneware is perfectly reliable to ensure safety and durability in their construction. The floor of the urinal is made to slope down towards the side occupied by the urinal, and the effluent channel is protected before being connected with the soil pipe by the interposition of a syphon trap. Automatic flushing is easily and effectively arranged for by special contrivances, and cleanliness and prevention of the ammoniacal odour, which so soon tends to be generated, are secured.

SINKS.—Kitchen or scullery sinks, carrying away the house waste water in "water-closeted" towns, ought to be provided with a grating to prevent foreign bodies from getting down the waste pipe and thereby causing obstruction.

Usually the waste pipe is fitted with a syphon trap underneath the sink, and is $1\frac{1}{2}$–2 inches in thickness, and leads into a grease-box. The grease-box is flushed from time to time, and cold water lies in it always, so that the hot grease coming into it is at once solidified and rises to the surface. The flush water breaks up the grease into pieces which are carried down the drains and not deposited on the sides of the pipe. Some grease-boxes are so arranged that the grease on the surface of the water of the grease-box and the sand and debris which fall to the bottom are cleared out at regular intervals.

The waste pipe "discharges *into the open air* over a channel leading to a trapped gully-grating (Fig. 27) at least 18 in. distant."—*Local Government Board Bye-laws.*

HOUSE-DRAINAGE.

House Drains may be constructed of circular glazed stoneware pipes, or of cast iron pipes coated with Angus Smith's material or by Barff's magnetic oxide of iron process. Iron pipes are more expensive than stoneware pipes, but are particularly strong, durable, and reliable, and may be carried under a house with safety—a procedure which should never be permitted with the employment of stoneware pipes, on account of the liability to fracture and consequent leakage. The joints between

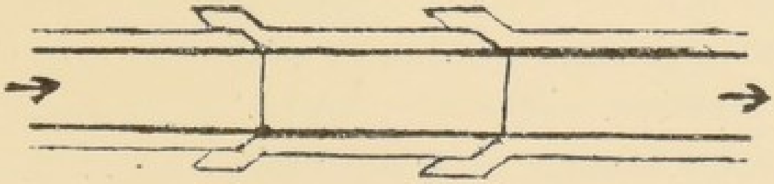


Fig. 22.

the various lengths of earthenware pipes must be socketed and cemented. The sockets of the pipes are placed so that they point to the head of the drain, the smaller end of the pipe above being received into the wider socket of the pipe below. (See Fig. 22.) The pipes are laid on a bed of concrete, or on a series of uniform bricks on a hard ground and with a slight incline. Each pipe is about 2 feet long and 4–6 inches in diameter. When the pipes pass under a wall a special arching ought to be built over them to prevent the possible sinking of the foundation of the wall snapping them across. They must be laid straight from point to point, and alterations in direction in them provided for by the interposition of special pipes. Means of inspection at suitable intervals ought always to be provided. Branch drains should enter very obliquely in a V-shaped manner so as to produce the minimum of resistance to the onward flow of the contents of the drain at each junction. (See Fig. 23.) These branch drains are of course smaller than the main drain, and where a smaller drain joins a larger one a "taper" or "diminishing" or "reducing" pipe is used.

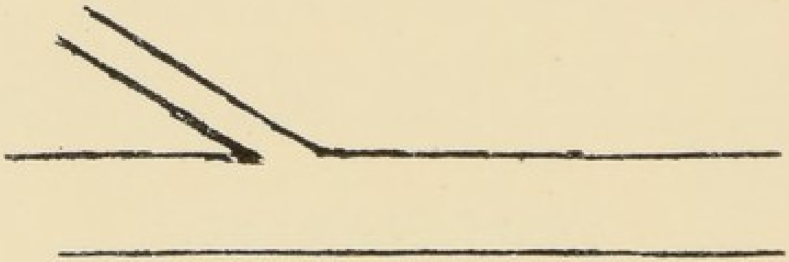


Fig. 23.—Branch Drain Junction.

For the purpose of inspection of the pipes *manholes* are placed at certain positions on the pipes, and preferably where an important junction occurs, or where there is a change of direction in the drain. The drains are straight from manhole to manhole, and any defect or obstruction can thus be readily detected and remedied.

Into these house drains pass the *soil pipes* of the house. The *soil pipes* receive the discharges from the *water-closets and urinals only.* In diameter these are 3 or 4 inches, are made of drawn lead, and are seamless; the joints between the various lengths of piping should be very secure, and for this purpose "wiped" joints are made, *i.e.*, hot solder is poured over the ends of the pipe lengths at their junction and this is then wiped round with cloth smeared with grease. Any branches are made with lead T-pieces. The pipes ought to be carried at once to the outside wall of the house and are for this purpose here connected with *iron pipes* coated with Angus Smith's solution or by Barff's magnetic oxide of iron. Where the iron (outside) pipe joins the leaden (inside) pipe a joint is made by means of a brass ferrule.* At the point of junction of the outside soil pipe with the house drain there is a simple bend, and, *for ventilation purposes,* the pipe is carried *upwards in its full calibre* to the top of the house, avoiding, however, bringing it into the proximity of windows or chimneys, and a cap of wire gauze fixed over the open end of the top of the pipe prevents any obstruction getting access or lodging there. In some cases the soil pipe, leading from a water-closet situated on an upper floor, passes down *inside* the house; when-

---

* The brass ferrule is joined to the leaden pipe on the one hand by a wiped joint of solder, and on the other hand to the iron pipe by lead run on in a molten state.

ever it reaches the basement it should at once be carried to the outside under the wall of the house by an iron pipe, and open into a syphon disconnecting trap, whose ventilator allows air to pass into the soil pipe right up to the top of its ventilating arm at the roof of the house. The junctions between the various lengths of iron pipes are effected by means of tow packed tightly round the pipe junction ends and then molten lead is run in to fix the whole together. The drain itself, in addition, is ventilated, and in this manner the access of foul air into the house is obviated.

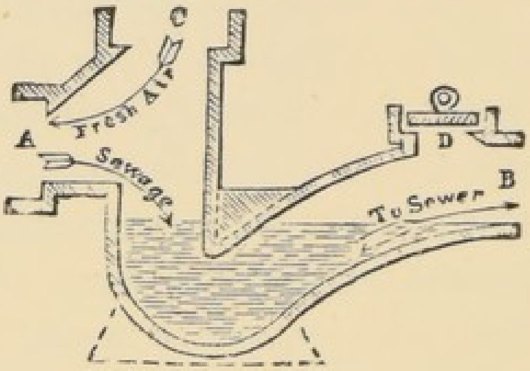


Fig. 24.
Disconnecting Ventilating Trap.
(Buchan.)

When water-closets, as in a tenement of houses, are placed in series one above another and open into a mutual soil pipe, the water flushing one of the water-closets near the top flat may syphon out the water from the trap of one of the lower water-closets (pipe A). This is prevented by having a 2-inch ventilating pipe from the distal end of the syphon bend of each water-closet leading right up to the top of the house (pipe B). (See Fig. 25).

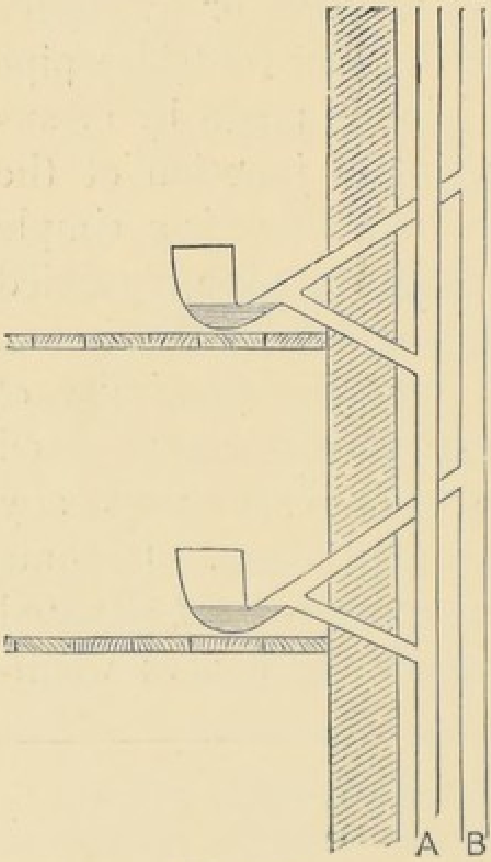


Fig. 25.

Rain water pipes, which carry away the rain water from the house roof to the drains, should never be employed as the ventilating pipes for drains or soil pipes, for during rainy weather the flow of water may force the syphon bend of traps and let sewer air escape into the house, and, moreover, when there is much rain they are of course full of water and consequently useless as ventilators.

It is essential that the *disconnection of the house drain*, where it enters the sewer, should be very thorough and complete, to prevent the passage back of sewer air into the house along any of its drainage arrangements.

This is accomplished in the case of *smaller houses* by means of a *sewer air interceptor* (Buchan trap) made of earthenware, and mentioned previously as being utilised for ventilation and trapping purposes when soil pipes have to pass from an upstairs water-closet down inside a house. It is placed on the house drain as it passes toward the sewer and is situated in the area or garden adjoining the house, being securely fixed on a pedestal so that it may not slip from its position, and thereby become incompetent. It is ventilated by a vertical pipe brought up to the surface of the ground and covered over by a grating (at C, Fig. 24), and at this point air is permitted to enter and at once passes up the soil pipe and its ventilating shaft, and ventilates it. The syphon of this interceptor should have an adequate water-seal of 2 inches at the least, and the calibre of the syphon is made a size smaller than that of the pipe leading into it. The inlet to the syphon is vertical, while the outlet has a slope on it at an angle of not more than 45° (see Fig. 24).

Large houses possessing several drains should have these drains led to a *disconnecting* or *intercepting* *manhole chamber,* built of bricks set in cement and on a concrete foundation. The floor slopes gently upwards towards the sides of the chamber, and has running across it the main house drain. Here are received the branch drains. The main channel passes onwards into a syphon trap, which is of smaller calibre than the main drain leading to it, and thence to the sewer. There is a branch pipe placed above the syphon and opening into the drain *beyond* the trap for the purpose of cleaning the drain, and this is often called the *raking arm* (*r* Fig. 26). The upper end of the raking arm is closed by an air-tight cover which is removed when the drain is about to be cleaned. The upper surface or roof of the ventilating chamber has at one corner an iron cover provided with perforations for the admission of air. The actual aperture of emergence of the house drains into the common sewer is occasionally guarded by an iron flap or ball valve arrangement, so constructed that, while fluids, &c., can pass from house drains to sewer, no flow in a backward direction is permitted. This safeguard is not always efficient in those cases where it seems to be required, namely, where there is a tendency to flooding and backward pressure in the common sewer, as may occur when the sewer discharges into a tidal river or into the sea.

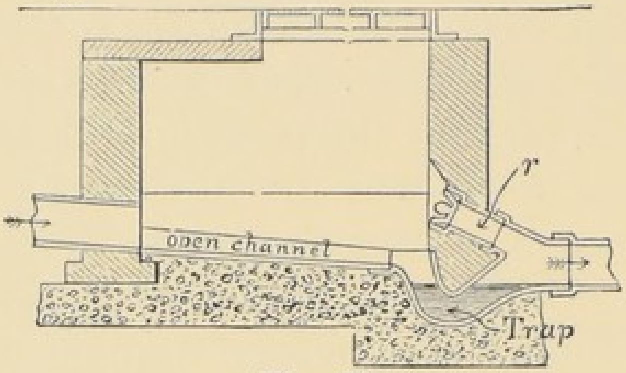


Fig. 26.
Disconnecting Man-hole Chamber.
r, raking arm.

Cesspools must not under any circumstances be permitted to exist in the system of drainage between house drains and sewer. If an old house possesses a cesspool and becomes connected with a public sewer, the cesspool must be at once removed and the earth round about also taken away, on account of the probability of the soil being impregnated with organic matter.

In country houses supplied with water-closets and where no sewers exist to carry off the excreta, and where a cesspool must be used, the house drain is disconnected from the cesspool by a syphon trap and ventilating manhole, while the cesspool itself is constructed according to the Local Government Board Bye-laws (see page 98).

Syphon gullies are situated in the yard adjoining the house and are used for receiving the waste water from the kitchen and scullery sinks and the discharge from rain water pipes. The surface waters of the yard or area are carried off by pipes which open as branches into the soil pipes. The water entering a syphon gully is discharged directly into the open air over the gully, and in consequence no foul air can possibly reach the house when a syphon gully is used to receive these waste waters. Still, in every case, further precaution is taken to prevent passage of foul air back along the waste pipes by the provision of a syphon bend on the pipe under the sink, as already seen in the case of kitchen and scullery sinks, on the waste pipe of the bath, &c.; and, in addition, to keep the syphon trap quite clear, it is provided on the under surface of the bend with a screw tap, which can be unscrewed from time to time so as to enable grease, dirt, foreign bodies, &c., which may have lodged there, to be removed.

TRAPS.

Traps have been already frequently referred to, and it may be advisable at this point to refer to the various

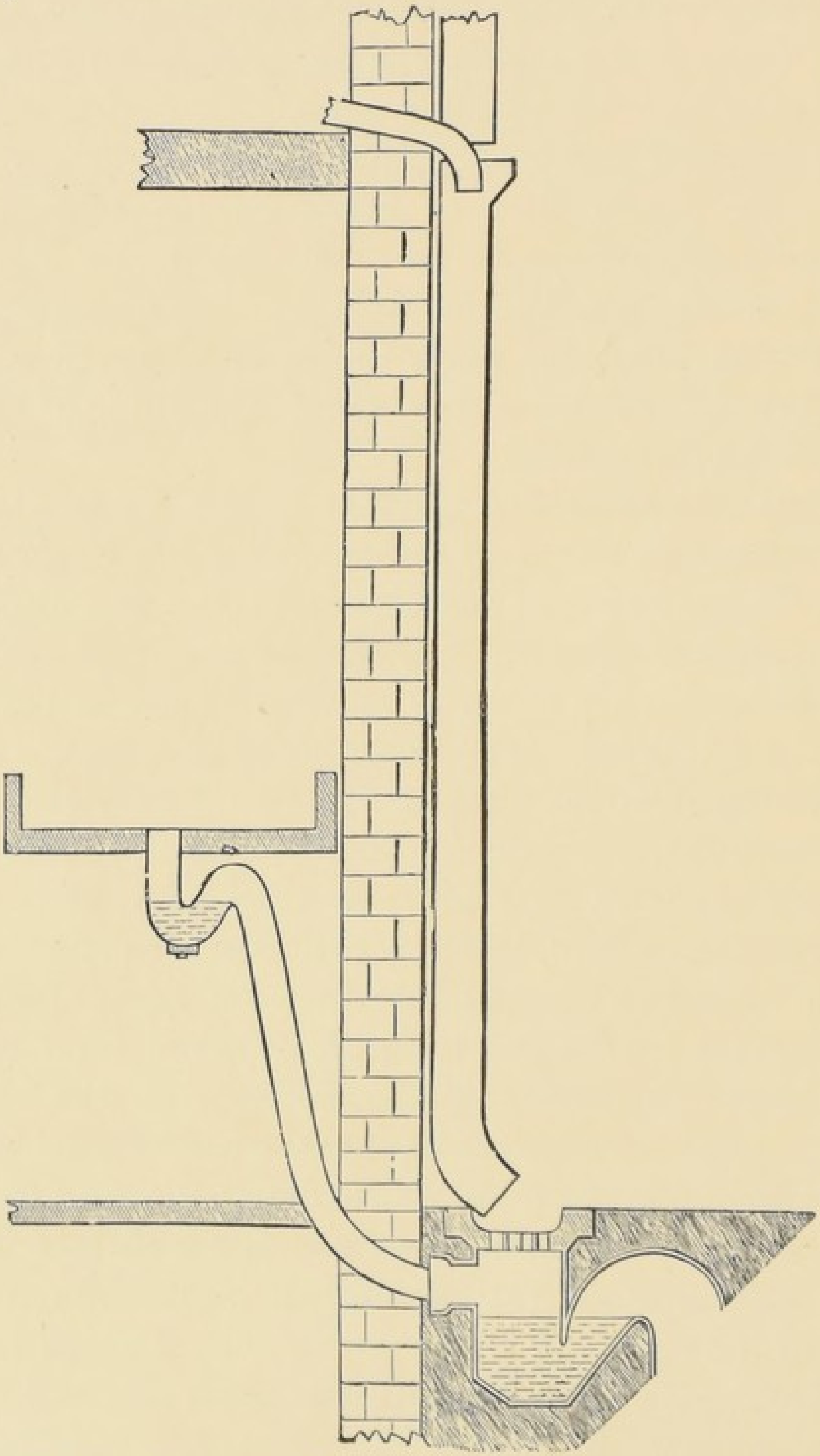


Fig. 27.—Diagram of Trapped Gully Grating (page 109).

kinds of traps which have been invented and made use of. Some of them are very faulty and have in old houses been the cause of a breakdown in the whole drainage apparatus of these houses.

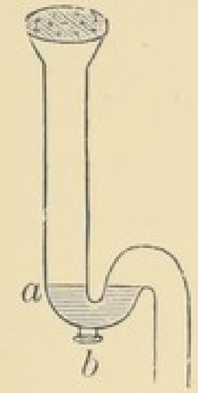


Fig. 28.
Syphon Trap.
a, Water Seal.
b, Screw Tap.

The *syphon trap*, so frequently alluded to, is one of the best and simplest of all traps. It consists of a curved pipe, the bend of which ensures that some part of the *roof* of the pipe is *always under water*.

The amount of water standing in the pipe *above* the roof at the downward bend is called the *seal*, and is frequently 2 inches. At the bottom of the bend there is fitted a screw tap which is unscrewed for cleaning purposes, as dirt, foreign bodies, &c., are liable to collect at this point.

Mid-feather traps have a partition dipping down into the water between the ingress and egress pipe, whereby a seal is constituted (see fig.). Examples of this form of trap are the Dipstone and Bell traps both of which are bad forms of trap. The former is bad because of the mechanical obstruction it causes (even when its lower ridge is rounded off), and the latter is faulty because the bell is fixed to the cover of the trap, so that when the cover is lifted for any purpose there is free communication between the open air and the foul gases in the drain.

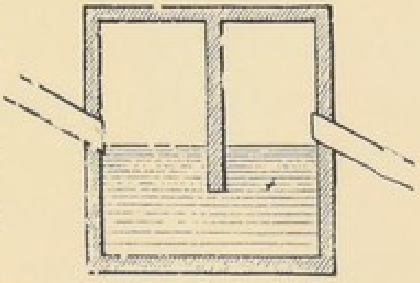


Fig. 29.—Dipstone Trap.

The D trap, shaped like the letter D placed on its side (thus , Fig. 30), is not a good form of trap because it gets very soon covered with excreta in those parts of it which are not directly flushed with water, and, being made of lead, it is rather easily corroded, so that it leaks; moreover, the foul coating gradually formed on its inner surface evolves noxious gases, which escape upwards into the basin of the water-closet (for it was in connection with the pan closet that this trap was most frequently used).

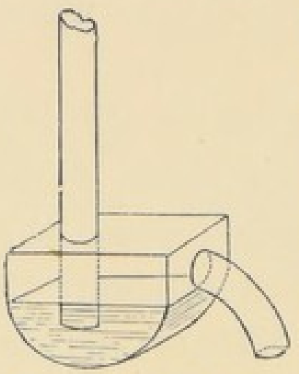


Fig. 30.—D Trap.

Gully traps for waste waters and surface waters are ventilated traps of half S form (see fig.). The grating on the top can be removed and substances in the bottom of the trap can be thereby removed.

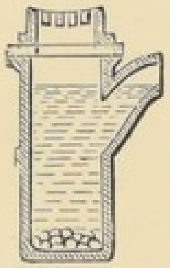


Fig. 31.
Gully Trap.

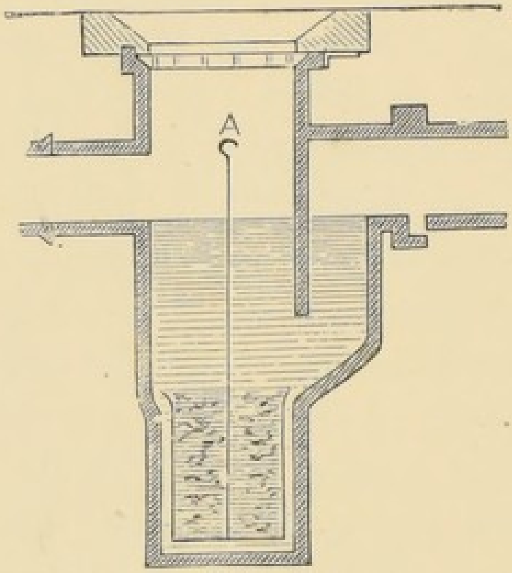


Fig. 32.
Gully Trap and Cleanser.

Testing of Drains.—It is often necessary to test drains in order to ascertain if the drainage arrangements are in good order, and if there be leakage, to determine where the default is. The methods used are the following:—

1. *Smoke Test.*—A smoke rocket or smoke machine is applied at the disconnecting air chamber, or sulphur is burned there and the air inlet is closed. Any leak is discovered by the visible escape of smoke or the easily perceived smell of sulphurous acid fumes at or over any default which may exist in the pipe.

2. *Oil of Peppermint Test.*—Half-an-ounce of Oil of Peppermint is poured down the highest water-closet in the house or the soil pipe ventilator, and is followed by a quantity of hot water. The volatile oil is at once volatilised, and if it is being allowed to escape by a leak at any point, then the smell of the oil is readily detected, and the situation of the leak definitely localised.

3. As a simple test of efficiency, the lower end of the drain is plugged and the drain thereafter filled with water. Fall in the level of the water of course will indicate that there is a leak somewhere.

4. The existence of foul deposits in the drain can be detected by pouring a large quantity of clean water down the drain and watching it emerging into the drain below. If the water be observed to be passing away in a filthy or dirty state, then it is clear that the drain must be harbouring foul deposits at some part of its course. The exact site of this deposit is then a matter of subsequent enquiry and is usually easily found out.

EFFECTS OF SEWER GASES ON THE INDIVIDUAL.—When, from any reason, sewer gases are being respired by an individual certain well-marked symptoms make their appearance sooner or later. No actual odour may have been perceived by the occupants of the house at any time, and this may put them off their guard. The children of the house are most commonly first and most severely affected, and then those members of the household who are least out in the open air. Headache, nausea, vomiting, with loss of appetite, and lassitude are very usually complained of and are particularly marked in the morning. Tendency to sore throat, either mere dryness and slightly painful throat or actual quinsy, is often seen; while eczema and boils all over the body are very frequent and suggestive symptoms. Erysipelas, septic action in wounds and hospital gangrene are seen in hospitals where the drains have got out of order; while puerperal fever is very liable to occur when a patient is confined in a house where air is vitiated with sewer gases. Diphtheria, scarlet fever and enteric fever are often spread by the agency of faulty drains, the toxic agency finding a ready means of access into the house by the default in the drainage arrangements, and being aided in its action by the debilitating influence of the sewer gases.

SEWERS.

The public sewers are the channels into which the house drains empty their contents, and by which the liquid refuse of towns is carried away. In former days, before the introduction of the water carriage system, these sewers only carried off the house waste waters together with the rain, storm and subsoil waters, and acted also as soil drains. In recent times some of these pipes have been employed to carry off the excreta as well. But it is obvious that pipes which serve to drain the soil should not be used for the removal of excreta; for, to collect and carry off rain, surface and subsoil water, the pipes are not constructed water-tight, but on the contrary are open; and, in consequence, if these pipes are able to admit water from the outside they can with equal facility allow escape of excreta and foul gases from their interior, with the result that the subsoil, ground air and superficial wells are all liable to become contaminated by the escaping organic matter. Accordingly, it has now come about that in towns where the water-carriage system is in operation the sewers are constructed water-tight when they convey excreta away, as well as rain, storm and surface waters; that is to say, when the *combined system* is employed. The *separate system* is also in some instances employed, and is that adopted when there are *two sets of pipes*, one for excreta and house waste waters only, and another set for rain and surface waters.

Under the *combined system* the sewers, which carry away excreta, rain water and surface water, &c., in one set of pipes, must necessarily be of large calibre and strongly constructed. Provision must be made for the accommodation and the escape of the large additional quantity of water liable to occur on an occasion of excessive rainfall, and this is done by having the sewers large, and furnishing *storm overflows* to carry the excessive water away, *e.g.*, to a neighbouring stream. The sewers are built of impervious bricks or stoneware blocks cemented together very firmly with Portland cement, 4½ inch brick being used in drains of 3 feet diameter, and up to 9 inch brick-work in larger drains. In section the drain is seen to be egg-shaped, with the narrower end of the ovoid below, in order that resistance to the flow may be as slight as possible. Sewers which are less than 18 inches in diameter can be constructed of impervious glazed stoneware pipes instead of being brick-built. In order that a steady even flow may be maintained at all times the sewers ought to have *an adequate fall.* The flow ought never to be less than 1 foot per second nor more than 4 feet per second, because in the former case stagnation is apt to happen, while in the latter case the sewer is apt to get worn too quickly. The larger the diameter of the sewer the less fall is required for the maintenance of a proper rate of flow, and the following figures will afford an idea of the fall required and the rate of flow which is proper for some of the various usual sizes of drains:—

Fall—

6 inch pipe, - -	1 in 65.
10 " - -	1 in 120.
48 " - -	1 in 800.

Velocity—

6– 9 inch drain, -	3 feet per second.
12–24 " -	2½ "

Under the *separate system* the sewage pipes for the excreta and household waters need be only of comparatively small size, for the rain, surface and subsoil waters go away by themselves in separate channels.

In some cases the subsoil drainage is effected by the use of agricultural drain pipes situated immediately over the top of the public sewers. In other cases the public sewers are made to rest on a pedestal arrangement formed of flat-bottomed pipes shaped in section like the capital letter D inverted (Fig. 33).

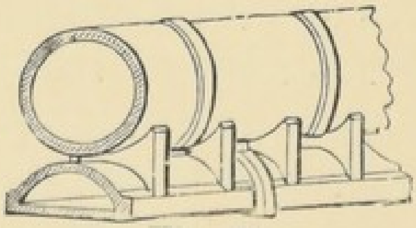


Fig. 33.

When the *separate system* is adopted the total volume of sewage to be dealt with at the outfall of the sewers is on the whole fairly constant in quantity* and concentration; there is no tendency to deposits forming on the sewers nor any accumulation of foul gases, because the pipes are much smaller and are more frequently flushed than in the combined system. Moreover, storm waters are readily carried off by the soil drainage pipes, and the sewers are not exposed to the risk of being suddenly overfilled, an occurrence which tends to happen when there is a specially heavy fall of rain, the water of which has to be dealt with and removed by the one set of channels under the combined system.

Outfall of Sewers.—The method of termination of the sewer will of course depend on the arrangements which are found to be best suited for the ultimate disposal of the sewage. For example, in towns where a lake is in the immediate vicinity or where a stream or tidal river flows by near at hand, the sewage cannot be discharged directly into either of these conveniently placed receptacles, if one may use the word in this relation. The sewage must undergo some process of purification first; because, if discharged directly into a tidal river, the constituents of the sewage are very liable to collect by the action of the tides into certain portions of the river, and constitute *sewage zones*, and when the sewage of these sewage zones is not properly carried away, the

---

* It may be reckoned that the amount of the household waste water and excreta per person is equal to the amount of water supply per person, and so the total amount is easily found by multiplying the number of gallons of water supply per head by the number of the population.

solid matters become deposited on the banks of the river and constitute a source of nuisance and intolerable annoyance, especially when the decomposition changes occur. Purification, to some extent at least, and keeping back the solid materials must therefore be resorted to, and the *strained effluent only* permitted to pass into the rivers.

When the sewage is conveyed directly to the sea, the pipe is carried out to such a distance that *its extremity is always under water* even at the lowest states of the tide, and its mouth is protected by an iron flapper or by a valve to prevent the rising tide driving back the sewage along the sewer pipe.

Should the fall toward the sea be slight, *Shone's system* can be employed, whereby compressed air is utilised to force the sewage on toward the end of the sewer. The method of operation is as follows:—The sewage is conveyed to ejectors situated in chambers placed below the streets, compressed air is conveyed to these ejectors by iron pipes, and when the ejectors are full the compressed air forces the sewage up to a certain level, from which a sufficient gradient can be obtained to secure a good fall toward the outlet.

In those cases where the sewage is to be treated chemically or by irrigation, or by the use of land, then it is led into one of a duplicate set of settling tanks in the first instance (see page 128).

The *ventilation of sewers* is favoured by a steady flow of the sewer contents, because air has a tendency to pass in the same direction as that in which the sewage is travelling. Movement of air inside the sewer is also induced by variations in barometric pressure, passage of hot fluids, &c., from houses and factories into the sewers, and variations in the outside temperature, causing change of pressure in the sewer air. In some cases also the direction of the wind has an influence on the air currents inside sewers.

Openings communicating with the external air at the surface of the ground may be made into the crowns of sewers, and, as a rule, about 18 of these openings are constructed for each mile of sewer. Some of these openings act as inlets others as outlets for air, and all may act either as inlets or as outlets at different times, according to the direction and force of the wind. Under the ventilator a *dust box* may be placed in order to prevent foreign bodies falling into the ventilating opening in the sewer. *Charcoal trays,* to deodorise any foul-smelling gases passing out to the external air by the ventilators, have been employed, but are not really necessary, and are indeed often of less than no value, in that they tend to cause obstruction to free ventilation of the sewer. Ventilators opening from sewers on to the surface in wide streets cause no annoyance or danger to people, but in the case of narrow alleys, &c., it is best to carry the ventilator by means of a shaft up to the top of the houses, in order that no nuisance may be caused by the ventilator opening into a confined space.

The *flushing of sewers* is often unnecessary when the flow is good and steady, but in some cases aid is called for to get a better flow. Sometimes an *automatic syphon flush tank* is made use of and serves the purpose well. In other cases *flushing gates* are used. These are gates hinged below their centre and are placed in the course of the sewer. When the flow is slight, the sewage impinges on the lower part of the gate below the hinge, and, being dammed back, collects and rises in level until it reaches above the hinge. The weight of sewage then, pressing on the larger upper portion of the gate above the hinge, forces it over and the sewage escapes down the sewer with some considerable momentum. When the sewage again falls back to its normal level, the same process is repeated, and so on *ad infinitum.*

Means of Inspection of sewers are found in *Manholes* placed at various points and intervals along the course of the sewers. They are constructed of brickwork, and reach from the street surface down to the sewer. Their orifice on the street level is provided with a locked iron door. At the position of the manholes the flushing gates are usually placed, and here also the junctions of branch drains to the main sewers are made, so that all of them are easily available for inspection, cleaning, &c. Ventilators also can be constructed in connection with these manholes additional to, or as a part of the system of sewer ventilation already referred to.

ULTIMATE DISPOSAL OF SEWAGE.

When a town has been supplied with proper means of removing sewage from its midst, there still remains for solution the problem of how the sewage material is to be dealt with and disposed of at the outfall of the sewer ; and in some cases this is a problem not admitting of easy solution. It has been already shown that the sewage cannot be discharged at once into tidal rivers or lakes on account of the great pollution which would thereby be produced. It is of course easy when a town borders on the sea, for into the sea the sewage is carried directly, and no further trouble is caused. True, all value which may pertain to the sewage is lost when it is led into the sea, but under rare conditions can a town hope to derive a profit from any means of adequate disposal and utilisation of its sewage. It is well if the excrementitious matters are satisfactorily and healthily disposed of, and any question of profit ought to be a secondary matter, and in fact any value the sewage has is usually merely a help towards meeting the expense of its proper removal.

When the sea is not available for the reception of sewage, as in the case of inland towns, it is necessary to adopt some means of purification of the sewage, to the end that, the solid parts being kept back, the effluent can be allowed without undue risk to pass on into rivers, &c. When sewerage is carried out under the separate system the sewage is of more constant quantity and degree of concentration than when the combined system is in operation, and in the former case what has to be dealt with consists of the excreta, slop and waste waters, and its amount nearly corresponds to the amount of water supply of the community.

The following are some of the processes to which sewage has been subjected in order to remove the solid and suspended matters, so that the effluent, when admitted into rivers, &c., may be fairly innocuous and not a source of annoyance or dangerous to the public health. It must be remembered, however, that the effluent, although largely freed of its suspended matters, may yet contain a considerable proportion of nitrogen, in both inorganic and organic combination.

1. Settling Tanks.—These are constructed in duplicate so that, when one set of tanks has been in operation and is being emptied, the other set may be brought into requisition, and the clarifying process may go on without interruption.

The sewage is delivered fresh, and is allowed to flow into large shallow tanks 4 to 6 feet in depth. Having entered the tank, the sewage fills it completely and flows over a weir placed at the end of the tank opposite the point of entrance. Meanwhile the solids and suspended matters gradually are sinking to the bottom as a sludge, and the effluent flows away. The sludge is removed from time to time, say twice a week, and is either employed as manure by being dug into the soil just as it is collected, or is dried by compression and subsequently used as manure; or it is burned, or carried out to sea. The sludge is not of great manurial value because of the fact that a great proportion of the ammonia is lost in the effluent in which it passes away in solution.

2. Simple Straining.—In this method the sewage is strained through beds of charcoal and ashes, the solids being retained and the effluent permitted to escape. It is not, however, a good method because of the fact that the beds become very speedily clogged and consequently useless, and the frequent renewal rendered necessary is expensive.

3. Chemical Treatment. — Chemical substances are employed to facilitate the precipitation of the solid matters suspended in the sewage, but are, as it were, merely adjuvant to the principle carried out in the

settling tanks. A great variety of chemical substances have been utilised to attain this end, among which are:—

(1) *Lime.*—In the form of milk of lime, or of lime water, lime has been used with good results. The lime combines with the carbonic anhydride—CO_2—present in the sewage and forms the insoluble calcium carbonate, which, as it falls in precipitation, entangles the suspended solid matters in the sewage and carries them to the bottom. Roughly speaking, the amount of lime which ought to be added should be equal to the hardness of the water supplying the town whose sewage is being treated in this fashion. On an average, if lime water is utilised, 3 grains for every gallon of sewage will suffice, and if slaked lime be used, 12 to 15 grains per gallon. Care must be taken not to add an excessive quantity of lime to the sewage, else the sewage will be rendered too alkaline, with the result that decomposition will freely occur with evolution of ammonia, and consequent loss of some of the manurial value of the sewage.

After the sewage has been so treated, the precipitate is removed as sludge, and disposed of in the manner described above—under "settling tank treatment." The effluent is allowed to pass off into a convenient running stream or other outlet.

(2) *Alum* is another useful agent for precipitation. The sulphuric acid of the sulphate of aluminium combines with bases in the sewage, as, for instance, lime, while the aluminium falls as Aluminium Hydrate, a very loose flocculent substance capable of entangling and carrying down a vast quantity of solid matter. Lime is useful in combination with alum for the more efficient carrying out of this process.

(3) *Sulphate of Iron* (Ferrous Sulphate) when added to alkaline sewage is converted into the flocculent Hydrated Oxide of Iron. It carries down with it much solid matter, and, being an antiseptic agent, it tends to arrest decomposition of the sewage. The effluent unfortunately contains some of the iron, and in consequence it blackens the sides of the stream into which it is discharged. Three grains for every gallon of sewage suffices for precipitation purposes.

(4) *A B C process.*—In this process the precipitating agent is a mixture of Alum, Blood, Clay, Charcoal and Magnesium Sulphate. The blood is of no use whatever; the other ingredients are precipitant and deodorising.

The *effluent waters* in all these processes are often discharged into a stream running close at hand, and whose rate of flow must be fairly rapid; it must not at any rate be sluggish, otherwise the effluent waters are not sufficiently quickly carried away, and the stream acquires too high a concentration of organic matters in solution. Sometimes the effluent is passed over filter beds consisting of sand and polarite (magnetic oxide of iron and carbide of iron), or is used to irrigate land.

4. LAND TREATMENT.—(1) *Surface Irrigation.* For this purpose the sewage ought to be conveyed to the land by gravitation, so that no pumping is necessary, and it should be freed of the bulk of its solid constituents before being deposited on the land. On an average, according to the nature and suitability of the land for this purpose, 1 acre of land will be sufficient to deal with the sewage of 1000 people. Any kind of soil almost can be made to answer the purpose, but *loamy soil* is best.

The piece of land should be levelled, and then drained by means of pipes placed 6 feet below the surface, and, so far as is possible, the ground should have no deep cracks or fissures running into it, else the sewage passes down these, and escapes unaltered into the effluent. The surface of the land is arranged in a series of furrows and very broad ridges parallel to one another, the ridges being as much as 40 to 50 feet broad and placed at right angles to the main sewage delivery pipe. The flow of the sewage on to the ridges and into the furrows is controlled by sluice arrangements, and may, by these arrangements, be allowed to pass on to the land for a certain time, or may be kept back at will.

(2) *Intermittent downward Filtration.*— This method of sewage treatment is carried out by means of a permeable and very porous piece of loamy soil. Either the soil or the sewage should contain a goodly quantity of lime, for the purpose of combining with the nitrates formed by the process from the nitrification of the nitrogenous organic matter in the sewage.

The surface of the land is levelled, and drained by porous drains lying 6 feet below the surface. The land is divided into *four portions,* each of which is of about the same size and is used for 6 hours at a time, and then is allowed to rest for 18 hours, each portion being utilised in rotation.

The sewage is allowed to flow on to the level surface of the piece of ground; or the land is laid out in furrows and ridges, and the sewage is poured down the furrows, while on the ridges are planted various kinds of vegetables, whose roots take up the organic matters of the sewage as pabulum. The result of this treatment of the sewage is that its nitrogenous organic matters and ammonia are nitrified by the action of organisms and the air in the soil, and converted into nitrates and nitrites which enter into combination with the lime salts in the sewage or in the land.

When sewage is passed on to land in an unfiltered state, 1 acre of land is necessary for 1000 inhabitants; whereas, if the sewage be previously strained and clarified, 1 acre can deal with the sewage of 5000 inhabitants.

Mangold wurzel, *cabbages*, and *Italian rye grass* can be grown with ease on a sewage farm conducted on these principles.

5. Bacterial Treatment.—This method of treatment depends almost entirely on the action of *micro-organisms*, aided in some cases by the oxidising action of the atmospheric air. The organisms which subserve this function are those concerned with the ordinary processes of putrefaction and fermentation, and they have a very decided action in breaking up the organic molecules in sewage. Organisms, as we have already seen, abound in the soil to a depth of 12 feet from the surface, and are of two kinds "aerobic" and "anaerobic," the former variety requiring oxygen for growth and development, the latter being independent of oxygen and being in fact inhibited by it. Organic matters in the soil are acted on by these organisms, and are broken up to form new chemical combinations of such a nature that they can be assimilated by plants as pabulum. Some of the organic matters are also oxidised by the oxygen present in the soil. As an additional result of these processes, ammonia, marsh gas, and sulphuretted

hydrogen may be liberated and then escape up through the soil into the atmosphere, while the nitrates, which are also formed, combine with the lime and other bases in the soil. This process is constantly going on actively under natural conditions, and has been made use of for the treatment of the large quantities of organic matter in sewage.

The sewage is brought to beds or tanks filled with masses of broken stones. Its solid matters are previously got rid of, so far as is possible, by straining, and by passing slowly over the broken stones the sewage is thoroughly exposed to the air, while the organic matter adhering to the surface of the stones speedily gets full of organisms which act on the sewage organic matter flowing over the stones and nitrify it. The *effluent* may subsequently be passed through sand filter beds, and can then be discharged with safety into a stream.

The *Septic Tank System* is conducted on similar principles in large tanks, covered over, and containing sewage only. The solids and suspended matters become liquefied by bacteria action; and it is found that the amount of sludge which falls to the bottom after a tank has been used for some weeks, or even months, is very slight indeed The tank is large enough to hold the sewage of 1500 inhabitants, being of 54,000 gallons capacity. The effluent is afterwards conveyed on to land, and treated by intermittent downward filtration.

There are no offensive effluvia liberated in connection with this process, because the tank is covered, and the ammonia, sulphuretted hydrogen, &c., are speedily acted on by the organisms, and by oxidisation are converted into odourless bodies.

CHAPTER V.

CEMETERIES AND CREMATORIA.

THE disposal of the dead, in a manner safe to the public health, has been the cause of a considerable amount of consideration of late years. The large number of persons who die in the course of a year in densely populated districts, creates some difficulty in satisfactorily disposing of the remains in such a manner that no nuisance will be created. From the earliest times the dead have been buried in the ground, and only within recent years has there been any systematic attempt to alter this custom by the suggestion and carrying into actual operation of cremation. The difficulties in finding sufficient cemetery accommodation in towns became so great, that some years ago the state of cemeteries throughout the country was very far from satisfactory, on account of the terrible overcrowding which had been allowed to take place. Some reform in connection with the disposal of the dead became necessary. This overcrowding was one of the reasons in favour of the adoption of cremation which was urged by its supporters, who also adduced other alleged advantages to be mentioned later.

The primary object to be attained in the disposal of the dead in *Cemeteries* is to bring about as rapid and complete decomposition of the body as possible, and consequently nothing should be done, or allowed to exist, in connection with the burial arrangements to retard this.

The dead body ought to be placed in a coffin made of light wood, wicker, or papier mâché, in order that the decomposition gases may have easy escape by the yielding of this light shell containing the body; because, if the gaseous and other products of decomposition are unable to escape from the coffin, the process of decomposition is greatly retarded by the accumulation of these by-products. For this reason massive oak coffins and metal coffins, such as leaden ones, are very unsuitable, while brick graves and vaults for the reception of the dead body must also be condemned.

The *Soil* of a burying ground ought to be *dry* and *porous.* The best kinds of soil are of loamy or sandy nature, or of vegetable mould. Soils of a loose gravelly character, or of clay, are not suitable; the former, because they permit of the too rapid escape of decomposition gases, before oxidation has taken place, and the latter, because they are too damp, and retentive of moisture. Clay excludes air which is so important for the oxidation of the organic constituents of the cadaver, while it is liable to crack and fissure, and allow decomposition products to escape too soon, that is, before oxidation is satisfactorily completed. When the soil, otherwise suitable, is naturally damp, it ought to be thoroughly drained before being utilised as a burial ground, and this can be done by drain pipes laid below the surface to carry off the water.

The construction of vaults under churches for the reception of the dead was of frequent occurrence prior to the Public Health Act of 1848, when they were forbidden as being dangerous, and not fulfilling the requirements of safe burial.

The products of the decomposition of the dead bodies in cemeteries pass into the soil and under favourable conditions become oxidised. Part of these oxidation substances are absorbed by plants, &c., part is drained away, and part escapes into the air or permeates the soil in the vicinity of the graveyard. The last mentioned result should be the reverse of common, however, if there are ample means of drainage in full operation. The drainage arrangements are intended to carry away moisture, so that the soil may be dry, and, in addition, to make it impossible for any accumulation of decomposition products to take place—a state of affairs which leads to the exhalation of noxious vapours and the establishment of a source of nuisance, and a serious menace to public health.

It need hardly be said that a cemetery should be in such a position that it cannot be flooded by a river overflowing its banks, or by the sea, on account of the risk of graves being opened into by the floods, and the soaking of the soil which would necessarily result from the overflow, the moisture preventing the decomposition processes, or at least greatly retarding them. A cemetery, in cases where there is the least danger of this, is surrounded by a strongly built wall. It is usual to have a wall of 8 feet or thereby, or high railings, placed round a cemetery. The cemetery is laid out in grass which tends to utilise some of the organic material passing into the soil, while the earth is kept dry by the absorption of water and subsequent evaporation of it by the growing grass.

The Home Office regulations require that a grave should not be opened for 14 years, except in the case of the interment of another member of the family, but it is difficult to see that this regulation is of much importance. Between each coffin in the same grave at least *one foot* of earth must intervene, and no part of any coffin must lie less than *four feet* from the surface.

The dangers in connection with cemeteries are:—

1. The possibility of effluvia rising into the air, and constituting a source of nuisance to the neighbourhood.

2. The passage of organic materials—infectious or not—from the burying ground to adjacent streams or wells, or into the soil in the immediate neighbourhood of dwelling houses. For the purpose of avoiding these contingencies, the cemetery should never be located near a stream or well, nor should it be on a hill or elevated ground, the natural drainage of which would tend to bring organic matters into the vicinity of dwellings at a lower level, and, in addition, the cemetery ought to be sufficiently remote from houses to exclude all possibility of this occurring. The Act forbids any cemetery to be situated within 200 yards of dwelling houses, without the consent of the owner and occupier of the houses; and this distance is sufficiently remote to be perfectly safe.

3. Another risk in connection with the burial of bodies in the earth is, that in those cases where death has been the result of infectious disease, the organisms may escape into the soil, may in some cases multiply there, and thereby constitute at a later date a source of danger to the public health. But this danger is practically negligible so long as there is no

overcrowding, and the processes of the decomposition of the body, and the subsequent oxidation of the decomposition products, are allowed to go on freely.

Since 1884 no building has been permitted to be erected on a burying ground, disused or otherwise, except in the case of the enlargement or extension of already existing churches.

Cemeteries are usually covered over with grass and turf, and are intersected by numerous walks, so that a considerable area of the ground is not used for graves, and the growth of the grass utilises a large amount of the organic matter in the soil.

The space allowed for each body is for adults 9 ft. × 4 ft., and for children 4½ ft. × 2 ft. on an average; or a quarter to half an acre per 1000 of population for 14 years.

CREMATION.—Of late years cremation has, in spite of much popular objection, come very much into vogue, and has been strongly advocated and supported by many authorities. The arguments in its favour have been based on the certainty of destruction of all pathogenetic micro-organisms, and the safe, sure, and speedy disposal of the organic matter of the dead body. The objection chiefly urged against it, besides those of pure sentiment, is, that in cases of foul play by the use of poison, exhumation is rendered valueless, for poisons of an organic or volatile nature are entirely dissipated by the process of cremation, and the means of detecting such crime completely removed.

It is possible that the supporters of burial on the one hand, and of cremation on the other, magnify the advantages of their own particular system, while at the same time they make the most of the disadvantages of the other to which they are opposed. For example, it is asserted that by cremation a large amount of organic nitrogen is dissipated and rendered useless. This may be so, but it is also pretty clear that little of the organic matter of graveyards is ever utilised again for the needs of the vegetable or animal kingdom.

By the process of cremation in a Siemen's furnace a body can be reduced to 3 lbs. weight of inorganic ash in 1½ hours; the ash is subsequently buried or preserved in an urn.

CHAPTER VI.

DWELLING-HOUSES, HOSPITALS, AND SCHOOLS.

BEFORE making a few statements as to the construction of hospitals and schools, it may be advisable to refer briefly to some of the general considerations connected with all buildings, it being obvious that such points as are of importance in relation to ordinary buildings, will be of at least equal importance in the construction of such special buildings as hospitals and schools.

The *site* of all buildings must be dry and free from moisture, so that the ground air may at least be free from humidity; and, accordingly, sandy and gravelly soils are good, because they do not retain moisture and are in consequence dry and warm. Should the soil of a chosen site tend to be damp, drainage must be secured by laying down a series of permeable agricultural drains covered over by gravel, and these pipes ought not to be connected with soil pipes or sewers, but should be carried separately into a conveniently situated stream or ditch.

In order to have the morning and afternoon sun shining into the rooms, the house should be built so that the back and front of the house face east and west. A house facing north and south has the sun all day in the rooms with the southern exposure, and little sunshine gets directly into those rooms which lie towards the north.

Ground air is prevented from entering the house by the deposition of a layer of concrete on the basement, the thickness of the concrete being about 6 inches. The lowest floor ought to be raised 2 feet above the surface of the ground. The intervening space thus produced gives free access to air, admitted by a ventilating brick, and thereby the occurrence of so-called dry-rot is prevented.

The walls must consist of stone or bricks well cemented together, and must not be too thin, else the house will be cold.

The foundations should rest on solid ground with an intervening layer of slate or glazed earthenware, in order to prevent damp rising from the ground up the walls; this intervening layer is called a *damp course.*

In thickness the walls are built from a minimum of 9 inches upwards, according to the height of the building. The " party walls " between adjacent houses ought to be carried up beyond the roof, to prevent, in the case of an outbreak of fire, spread of fire from one house to another; and the roof itself should be fireproof, and constructed of tiles or slates, and provided with gutters to carry off the rain.

Between the roof and the rooms immediately underneath it a certain amount of space should be left, in order that these upper rooms may not be too cold in winter and too warm in summer.

Each room should be 8–10 feet in height, well lighted, and supplied with large windows opening at the top and bottom.

In the building of *hospitals* all the important points indicated above require particular attention, and special arrangements are, in addition, necessary on account of the continuous aggregation of a number of persons suffering from a variety of diseases, and the presence, more or less constantly, of their attendants.

Among patients in hospital wards there is a decided tendency for infectious diseases to spread very rapidly from one to another by means of the air, and by the hands and clothing of the nurses and medical attendants, unless careful precautions are taken. The *ventilation* therefore of the various hospital wards is of the first importance. The floor space for patients should be at least 100 square feet, and 1000 cubic feet of air space ought to be provided, so that the air when changed 3 times every hour may give the needful 3000 cubic feet of air *for each patient* per hour. In hospitals set apart for infectious diseases 120–140 square feet of floor space, and 1500 cubic feet of air space per person are necessary, owing to the greater and specific vitiation of the atmosphere, which necessarily occurs, and must be arranged for.

Each ward ought to be oblong in shape, and, where possible, 120 feet long by 25 feet wide, so as to adequately and comfortably provide for the reception of 30 patients. The walls should be 10–12 feet in height, but not more, else the ventilation will be faulty and the proper and efficient removal of foul air difficult of attainment, except by the use of special foul air extraction apparatus. The windows should reach up to the ceiling and be placed opposite each other, with the upper part of the window opening from the top by a hinged arrangement, so that, when open, the slope of the window may direct the entering air in an upward direction toward the ceiling. Extraction shafts are commonly necessary to carry away the vitiated atmosphere, and, when coal-gas is used as the illuminating agent at night, the gas brackets ought to be fitted with extractors above them, so that, by carrying off the combustion products at once, no foul gases may be allowed to mix with the air of the ward; and at the same time these extractors are utilised for withdrawing the impure respiratory products of the occupants of the ward.

The *Pavilion System* is the best model on which to construct an hospital, each pavilion communicating with the adjacent one by means of a covered passage, and also opening by a door out to the open air.

The *Heating* is carried out by the use of an open fireplace with fireclay sides and back, and also by hot water pipes placed all round each ward.

The walls and floor and ceiling are all constructed with as smooth a surface as possible, in order that the collection of dust on their surface may be reduced to a minimum.

In towns, *infectious disease hospitals* ought to be provided on the scale of 1 bed for each 1000 population. Generally speaking, they should be provided with an administration block, containing accommodation for the doctors, nurses, and servants; offices, kitchen, larders, &c.; and an hospital block for each important and commonly occurring variety of infectious disease, each hospital block consisting of 2 large wards, one for male and one for female patients. A special isolation and observation ward, disinfecting room, post-mortem room, and mortuary, are also necessary, and built at no great distance from the ordinary hospital wards.

Temporary Hospitals.—During epidemics of such diseases as small-pox, a temporary hospital of wood can be built, and, after the epidemic is over, the hospital can be burnt. It can be constructed very quickly of wood, and should have double walls with the intervening space packed with saw-dust. The floor is raised at least 1 foot above the level of the ground, and the general arrangements are otherwise on similar lines to those adopted in the construction of permanent hospitals.

SCHOOLS.

In the construction of schools the details of the building are the same as for dwelling-houses. It is essential, however, that the school should be built in a place as well-lighted and airy as possible, because the illumination and ventilation of the school are of the first importance for the health of the scholars, who have to spend several hours of the day continuously indoors. The school, therefore, should not be overlooked by any neighbouring buildings, otherwise the rooms may tend to have insufficient light, particularly those upon the ground floor. The front of the school is best placed facing the south.

The minimum amount of floor space per child is laid down at 8–10 square feet, but this is rather a small allowance, and *12–15 square feet* would be much better. The cubic space per scholar should never be under 90 cubic feet, but this figure is too low, and it is found beneficial to have *120–150 cubic feet* per scholar.

When the total floor space of the room amounts to 360 square feet, the height of the walls should be

13 feet; where the floor space is in excess of this figure, then 14 feet walls should be built.

The *ventilation* must be free, for if it is not efficient the foul air speedily tells on the energies and health of the scholars and teachers. Definite arrangements must be made whereby a satisfactory interchange of air can be always carried out without causing draughts. A very good system for schools is that of Boyle (Figs. 3 and 34) the principles of which have already been indicated, and which secures an efficient entrance of good fresh air, and a constant removal of vitiated air by means of exhausts and extraction apparatus. The air should be heated in winter and cooled in summer before being admitted into the schoolroom. The windows also can be utilised for ventilation purposes at times when the children are out or when the pupils are changing their classrooms, and the aid of the fireplace is also to be recognised as a means of ventilation.

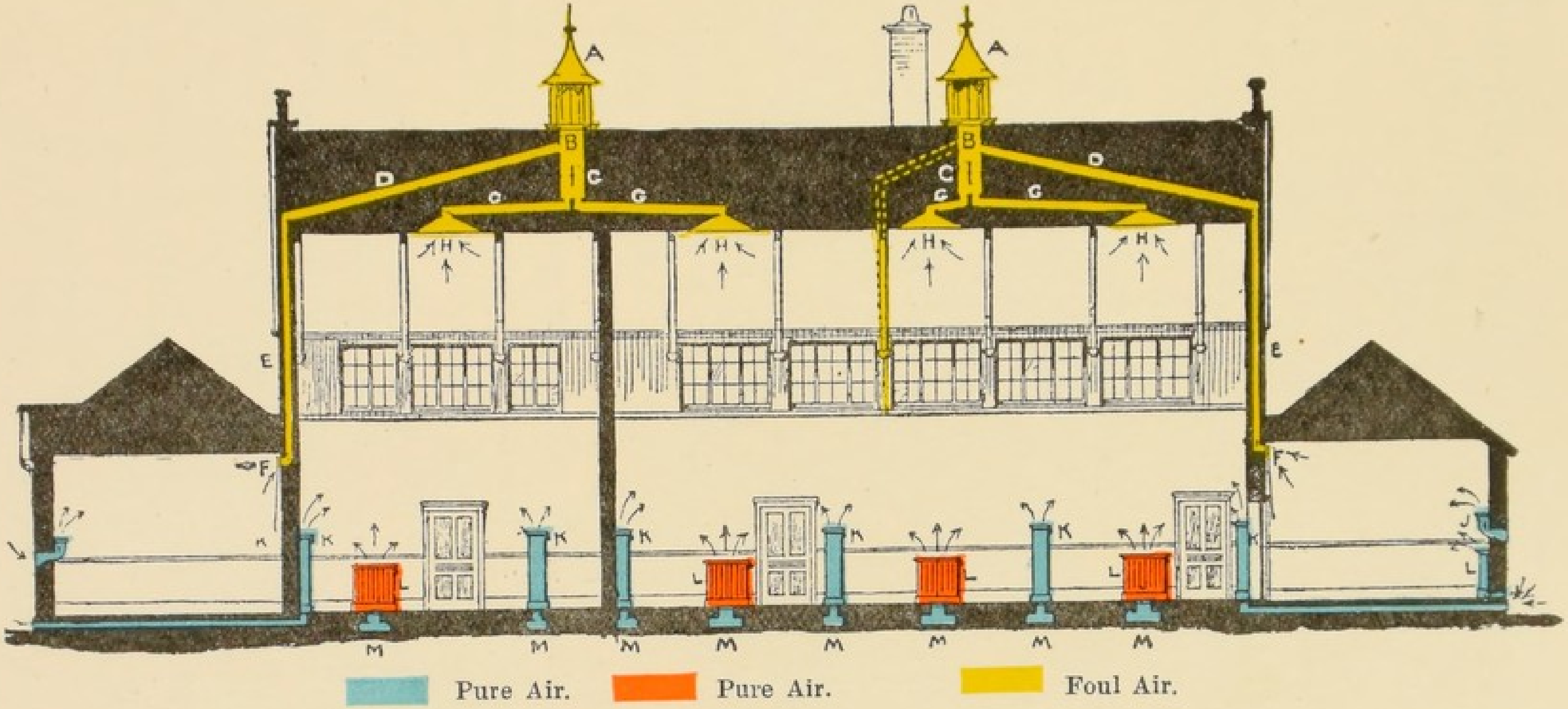
The *warming* of the schoolrooms is effected by means of *open fires* burning in grates with fireclay back and sides, grates such as the Marlborough already described; and, in addition, by the use of *hot water pipes,* which provide more equable heat over all parts of the room and at all times of the day.

The *illumination* is of course best carried out by windows allowing sunlight to fall into the rooms at the side of the scholars, and preferably, when this is possible, at their left side. If it is admitted straight in, it gets into the children's eyes, preventing them giving proper attention to their instructors, and giving rise to headaches. The *windows* ought to reach quite up to the ceiling, and be able to open at the top and at the bottom.

Fig. 34.—Boyle's System of Ventilation.

M. L. K. J., Fresh Air Inlets. A., Extraction Cowl.

B. C. D. E. F. G. H., Foul Air Exits.



The *seats* for the children vary between 12–18 inches in height above the floor, according to the stature of the scholars, and ought to be 9 inches in breadth. The front edge of the seat is placed just below the back edge of the desk above, and the seat itself should, if possible, be provided with a back.

The edge of the desk, which is sloped 10° for writing purposes, should be just a little higher than the distance from the seat to the scholar's elbow. When the desk is movable on hinges, it should be sloped to an angle of 45° for reading purposes, but usually it is not found convenient to alter the slope of the desks. Consequently the writing slope of 10° is retained for all purposes.

Flush closets are attached to the school for the use of the children—separate ones for boys and for girls. For every 20 children one such closet is provided.

CHAPTER VII.

COMMUNICABLE DISEASES.

THE subject of the present chapter is one of the greatest importance, not only to the public health student, but to every practitioner of medicine; for with these diseases the physician is brought into contact every day, and is called upon to give immediate decided opinions, and to issue important instructions. For long the existence of communicable or infectious diseases has been known, but it is only in comparatively recent years that their true nature, and the methods by which they may be spread and transferred from the sick to the healthy, have been recognised. The discovery of micro-organisms and the important part they play in connection with the various morbid processes has opened out a new and vast field of research, which has already yielded many brilliant results, and let in a flood of light on processes formerly totally inexplicable. It seems now to be established beyond all reasonable doubt that infectious diseases are for the most part due to the life, growth, and special action of some of these micro-organisms in the blood and tissues of the human body. In some diseases the particular organism has been demonstrated in the tissues or blood, isolated, and grown outside the body; while in other cases, although no organism has been as yet actually found, it seems, judging by analogy, tolerably certain that an organism must be the causal agency, and in time will be discovered by appropriate means of investigation.

When it is desired to prove absolutely without doubt that a given disease is produced by a particular organism, it is essential, according to Koch, to produce satisfactory evidence that the following desiderata be conformed with :—

1. The organism must be found in the blood and tissues of the person suffering from, or dead of the disease.

2. The organism should be capable of being cultivated in suitable media outside the body, and be able by inoculation into a healthy animal to produce the same disease in that animal.

3. It should be possible to recover the organism from the blood or tissues of the animal so inoculated, and the disease so produced artificially should be similar to that produced by natural infection.

4. The organism should never be found in normal blood or tissues.

Although these conditions are essential to the proof that a given disease is certainly organismal, yet one is forced to the same conclusion even where it is impossible, for obvious reasons, to carry out all the experiments necessary to the proof as formulated by Koch.

Organisms capable of producing disease may be divided into three groups, viz., *Moulds*, *Budding Fungi*, and *Fission Fungi*.

1. *Moulds* or *Hyphomycetes.*—These consist of a branching network of delicate filaments, called the *mycelium.* From this mycelium spores are developed by

the formation of branches, the terminal cell of which divides transversely or enlarges to contain spores in its interior. Examples of these moulds causing familiar diseases are *Tinea Trichophytina,* the active agency in the production of Ringworm; *Achorion Schönleinii,* the parasite of Favus; *Microsporon Furfur,* causing Pityriasis versicolor; and *Actinomyces* or *Ray fungus,* the cause of Actinomycosis in man and cattle.

2. The *Budding Fungi* or *Blastomycetes.*—These organisms manifest their characteristic feature by developing by the formation of buds, although some of them are capable of producing a mycelium, and some form spores. The most common one, found in the stomach or vomited matters in cases of gastric dilatation, is the *Torula.* In this group occurs also Saccharomyces, an organism capable of producing alcoholic fermentation under suitable conditions.

3. *Fission Fungi* or *Schizomycetes.*—These fungi constitute the most important group of micro-organisms as producers of disease, and they are more generally known as the group of *Bacteria.* They are vegetable organisms consisting of a single cell, non-nucleated, and they multiply by extremely rapid fission. When dead, the protoplasm of which they consist is readily stained by such dyes as methylene blue, fuchsin, and gentian violet. In shape they vary considerably, some of them being rounded or ovoid—*Micrococci;* occurring singly or in pairs—*Diplococci;* or in chains—*Streptococci;* or yet again occurring in irregular masses—*Staphylococci;* while, surrounding massed groups of cocci, there is not infrequently an amorphous mucoid material known as *Zoöglœa,* as, for example, around the diplococci that are found in association with Croupous Pneumonia.

Other members of this group of fission fungi are rod-like in shape, and are either narrow and slender, or broad, and are called *Bacilli*. Others again are spiral or curved, and are known as *Spirilla* or *Vibrios*.

All these forms then multiply by fission, and the bacilli by spore formation also, these spores being ovoid or rounded and highly refractile.

The spores are exceedingly resistant to external influences such as heat, cold and chemical agencies, some of them being of course more tenacious of life than others. Their formation in bacilli can only occur in the presence of abundant warmth and nourishment, and in some cases the presence of oxygen is also an essential.

Many bacteria are capable of vigorous active movements on account of their possessing flagella, which are situated at one or both extremities or all round the bacterium, and these flagella commonly exceed the length of the organism itself.

Under certain conditions of environment bacteria are capable of altering their form to some extent, becoming either longer or shorter, more or less slender, and Vibrios sometimes becoming Spirilla. At the same time as this change of form occurs there may also be a *change of function* of the organism to a certain extent. In this relation one may simply point to the discussion which has occurred as to the bacillus of typhoid fever being merely a metamorphosed variety of the bacterium coli commune, and not a distinct bacillus at all. Now, however, it is regarded by most observers as settled that these two are perfectly distinct organisms.

The *temperature* suitable for the life and development of different organisms is subject to wide variations, according to the different organisms concerned. Those germs which are pathogenetic grow of course most readily at or about blood heat, 98·4°F., but some organisms are able to grow at 0°C. and are found in ice and snow, while others cannot grow at all well at a temperature under 50°C.

While the majority of organisms grow best in the presence of oxygen, there is a considerable number, including notably the tetanus bacillus, which grow best in the absence of oxygen. The former class, flourishing in oxygen, are called aërobic; the latter class anaërobic.

The effect of sunlight on organisms is that it tends to arrest their growth in many cases, and the blue and violet rays of the spectrum are more potent in this respect than the red rays. What the exact nature of this inhibitory action of sunlight on the life of organisms is, we cannot definitely state.

Organisms, especially the pathogenetic ones, are parasitic in their nature, being able to flourish in, and derive nutriment from the *living tissues* and fluids of their host. But they are often at the same time saprophytic—that is to say, they can keep alive (and sometimes even multiply) in *dead* organic substances, both animal and vegetable, *outside the body.*

As organisms grow in tissues inside the living body or in culture media outside the body, they always tend to modify and alter their surroundings by utilising the pabulum found there for their own nutrition, and by excreting certain substances as a result of their metabolism. These excreted substances are of very diverse chemical and physical character. Some are chemical substances, such as acetic, butyric and lactic acid, phenol, indol, and gases like ammonia, carbonic anhydride, sulphuretted hydrogen and marsh gas. Other organisms produce pigmentary bodies—yellow, red, and blue—while others produce enzymes or chemical ferments, and others ptomaines and toxic proteids. The last named—toxic proteids—appear to be powerful factors in the production of disease and morbid symptoms, being capable of causing severe constitutional manifestations when introduced into the blood, and even when so introduced in small quantity.

When organisms admitted into the human body, or engrafted on the skin or mucous surfaces, give rise to a disease, they are called *Pathogenetic.* All organisms are not pathogenetic; while some organisms are provocative of disease in some animals but not in others. In some cases the organisms deposited on the surface of the body grow there, multiply, and give origin to poisons, which, when absorbed into the blood, produce definite and well-recognised symptoms, such, for example, as those associated with diphtheria and tetanus.

In other cases the organisms themselves invade the blood and tissues, and in such morbid conditions the evil results from the mechanical presence of organisms in the capillaries, and from the toxins which are liberated into the blood by the activity of these organisms.

Now, it is not always possible to prove that a given disease of undoubted infectious character is actually produced by a given organism, for, although a definite organism is constantly found associated with the disease in question, various obstacles may come in the way of the attempt to get all Koch's requirements of a "specific" organism (page 149). And again, although a given infectious disease has all the features belonging to an organismal disease, so much so that we are practically certain it is due to a distinct and specific organism, it has not yet been possible, as in the case of measles, mumps, &c., to isolate any constantly occurring organism from the blood or tissues. But arguing from the characters of diseases definitely known to be of specific organismal nature, we cannot avoid the conclusion, at least provisionally, that many diseases of similar clinical nature must also own a specific micro-organism as the *causa causans.* Thus we know that anthrax and diphtheria are undoubtedly solely due to specific organisms, as also are gonorrhœa, tuberculosis, actinomycosis; while typhoid fever is almost certainly due to Eberth's bacillus typhosus. Judging by similarity of clinical behaviour, we infer, though the organisms have not yet been definitely isolated, that yellow fever, small-pox, measles, German measles, whooping-cough, syphilis, and scarlet fever are also micro-organismal in their causation.

Nearly all the group of infectious diseases have a *Period of Incubation*, a more or less definite space of time elapsing in each disease between the reception of the virus and the earliest manifestation of the disease. This time is occupied by the organisms multiplying till they attain a potency capable of overcoming the resistance of the living tissues to their unwelcome presence, and then, when they obtain a footing, the organisms produce effects and give rise to symptoms, by liberating the products of their growth into the blood and tissues of their host, these organismal products, as it were, poisoning the blood and causing what is often called an *Intoxication.* The duration of this period of incubation varies with the different infectious diseases, and depends on the dose and virulence of the poison, and the resistive power of the tissues of the individual.

After an infectious disease has run its course and the patient has recovered, there is established in many cases a peculiar state of the system, whereby the individual is protected against another attack of the same disease. This condition is what is known as *Immunity*. It varies in completeness within wide limits, and is subject to certain variations and exceptions. In the case of small-pox, whooping-cough, syphilis, and some others, the immunity conferred is practically life long, while in diphtheria it is evanescent; on the other hand, one attack of erysipelas and influenza seems not only not to protect against another, but actually appears to favour subsequent attacks.

The fact that a mild attack of certain diseases confers immunity against a subsequent attack has been taken advantage of, and is the fundamental basis of an important kind of prophylactic treatment against certain infectious diseases. For instance, vaccination is a means of acquiring immunity from small-pox by the inoculation of an attenuated and peculiarly modified type of small-pox virus in the form of lymph derived from cow-pox vesicles. Vaccinia is now known to be the actual small-pox virus, wonderfully modified by transmission through the cow, so that when inoculated again into man, a local disease is produced with a certain general systemic effect accompanied by pyrexia, &c., and conferring immunity against ordinary small-pox.

Immunity can also be conferred by injecting into the individual the *chemical toxins* of a disease in an attenuated form, gradually increasing the dose as immunity is gradually being acquired. Moreover, to quote Behring's words, there is this important fact that "if an animal has been artificially protected against a particular infective agent, its blood or serum acquires the power, when injected in sufficient strength and quantity into another animal, of directly transmitting an immunity from that infective agent." (See Allbutt's "System of Medicine," Vol. 1.)

It is not easy to explain the occurrence of racial, natural, and hereditary immunity, nor for that matter of racial, natural, and hereditary predisposition to certain diseases. Many theories have been advanced to account for these peculiar states of the system, but we are certain of nothing save the fact of their existence.

One other point of interest is that certain of these infectious diseases, notably typhoid fever, exhibit in the blood serum of the patient an interesting important feature and diagnostic aid. This is the phenomenon, so readily seen and often made use of in typhoid fever, of the behaviour of the specific organisms of the disease in the presence of blood serum from an acute case of typhoid. Widal showed, and his observations have been confirmed abundantly by contemporaneous and subsequent observers, that when the blood of a typhoid patient—say in the second week of the disease—has added to it living organisms from a pure culture of typhoid bacilli, the latter in from a few minutes to two hours become agglutinated together or "clumped"; similar organisms added to any other blood will not clump, but will continue to manifest great activity in motion and in reproduction.

Having thus briefly mentioned these points of general interest in connection with the Communicable

Diseases, we may now pass to consider the individual members of the group in a special manner.

MEASLES OR MORBILLI.

This disease is one of the *Exanthemata*, a group of diseases, each of which is characterised by the appearance of a distinct rash.

Measles is a highly infectious disease of childhood, occurring especially in infants and young children, but also in adults who have not yet suffered from an attack of the disease in the earlier years of their life. Although one attack generally affords immunity from a second, cases not unfrequently are met with where a second attack of true measles occurs, although one must be careful not to misname a case of German measles as a second attack of ordinary measles.

The *incubation period* is usually 10 days, but varies between 5 and 14 days, and during the later stages of this incubation period the disease is without doubt already infectious; hence the great rapidity of spread of measles, for a child incubating measles is spreading the disease right and left, before he himself is recognised as being in the least out of health, and is therefore mixing freely with his fellows at school and at play.

The *initial symptoms* are headache, coryza, cough, lachrymation, and a rising temperature which speedily (3rd day) reaches 100°–104°F., and on the *3rd or 4th day* the very characteristic *rash* appears. The eruption is very profuse, appearing on the forehead, face, neck, back, then on the trunk generally and on the limbs: it can also be seen on the palate. It consists of a multitude of spots or blotches, bright red and then dullish red in colour, slightly elevated above the general surface of the skin, and smooth to the touch. The spots at first disappear at once on pressure, and are arranged in a somewhat crescentic fashion.

Laryngitis and bronchitis frequently are present as the rash comes out, and in most cases the temperature begins to fall about the 5th or 6th day. At the end of a week the eruption has faded and has almost completely disappeared, and there often supervenes a slight fine desquamation, not demonstrable, however, in all cases.

As a cause of mortality and subsequent ill-health among infants, measles occupies a position of high importance. Its most fatal time is in the end of the first year of life and during the whole of the second year, and among the most serious complications of the disease we have to recognise during its acute manifestation are bronchitis, pneumonia, empyema, laryngitis, otitis media and its complications, while as sequelæ there occur corneal ulcers, gangrenous stomatitis, and tuberculosis affecting the lungs, glands, bones and joints.

Measles is epidemic in cities every 2 or 3 years, more or less, with intervals of practically complete freedom from the disease. It is a scourge when it breaks out among the poorer classes, on account of bad hygiene, bad or insufficient diet, filth, overcrowding and actual neglect. In this last particular we must call attention to the fact that many persons take little heed of their children having measles; they talk of it as "only measles," and it is not until the disease takes a serious turn from complications that they consider it necessary to seek advice.

In order to control epidemics of measles it is of the first importance to localise the source of the outbreak at the very commencement, and as schools and all places where children are congregated together are the factors which chiefly determine the spreading of the disease, it should be seen that control is exercised in these particular directions. When it is definitely ascertained that a school has become contaminated, the safest, and in the end the most rapid and efficient method to check further spread from this source is to close the school for 4 to 6 weeks, and carry out a systematic disinfection of all the schoolrooms. Where possible, isolation of individual cases ought to be carried out in as efficient a manner as is practicable, and all unaffected children carefully prevented from having any communication, direct or indirect, with those suffering from the disease. *Compulsory notification* is a valuable means of detecting at the very outset in what particular district the disease has broken out, so that, the source of origin being got at, prompt measures can be immediately taken with a view to limiting further spread of it.

Children exposed to the infection of measles cannot be said to be secure from developing the disease, until at least 14 days have elapsed without the appearance of any symptoms during that time.

SCARLET FEVER OR SCARLATINA.

Scarlet fever is also one of the exanthemata, and, with the exception of the first year of life, is exceedingly common under 10 years of age, the ages of 5 and 6 being perhaps the ages of greatest susceptibility. In the great majority of cases one attack confers immunity for life, but here, as in measles, we occasionally meet with cases of a genuine second attack.

The *Incubation Period* is from *2 to 5 days*, some cases have 24 hours only elapsing between exposure to the infection and the onset of symptoms, while in others the symptoms may not appear for 6 days; but, while this is so, the great bulk of the patients exhibit the 2 to 5 days incubation period. Accordingly, if an individual shows no symptoms a week after exposure to the infection of scarlet fever, one can give the assurance that scarlet fever will not follow on that exposure.

The disease is easily recognised by the following symptoms:—Sore throat with submaxillary glandular enlargement and tenderness, headache and vomiting, together with the temperature rising to 102°–104° F. after a shivering, and with the constitutional accompaniments of pyrexia.

The *Rash* makes its appearance on the *second day*, and is a closely set punctiform eruption, which, with the erythema that accompanies it, produces an appearance of uniform redness of the skin. It is bright red in colour, disappears on pressure, and appears first on the skin behind the ears, then on the neck, the chest, trunk, and extremities. It is absent from the face, and herein lies an important difference between scarlatina and measles and German measles, because the two last-mentioned exanthemata show the rash quite distinctly all over the face.

In 5 or 6 days the rash disappears, and then there ensues a copious and complete desquamation, the epidermis being shed as a powdery or branny dust, or in flakes, and sometimes coming away as casts of the desquamating region, such as the hand, fingers, or toes.

The various regions of the body desquamate in the order in which they showed the eruption, and the last parts to desquamate are those where the skin is thickest, *viz.*, the palms of the hands, the heels, and the balls of the toes. The whole process occupies 6 to 10 weeks, and even more in some cases. Occasionally the teeth may show loss of enamel, the nails may be striated or marked, and the hair may fall out in considerable quantity from the scalp.

Complications are frequent and severe, and include nephritis, acute rheumatism with cardiac lesions, otitis media, deep-seated suppuration in the neck, adenitis, hyperpyrexia; while noma is liable to occur in debilitated children.

In puerperal women the occurrence of scarlet fever is to be regarded with some degree of anxiety, because it may lead to the occurrence of septic mischief with the well-known serious results of that dreaded complication of parturition.

Post Scarlatinal Diphtheria, it may be stated, occurs chiefly among hospital-treated cases, and appears to be the result of diphtherial infection lingering about the scarlet fever ward from a previous case of diphtheria which has found its way, perhaps by accident, there. It is a most serious condition, being in a high proportion of cases (40–50%) fatal, and it occurs usually during *convalescence* from scarlet fever.

That an organism causes this disease seems to admit of hardly any doubt, but what that organism is cannot be regarded as by any means decided. Dr Edington described one more than ten years ago, and Dr Klein in 1885 described a streptococcus which he found in the blood and tissues of patients. He made his discovery in connection with a peculiar observation of Wynter Blyth, who, in a certain epidemic, found that the sufferers were all supplied with milk from a particular dairy farm at Hendon. The cows furnishing the milk were found, on examination, to be suffering from an ulcerative affection of the teats and udders, and in the ulcers Klein was able to demonstrate the presence of the same micrococci which he had already found in the blood and tissues of the scarlatinal patients. Such an observation as this is highly suggestive, but cannot be regarded as quite conclusive. Whatever the nature of the virus may be, however, we know at any rate that it is very tenacious of life, and may cling to fomites (*i.e.*, clothing, books, toys, &c.) for a very long time, even for 3 or 4 years, and all this time it is capable of producing the disease in healthy susceptible individuals.

From a recent case of scarlatina the infection is spread by the breath, desquamated epithelium, and the discharge from the mucous surface of the mouth and fauces, and may be transmitted directly from A to B, or indirectly by the intermediation of C. For instance, C may convey the virus on his clothes or hands from A to B, or C having been contaminated by A may meet D, who may receive the virus on his clothing or on his person from C, and then convey it to B, who contracts the disease. C and D may or may not suffer in this process.

Sometimes a person coming in contact with a scarlatinal patient develops a sore throat, but does not show any rash or other scarlatinal manifestation. Yet it seems possible that this individual is capable of infecting healthy persons with true scarlet fever.

The infection is readily conveyed by *milk*, either by one or more workers in the dairy suffering from a mild attack of scarlet fever and continuing to attend to the milking of the cows, &c., and thereby contaminating the milk, or possibly by the cows suffering from the so-called "Hendon Disease" and the milk being of course full of the micrococci described by Klein.

Scarlet fever is more prevalent in autumn and early winter than at any other time, and occurs in fairly extensive epidemics from time to time. These epidemics show marked variety in their severity and in the number of fatal cases, and in some epidemics the disease appears to be of a particularly malignant type when the proportion of fatal cases is very high.

It is found that a certain percentage of cases sent home from hospital, apparently entirely desquamated and free from infection, convey the disease to other susceptible members of the family, and this in spite of the exercise of all reasonable care and vigilance. It is supposed that the respiratory tract may be the seat of numbers of the scarlet fever organism inhaled from the hospital air, and that mucus secreted from the respiratory tract may be the vehicle whereby the virus is communicated to the children in the household, who are infected from the patient sent home. These "return" cases occur in 1 to 2% of the patients sent home from hospital into susceptible households.

In the treatment of scarlet fever particular care must be taken to avoid any spread of the disease, according to the principles already indicated, and during desquamation the patient should be bathed frequently, at least once a day, whereby much of the desquamated epithelium is washed away. The body should be anointed with some oil, such as carbolic oil, to prevent the dry epithelium being liberated into the atmosphere.

Compulsory Notification of scarlatina is of the utmost value in determining the exact *locus* of a given outbreak, and enabling the source to be ascertained at once. It has been found that a restriction can often by this means be put on further spread of the disease. Thus, not unfrequently the origin of the disease can be traced to a dairy supplying milk to a certain area in a city. At once this source is put a stop to by the closing of dairy.

GERMAN MEASLES—Rubeola, Rubella, Rötheln.

This exanthematous disease is of importance, not so much on account of any particular severity of symptoms or sequelæ it possesses, but more because of the difficulty that sometimes occurs in distinguishing it from measles and scarlatina. Rubeola resembles both these affections, but an attack of it does not give protection from either, nor does a person who has already suffered from them receive thereby any immunity from German measles. It is in fact quite a distinct disease. A second and even a third attack of German measles has been known to occur in the same individual, although usually one attack confers immunity.

The *Incubation Period* is prolonged, and is commonly *12 to 21 days.* During the later days of the incubation period, and while as yet no symptoms have made their appearance, the disease is infectious. Herein it resembles measles.

The symptoms, in a few words, are characterised by a short sharp pyrexia lasting 2 or 3 days and reaching 102°–104°F., accompanied by headache, *sneezing*, lachrymation, *slight sore throat*, and a rash on the *second day*.

The *eruption* appears first on the ears, alæ nasi, lips and angles of the mouth, spreading thereafter over the trunk and limbs. It consists of an aggregation of bright red spots, smaller than those of measles, but larger than those of scarlatina. The eruption fades in 3 or 4 days, and is usually followed by a distinct desquamation, either fine and branny, or in flakes; and, when the desquamation is copious, its completion may not occur till after the end of 3 or 4 weeks.

A very important and characteristic accompaniment of the disease is a general symmetrical *enlargement and tenderness* of the *lymphatic glands* of the body, and this is readily detected by palpation of the glandulæ concatenatæ in the neck, and of the axillary and inguinal glands.

The disease is a mild one, and complications do not often occur, although tonsillitis may occasionally be severe, while laryngitis and otitis media may in some instances give rise to some trouble.

Infection occurs from patient to patient, but fomites do not appear to be capable of conveying the disease from the sick to the healthy. In most cases danger of infection is at an end in about a week after the pyrexia subsides, except in those cases where the desquamation is free, when risk of infection remains till complete desquamation has occurred.

Precautionary measures are conducted on lines similar to those indicated for measles and scarlet fever, and although the disease is a comparatively trivial one, it is advisable that they should be carried out in the case of households where there are several young children.

SMALL-POX OR VARIOLA.

This disease is one of the most serious which can attack an individual, or a community, on account of the great severity of its symptoms and the number of its complications and sequelæ, and because it is very easily spread from the sick to the healthy. In time past small-pox was a veritable scourge, ever present, and a cause of great mortality, ill-health and disfigurement. The brilliant observation of Jenner a little over a century ago has supplied us with a wonderful means of combating the disease, a means so efficient that, but for the ignorant prejudice of some persons who refuse to recognise the obvious blessings of vaccination, small-pox might ere now have been practically entirely eradicated from our midst.

Among unvaccinated and susceptible individuals small-pox readily occurs at any age, children under a year not being in any degree less susceptible than other persons. All races are prone to acquire the disease, but negroes take it more readily than people of other races, and take it badly.

In pre-vaccination days small-pox was practically an endemic disease, and had exacerbations in the way of epidemics every 3 or 4 years. Even yet there are occasional epidemics, especially in districts where ignorance, or carelessness, or prejudice, in relation to vaccination happens to exist, and where, therefore, vaccination and re-vaccination have not been accorded proper attention.

Small-pox is exceedingly infectious during the whole of its pyrexial stage, and particularly on and after the 8th day, when the pustules have developed. The infection spreads both by the exhalations from the body and from the crusts of the pustules; and not only is the disease infectious during life, but the dead body can also infect healthy persons who may happen to have come into contact with it. The infection is carried and spread by the wind, and it has been a matter of common observation that in the vicinity of small-pox hospitals the inhabitants are exposed to a distinct and constant danger. The infection from an hospital spreads chiefly in the direction of the prevailing winds.

Small-pox begins acutely with a rigor, or in children with an initial convulsion, accompanied by a temperature rising to 102°–104° or thereby, with pain in the back, vomiting and headache. These early symptoms last until the rash comes out on the third day, and for a time, viz., till about the eighth day, the patient is left comparatively free from pyrexia.

Initial Rashes.—These rashes appear in the first 24 hours after the onset of the disease and are of much interest, although they are not observed very often, owing to most cases not coming under observation till they have disappeared. They are of two chief kinds, viz., (1) Erythematous, and (2) Hæmorrhagic, and are distributed all over the body, or are confined to special regions. The erythematous ones are rather like scarlet fever, though not so punctiform, and are especially seen in the region of the lower abdomen and groin. They occur as a matter of fact in the region known as Simon's triangle, which is bounded above by a base drawn between the umbilicus and the top of the iliac crests, while below, the apex of the triangle corresponds to the apex of Scarpa's triangle on the thighs. When the initial rash is hæmorrhagic in type, the hæmorrhages may or may not be associated with the erythematous rash, and in all cases the hæmorrhagic initial rash is of evil omen.

The *Eruption* appears on the third day and simultaneously the temperature begins to fall either to normal or near it. The rash is hard and shotty, and can be felt under the skin of the back, face, scalp, and limbs. On the fifth day the shotty papules become vesicular, and are clear, contain serum, and are umbilicated, owing to each vesicle being divided by septa into loculi.

On the eighth day the vesicles become pustules, some of which burst and form crusts, while others dry up without first rupturing. At this time the temperature again rises to 102°F. or thereby, with quick pulse, headache, and the usual concomitant febrile symptoms, and, in about two weeks from the beginning of the disease, the patient becomes convalescent. The rash is attended with great œdema of the skin, and the face is often so swollen that the features cannot be recognised. Besides occurring on the skin, the pustules often are found on the mucous membrane of the mouth. The fever at the onset of the disease is called the primary fever, while that occurring after the eighth day is called the secondary, or pustulation, or maturation fever.

The rash is very itchy and leads to the patient seeking relief by scratching, which of course makes the subsequent cicatrisation and pitting worse than it would otherwise be.

When the individual pustules are separate one from the other the rash is called discrete; when one pustule runs into another it is confluent, and this feature marks a bad case. Occasionally bleeding occurs into the pustules — hæmorrhagic variola — when the prognosis is also bad, and in such cases hæmorrhages from mucous surfaces are frequent and severe.

The complications of small-pox include erysipelas, multiple abscesses, septicæmia, conjunctivitis, corneal ulcers and perforation of the cornea, otitis media, meningitis, laryngitis, nephritis, pneumonia, empyema, delirium ferox, and, in pregnant women, abortion or premature labour is frequent.

In dealing with small-pox, the extreme facility with which the disease spreads must be borne in mind. The patient must be kept isolated in a very rigid manner, and this is best done in a small-pox hospital. He must be kept isolated till every scab has cleared off his skin, and this never occurs in less than 3 or 4 weeks after the onset of the disease. All clothing and fomites must be carefully disinfected, or better, destroyed, as the virus clings with much persistence to fomites.

Remembering that the *Incubation Period* varies from 5 to 17 days (on the average 12 days), one must isolate a person who has been in contact with variola for a period of 3 weeks before one can give him a clean bill of health. Meanwhile the individual so exposed must be vaccinated, or if already vaccinated should be re-vaccinated. Where this re-vaccination is performed within 3 days of exposure, there is a fair probability that small-pox will not appear in the individual, and in any case, if it does occur, it will be of a mild type.

VACCINATION.

For rather over a century (since 1796 when Jenner introduced vaccination as a prophylactic and therapeutic measure against small-pox) vaccination has been in use, and in that time has saved more lives, and prevented more physical deformity than any other therapeutic discovery. These results have been attained, moreover, in the face of much determined opposition, but at this day vaccination is recognised by all intelligent individuals as one of the greatest blessings that has ever been placed at the disposal of the human race.

Vaccinia or *cow-pox*, which is really a local manifestation of human small-pox in the cow, appears on teats and udders of cows as small vesicles surrounded by an inflammatory œdematous zone of tissue. The cows affected are out of sorts, do not eat, and give a diminished amount of milk. If the contents of the vesicles be applied to any abraded surface of the skin of a human being, then characteristic appearances are readily seen. Thus, when, intentionally, the virus is applied from the cow to the arm of an individual by puncture or by a superficial scratch with a lancet, then we get in due course the following appearances:—

On the third day the point of insertion of the virus is occupied by a *papule*, which by the fifth day has become *vesicular*. The vesicle has its edges elevated somewhat, and it gradually gains in size until on the seventh or eighth day it is fully formed, and is tense, whitish, and has around its base an areola. The serum in the vesicle tends to become turbid on the ninth or tenth day, and then it begins to dry up and form a scab. This crust on the twelfth to the fourteenth day is brownish in colour, adherent to the skin, and can be removed after the end of the third week, leaving the subjacent skin reddish and cicatrised, the scar mark lasting a long time and being an evidence of vaccination for many years.

Constitutional effects may be slight or considerable, and comprise headache, pyrexia, quickened pulse, loss of appetite, swelling and tenderness of the neighbouring lymphatic glands.

From the serum contained in the vesicles on a child's arm other children can be vaccinated very easily by a similar proceeding, viz., by puncture or incision, but nowadays arm to arm vaccination is less often performed than formerly, on account of some degree of popular prejudice; though it is very doubtful if disease can be transmitted from one child to another by this means.

The complications of vaccination include severe pyrexia and constitutional symptoms, erysipelas, abscess formation in the adjacent lymphatic glands, local ulceration of the skin at the area subjected to vaccination.

Vaccine lymph, as generally used at present, is stored in capillary tubes as an emulsion with glycerine, the lymph taken from the vaccinated calf being mixed with four times the amount of sterilised glycerine, 50%, and water 50%. Each tube is $\frac{2}{3}$ full of this mixture, and each end of it is sealed by heat. The contained lymph is active for 7 to 14 days after being introduced into the tube.

Vaccination should be performed in infancy, and again at puberty, and when this is done the individual is afforded great protection against variola. Should he happen to acquire small-pox, his attack will be certainly rendered milder in type, shorter in duration, and less attended by complications and subsequent pitting of the skin, than would be the case were he not vaccinated.

VARICELLA OR CHICKEN-POX.

This is a disease occurring frequently among children, and possessing a slight likeness to mild small-pox. It occurs in epidemics very often, and may cause some trouble from its breaking out among school children.

Its *Incubation Period* usually is *14 days*, but it may develop in 10 days, and, on the other hand, may not appear until nearly three weeks after exposure to infection. The symptoms which usher in the disease may be, and often are extremely slight. The temperature rises to about 100°F., with slightly marked constitutional disturbance. In adults there may be pain in the lumbar region, vomiting, and a feeling of general uneasiness.

The *Eruption* appears in crops, on five or six consecutive days, and takes the form of papules, speedily becoming vesicles, which contain a clear fluid. These spots are separated one from another, and after remaining clear for a few days become turbid, dry up, and form crusts. They are seen on the abdomen, back, shoulders, face, scalp, and limbs. As a rule they do not suppurate, unless they are scratched or abraded. In rare instances there may be a *gangrenous* or a *hæmorrhagic* condition of the eruption, and in each of these cases the symptoms are severe. Infection remains till the skin becomes normal again, that is in about three or four weeks, as a rule.

Isolation of the individual should be carried out, and the child should not be allowed to get access to any other children for four weeks from the beginning of the disease, *i.e.*, till all the crusts have disappeared. Local treatment is not usually necessary, but where the eruption is gangrenous or hæmorrhagic the urgent constitutional symptoms will require careful attention in view of the possibility of complications, such as empyema or secondary abscesses elsewhere, or hæmorrhages from mucous surfaces.

The disease can be transmitted by fomites, and is also spread, in all probability, by the breath.

Quarantine of three weeks is necessary where an individual has been exposed to the infection; if no symptoms appear by the end of that time, then the individual will not acquire chicken-pox from that particular exposure.

PERTUSSIS OR WHOOPING-COUGH.

Whooping-cough is of very frequent occurrence among young children, and is a source of considerable child mortality. It is uncommon to find whooping-cough affecting adults, but this is solely due to the fact that few persons reach adult life without having suffered from the complaint. The disease occurs in epidemics which are worst usually in spring, although they may also break out in autumn.

The *Incubation Period* varies between *four and fourteen days*, at the end of which time the symptoms commence. The symptoms may be divided into those of the first or bronchitic stage, and the second or spasmodic stage, and are followed by a period of convalescence, in which the cough gradually diminishes and the spasms become less severe, till they finally pass away altogether.

The first stage lasts one or two weeks, and is of the nature of bronchial catarrh, the temperature being raised to 100° or 101°F., and accompanied by some degree of constitutional disturbance, such as headache, anorexia, dry skin, and constipation. There is also a dry cough, with sibili and rhonchi to be heard on auscultation of the chest, and the cough has a tendency to become aggravated in the evening. Then there is gradually developed a *spasmodic* element, the attacks of spasmodic coughing becoming more and more frequent and severe. The child is observed to become alarmed and run to his mother, grasping her with both hands and often burying his face in her dress. The cough then shows itself in a series of, say, 12 or 18 paroxysmal expiratory puffs, while the child's face gets deeply cyanosed and the head perspires, and then a long crowing inspiratory effort occurs, bringing relief with it, or merely constituting an interval between a fresh spasmodic seizure and the preceding one. Very frequently vomiting occurs, either at the beginning or at the end of such a seizure.

This stage lasts for three or more weeks, depending often on the state of the weather and the child's health, and occasionally is prolonged by the existence of enlarged tonsils or adenoids in the naso-pharynx.

Among the *complications* of whooping-cough we have to note gastro-enteric catarrh, convulsions, cerebral or meningeal hæmorrhage, otitis media, catarrhal pneumonia, and emphysema. In infants who have cut their two lower incisor teeth only, it is found that owing to the tongue being drawn over these teeth during the attacks of coughing, there may be produced sublingual ulceration on either side of the frænum. Whooping-cough is infectious for six weeks from the beginning of the disease, and the infection is conveyed by respiratory mucus, and perhaps also by the breath, while it clings persistently to fomites.

Quarantine, after exposure to pertussis, must be enforced for 21 days.

Prevention of spread by means of isolation should be attempted in all cases, but this is a matter of some difficulty when the patient feels comparatively well in the intervals between the spasmodic attacks, and yet mild cases are quite capable of readily spreading the disease to the healthy and susceptible.

DIPHTHERIA.

Among the various infectious diseases diphtheria ranks as one of the first importance, on account of its frequency of occurrence, the severity of its manifestations and sequelæ, and the interest attaching to its therapeutics.

Although diphtheria occurs at all ages, it shows a particular affinity for attacking the young, and its mortality is greatest among children under the age of five years. It is more fatal in females than males of similar age. The disease shows a special tendency to occur in autumn, beginning in the end of September and attaining its maximum severity in November.

The specific cause of diphtheria is the Klebs-Löffler* bacillus, which can easily be isolated from the mucous membrane, secretions, and membranous deposits of any case of diphtheria. The bacilli when stained by Gram's method, or by a stain containing dahlia and methyl green (Roux), may be recognised as slightly bent or f-shaped rods which stain more

---

* Löffler or Lœffler.

deeply at either end than in the centre—that is to say, they display bipolar staining. Two forms can be recognised, both of them true diphtheria bacilli; one is long and the other short. Both varieties can be found in the same case and have no prognostic significance—that is to say, it is impossible to declare that when one or other variety of bacillus is present in preponderating amount the case will be specially mild or severe. Croup, having no Löffler bacilli, is a disease distinct from diphtheria.

Diphtheria is a disease which spreads very readily whenever the Klebs-Löffler bacillus gains access to a mucous surface, and especially the mucous membrane of the fauces, or to an abraded or freshly cut surface of skin. It occurs in conjunction with other specific febrile diseases, such as scarlet fever, and finds the individual so debilitated by his primary illness that it exercises a specially severe effect upon him. Persons suffering from slight sore throat are very liable to develop diphtheria if they be exposed to the poison, the bacilli finding it easy to obtain a footing on the mucous surface already congested and in a depressed state of vitality.

Diphtheria owes its spread in many instances to *milk*. Milk of course is a fluid full of organic materials, and when diphtheria bacilli gain access to it they tend to multiply and show signs of great activity. Thus, should a dairy-worker happen to be suffering from mild diphtheria, so mild as to cause no actual feeling of illness, and not preventing him from working, then it is easy to see how the specific bacilli would gain ready access to the milk, in which rapid growth and multiplication would occur, and fresh cases would speedily break out in these districts supplied with milk from this particular dairy-farm. Or, again, the child of a dairy-keeper may be suffering from diphtheria, and as the result of accident, or imperfect isolation, some of the diphtheria bacilli may obtain access to the milk and accordingly infect it. But the cow itself may be directly responsible for infecting milk, for we occasionally find among cows outbreaks of a peculiar disease affecting the teats, and called "chapped teats," in which there is a papular and vesicular affection of the teats and udders. In these vesicles, and in the milk of such cows, there can be found true Klebs-Löffler bacilli, capable of transmitting diphtheria to the human subject.

Diphtheria is in all probability in no way connected with water supply. Drinking water is not a good medium for the development of Löffler bacilli, which, indeed, usually soon die off when placed in ordinary tap water.

Bad drains and sewers may cause a proclivity to diphtheria by producing ordinary sore throat, which undoubtedly predisposes an individual to acquire diphtheria, by rendering the depressed mucous membrane more vulnerable to the attacks of the diphtheria bacillus. But it is doubtful whether diphtheria bacilli are ever actually inhaled with sewer gas in sufficient amount to cause the disease in cases where sewer gas is escaping near the windows of a house, or up faultily trapped pipes into the rooms.

The relation of soil conditions to the occurrence of diphtheria is one about which a difference of opinion exists. The opinion of the majority of observers is that in districts where there is a large degree of soil dampness, there is a larger proportion of diphtheria cases, especially if there is much organic matter contained in the soil along with the moisture. Dr Newsholme, however, is of opinion that when there is a long period of drought, and consequently a lowering of the subsoil water, there is liable to be a greater tendency to outbreaks of diphtheria.

Diphtheria affects cats, dogs, hens, and pigeons, and can be transmitted from these creatures to man, and conversely. It is well recognised that diphtheria is spread with great facility by the congregating of children in schools. This is due of course to the close proximity, for more or less prolonged periods of time, of the children to each other, with a certain degree of vitiation of the atmosphere. Consequently, if a child comes from the vicinity of a diphtheria patient, or from a case of mild "sore throat," or should any child have his clothes contaminated with the poison, then a great opportunity is afforded for the dissemination of the disease among the scholars.

The *Incubation Period* is from *two to seven days*, and most usually three days; and the initial symptoms are very often of a most insidious character. The child is exceedingly depressed, and there may or may not be pyrexia; but the *pulse* is always accelerated from the very beginning. Sore throat is soon complained of, and on looking into the throat the observer sees that the mucous membrane over the uvula and tonsils is deeply congested. On this congested surface a tough greyish coloured membrane forms, elevated above the general surface of the faucial mucous membrane, and when it is forcibly detached there is left behind a bleeding surface which speedily becomes covered over with a new greyish-looking exudation. The submaxillary glands are enlarged and tender, but do not usually suppurate. Swallowing becomes increasingly difficult, fluids being frequently regurgitated through the nose. The disease may spread up to the posterior nares, when there occurs a watery blood-stained exudation from the anterior nares, a secretion which is acrid and irritates the upper lip. It also spreads into the larynx, when hoarseness, aphonia, and dyspnœa with cyanosis develop, and increase the gravity of the case. Extension of the membrane downwards along the œsophagus to the stomach may also occur, and greatly interfere with the feeding of the sufferer.

The heart is specially affected by the poisons formed by the organisms at the site of the local lesion and afterwards absorbed into the blood. These poisons cause a marked and serious degree of cardiac depression, as evinced by rapidity and weakness of the pulse, and feebleness of the first sound of the heart.

Albuminuria is of frequent occurrence.

Among the *Complications* may be enumerated cardiac failure, laryngitis, bronchitis, catarrhal pneumonia, severe vomiting, nephritis, middle ear disease; while, as sequelæ, we have to note toxic neuritis, affecting the nerves supplying the ocular muscles, ciliary muscle, palate, larynx, diaphragm, and muscles of the extremities.

The disease, as has already been said, is of a highly communicable character, and the virus is contained in the buccal secretions, breath, and perhaps in the other secretions of the body. The virus, moreover, is tenacious of life and clings to fomites, viz., to clothing, bedding, toys, books, wall-paper, &c. The patient accordingly must be kept scrupulously isolated, and the nurses must have no communication whatever with other members of the household. Better would it be were all cases at once sent to infectious disease hospitals, but, where for various reasons this is not done, a room at the top of the house must be used to accommodate the patient. At the outset of the disease anti-toxin should be exhibited, 1500–2000 units or more being subcutaneously injected. The effect is to speedily mitigate the symptoms, to cause separation and casting off of the membrane; and the sooner the anti-toxin is given the better will be its effect. Occasionally there will occur after the exhibition of this remedy, cutaneous erythematous rashes, and in some instances albuminuria, but it is hardly possible to ascribe any bad effects to its use. It may not always be successful, but it often is wonderfully quick in its remedial action, and it cannot do any harm.

Early notification of the disease will do much to control the spread of epidemics, enabling measures to be taken to locate its origin; while no individual in the house where diphtheria is should be permitted to go to school until such time as all infection is removed from the house and the individuals inhabiting it. Two or three weeks should be allowed to elapse, after the complete disappearance of the membrane from the throat, before the patient is allowed to mix with other individuals, and all this time the throat should be carefully and systematically washed out with antiseptics.

The room must be thoroughly disinfected after the patient has ceased to occupy it, and the wall-paper ought to be stripped off and new paper put on. In this manner danger of retention of the virus in the room is removed.

MUMPS, PAROTITIS EPIDEMICA, OR CYNANCHE PAROTIDEA.

The *Incubation Period* of mumps is two to three weeks. Immediately after this period is over and the disease begins to show its special symptoms, it is highly infectious. It occurs chiefly among young people, but may affect adults. The disease is characterised by the occurrence of pyrexia, the temperature very frequently reaching 103°F., with swelling and tenderness of the salivary glands, beginning first in the parotid of one side. This gland is excessively tense and tender, and the skin over it may be reddened, but suppuration does not tend to occur. After three or four days the opposite side becomes involved, and great pain on mastication and on swallowing is experienced. Gradually the glandular enlargement subsides, and the patient is well.

Complications include orchitis, which may be followed by atrophy of the testicle, mastitis, ovaritis, and occasionally meningitis, while facial paralysis from affection of the 7th nerve may occur. Deafness is not infrequent, but is not permanent.

Children suffering from mumps must not return to school for three to four weeks after the onset of the disease—that is to say, for a week after complete disappearance of all the symptoms.

A quarantine of three weeks must be regarded as necessary, after an individual has been exposed to the infection, before he can with safety mix with others.

INFLUENZA.

This is an infectious disease, and appears to be caused by a bacillus, described by Pfeiffer, and found in the bronchial mucus of patients suffering from influenza. The disease is partly air borne, and partly spread by means of human communication, and by fomites.

Its *Incubation Period* is usually about two days, and the symptoms come on abruptly, with severe headache, vomiting, pain in the back, with high temperature, coryza, and coughing. Diarrhœa, and in some cases cerebral and mental disturbance, may occur, according to the type of disease which affects the individual. Adults, and more particularly male adults, are very prone to be attacked by influenza, and it is very fatal among old people.

Isolation and disinfection of the secretions from the bronchial and other mucous membranes would tend to mitigate the extensive spread of the disease, but the shortness of the incubation period, and the difficulty of carrying out these measures efficaciously, militate against all efforts to arrest the spread of the affection. Special carefulness must be enjoined, however, to prevent a relapse by a slow and gradual convalescence, as the danger of relapse is particularly noticeable in influenza, and a relapse is even more serious than the original attack.

TYPHUS FEVER.

This disease is one which is essentially one of the results of over-crowding in large cities, and occurs amid conditions of poverty and bad hygiene, particularly when many individuals are huddled together in a badly ventilated room. The contagion passes through the air from the sick to the uninfected, and is exhaled from the cutaneous and respiratory surfaces. When ventilation is free, as in hospitals, the risk of the healthy being attacked is comparatively slight. Several observers have isolated an organism from the blood and tissues, but it is not definitely settled that the pathogenetic organism has been discovered.

The *Incubation Period* varies from a few hours to 14 days, and at the end of this period the disease is ushered in acutely with headache, rigor or convulsion, pyrexia reaching to 103° or 104°F. and quickened pulse. Deafness and mental dulness soon appear, and about the fourth day the characteristic mulberry coloured rash is seen on the abdomen, thorax and arms.

The eruption is very copious, at first disappears on pressure, and the skin shows the peculiar appearance called subcuticular mottling. The tongue is dry, furred, and becomes dark brown or black, and the loss of appetite is complete. The symptoms increase in severity, delirium or coma often supervenes, and the pupils are contracted. Retention of urine is of frequent occurrence. The disease in a favourable case is terminated about the 14th day by a crisis, and convalescence speedily follows. Among the complications it is necessary to mention cardiac failure, pneumonia, meningitis, delirium ferox, coma vigil, hæmorrhage from mucous surfaces in association with those cases where hæmorrhage occurs into the eruption; while among the sequelæ are phlegmasia alba dolens, and inflammation of the long bones—*e.g.*, the tibia.

Isolation is of much importance, and can be carried out in one of the rooms on the upper floor of the house, or in hospital wards, and one of the essentials to be observed is free ventilation of the room occupied by the patient, as free dilution with air vastly diminishes the power of the virus.

Clothing and everything used by the patient must be thoroughly disinfected, and the room occupied by him must be similarly purified. The infection ceases to come from the patient a fortnight after the crisis. Quarantine after contact with a case must be observed for three weeks in order to ensure safety. In dealing with outbreaks of typhus in poor and filthy localities, it is essential that the patients should be at once removed to hospital, while the as yet unaffected "contacts" should be quarantined.

TYPHOID FEVER OR ENTERICA.

Typhoid fever is one of the most prevalent fevers we have had as yet to consider, and a melancholy interest surrounds it at present on account of its ravages among our troops in South Africa during the past 18 months. The disease is easy of propagation, and unfortunately it is capable of being spread in many ways. Its pathogenetic organism—the bacillus typhosus of Eberth—is known, and is a slightly curved flagellated organism, occurring in the stools of the patient suffering from the disease. It flourishes best in alkaline media, and is destroyed by acid media. When present in a motion recently passed by an enteric patient, the bacillus is not virulent, but in a few hours it is able to reproduce the disease when introduced into the alimentary canal of another individual. Should, however, the bacillus reach the stomach of a healthy person whose gastric secretion is active and acid, then it is more than likely that it will be destroyed in this acid medium.

The disease is spread when typhoid dejecta, with the innumerable bacilli therein, are thrown without disinfection into sewers; and, where ventilation of the sewers is imperfect, foul air may be forced into houses, bearing bacilli with it, and this foul air being breathed, the bacilli are deposited in the buccal mucous membrane or secretions, and so reach the stomach. Again, leaking sewers may allow percolation of infected sewage into the soil, whence the bacilli may find access to water-pipes, and in this manner a large district of a town may become the seat of a typhoid epidemic. Faulty construction, or need of repair, of the traps of water-closets may also permit of contaminated sewer air reaching the interior of a house and infecting the occupants.

Leaking cesspools, leaking wells, and surface wells, whose water gets contaminated by typhoid dejecta thrown directly on the soil, will, as is obvious, afford ample and ready means of typhoid propagation.

Milk supply is another mode whereby typhoid is spread, for milk cans may be washed out with infected water, when the bacilli, adhering to the interior of the milk cans, will flourish in the warm milk added, and will thus gain access to the alimentary canal of the many consumers of the milk.

Fomites and direct contact with dejecta will in certain instances be the means of transmitting the disease, and in the case of nurses attending typhoid patients, particular care must be observed as to scrupulously cleansing the hands after contact with soiled bedclothes, &c.

Oysters collected near the mouth of a river, into which typhoid dejecta have been passed, have been without any reasonable doubt to blame for more than one epidemic of enteric fever.

And, lastly, flies have been seen to pass from the immediate neighbourhood of typhoid dejecta on to meat, and, no doubt, when this meat has been consumed, typhoid bacilli have been ingested at the same time. The spread of enteric fever by flies certainly occurred with frequency in the South African Field Force.

Typhoid fever occurs at all ages and in both sexes, but is especially frequent between the ages of 15 and 25 years or thereby, and in this country at least is of greatest prevalence in the autumn months.

Pettenkoffer's views have already been dealt with, and need not be further referred to.

The *Incubation Period* seems to be about *twelve days*, at the end of which time the disease begins very insidiously with headache, bilious vomiting, epistaxis, and bronchial catarrh, and with a gradually ascending evening temperature. The tongue is covered with a creamy white fur, while its edges and tip are red. The abdomen is tumid, and the spleen is enlarged. At the end of a week the temperature is about 104°F., but the *pulse is comparatively slow*, about 96 or so. A rash appears in half the cases, about the seventh to tenth day, of rose-pink colour, occurring in successive small crops of four or five, on the abdomen, chest, and flanks, each spot being slightly raised above the surface and readily disappearing on pressure. Diarrhœa may or may not occur; if it does, it is characteristically of pea-soup consistence and colour, foul smelling, and alkaline. The patient's face is flushed, and his pupils dilated. The disease proceeds into a third week, characterised by great increase in the weakness, pulse 110–120 and dicrotic, and an evening temperature falling gradually as the attack of enteric terminates by lysis.

Among the complications we have to note peritonitis, perforation of the bowel, intestinal hæmorrhage, pneumonia, bronchitis, hyperpyrexia, and, as a sequela, phlegmasia alba dolens.

The mortality of typhoid varies between 15% and 20% of all the cases, but is greater in some epidemics than in others.

In dealing with outbreaks of typhoid fever we must keep in mind what are the possible causes, and at once institute a careful inquiry into the sanitary conditions prevailing in the locality. Any defect must be at once remedied. All cases should be isolated, and the dejecta must necessarily be thoroughly disinfected by crude carbolic acid or other means, before being disposed of. Scrupulous care of soiled linen, &c., must also be taken to see that it is all adequately disinfected.

One word must be added as to the great value of the serum method of diagnosis; this is often referred to as Widal's Reaction, and, roughly speaking, is carried out as follows:—Some blood is drawn from the ear or finger of the suspected typhoid patient. In a diluted state it is added to a pure culture of typhoid bacilli in weak bouillon, and examined under the microscope. After a certain time, say an hour, the typhoid bacilli are aggregated into clumps when the serum is that of a typhoid patient; whereas, if the serum is not from a typhoid case, then no such clumping occurs. The clumping occurs if the serum of a person, who has had typhoid fever, is similarly added to typhoid bacilli in bouillon.

It is at present premature to speak of the prophylactic value of anti-typhoid vaccination, as the data are too scanty, and the evidence, as to whether it is of value or not, is too conflicting.

EPIDEMIC DIARRHŒA, GASTRO-INTESTINAL CATARRH, OR EPIDEMIC ENTERITIS.

This disease is of frequent occurrence under the following conditions:—

1. Summer weather. So often is it the case that epidemic diarrhœa is noticed to occur with markedly greater frequency from July to September, that the disease is sometimes called summer diarrhœa.

2. Increase in soil temperature. When the soil temperature, taken four feet below the surface, reaches and exceeds 56°F. (Ballard).

3. Damp and organically contaminated soil. Dwellings built on soil which is so constituted are fraught with special danger to the infant members of the community, and in certain districts where improvements in the soil conditions have been brought about, the death rate from diarrhœa has undergone a notable diminution.

4. Conditions of bad hygiene, in respect of overcrowding, bad ventilation, and want of sunlight.

5. Improper feeding and neglect. These factors have very much to do with the causation of the scourge among infants, for infants and young children are first and most seriously affected. Children whose mothers have not sufficient milk to give them, or have not time to attend to them on account of having to go out to work, are of necessity brought up on artificial foods or cow's milk. Frequently the bottles used for the infants are not clean, or the milk is half sour, or is kept in places where organisms abound, and in consequence the milk ferments and sets up catarrhal

conditions of the gastro-intestinal mucous membrane, which often carry off the child with great rapidity.

All these conditions must be combated by erecting dwelling-houses only on ground which is dry and free from organic contamination, by insisting on free ventilation of dwelling houses and personal cleanliness, and by sterilising the feeding-bottles and milk before use.

CHOLERA.

Although cholera is a disease endemic in certain parts of India, such as at the mouth of the Ganges, it is of importance in relation to the public health of European countries, on account of its occasional occurrence in isolated cases or in epidemic outbreaks. Cholera is spread by *specifically polluted water*, drawn, for instance, from wells to which the dejecta and organisms from a cholera patient have obtained access. It is conveyed also by *fomites*, and often follows the routes of human traffic whether by land or by sea. As in the case of typhoid fever, so also in cholera, we find that *milk* may be the means of disseminating the disease, owing to adulteration of the milk with specifically contaminated water, or by such water being used to wash out the milk cans. Oyster beds, within reach of river water containing cholera dejecta, may become invested with the power of spreading the disease, and it has happened that on more than one occasion outbreaks of cholera have been traced directly to the eating of oysters, which, on inquiry, have been ascertained to have come from infected oyster beds.

With a short *Incubation Period*, of a few hours to a few days in some cases, the symptoms of cholera come on abruptly, and are characterised by urgent vomiting and diarrhœa, quick pulse, and a rapid tendency to collapse. The vomited matters and dejecta speedily become typical of the disease, and are called the rice water evacuations. Cramps in the muscles, thirst, rapid wasting, often suppression of urine, occur, and may be followed by death in a few hours. Recovery from this, the algide stage, may take place, and may go on to convalescence, or the patient's temperature may rise to 102°F., with bilious vomiting, headache, quick pulse, diarrhœa, and great feebleness, a condition which has been called cholera typhoid, and is usually fatal.

In the stools of cholera patients the pathogenetic organism can be detected, and is called Koch's cholera vibrio or comma bacillus.

The prevention of cholera is to be undertaken on the same lines as we indicated as necessary for typhoid fever.

Haffkine's inoculation has in many cases been followed by very gratifying results, which give encouragement to hope that further use of his prophylactic measures will be exceedingly beneficial in mitigating the ravages of this serious disease. Haffkine's method is to give injections of attenuated living virus. Certain results have been obtained, sometimes of a satisfactory nature, by introducing the vibrios through the mouth in gradually increasing doses, so as to create a tolerance to cholera vibrios on the part of the alimentary canal.

PLAGUE OR PESTIS.

Plague is to be found as an *endemic* disease in certain parts of the world, such as North-West India, the province of Tripoli in Northern Africa, Southern

China, and Persian Kurdistan (Payne). From time to time it becomes *epidemic*, and occurs under such conditions in any part of the world. The disease is due to a bacillus, which is short and thick, and shows bipolar staining, and is found in the lymphatic glands and spleen, although it is also detected in the blood in severe cases.

The bacillus is capable of life in the soil, but when there it tends to diminish in virulence. Certain flies and rats are capable of acquiring the disease, and the latter die in large numbers during epidemics of plague, and show the characteristic bubonic swellings and abscesses. The existence of filthy surroundings, overcrowding of individuals, poverty and want of food, and times of severe drought, tend to favour the outbreak of epidemics. The disease passes from the infected to the healthy by the atmosphere, and that is why ill-ventilation and over-crowding are so potent factors in determining its spread; and, moreover, fomites may readily transfer the disease to localities which otherwise might escape being infected by plague.

The *Incubation Period* is less than seven days, usually three to five days, and the symptoms are ushered in with mental torpor, giddiness and uncertainty of gait. The conjunctivæ get red; malaise, headache, and pyrexia occur, with quick pulse. These symptoms are often preceded by a rigor. The lymphatic glands of the groin, axillæ or neck enlarge and become tender, and may soften and form abscesses. Hæmorrhages under the skin and from mucous membranes are common, while pneumonia and nephritis are often met with. The mortality is high, being frequently over 80%.

On the occurrence of plague strict precautions as to isolation and quarantine of all persons who have been in contact with cases must be enforced. Overcrowding in dwellings must be so far as possible avoided, and filthy dwellings must be cleansed and disinfected. Infected areas in towns must be under strict observation, so that no persons may pass out to infect healthy areas, till they have been quarantined; and this principle is specially applicable to infected ships.

As a prophylactic measure and also as a means of treatment, anti-plague serum has been found of undoubted value.

EPIDEMIC PNEUMONIA.

Croupous pneumonia of an epidemic character occurs very frequently, and perhaps all cases of pneumonia are more or less infectious.

The disease, after a short incubation period of about five days, exhibits the usual symptoms and signs of lobar pneumonia, which need not be detailed here. The organism which causes the disease is not yet definitely known, for several have been described, all having a more or less close association with the disease. For instance, Fränkel's pneumococcus (a diplococcus) has often been found in pneumonic lungs, but is on the other hand found in the saliva of healthy persons. Klein discovered during the Middlesborough epidemic of 1888 a short bacillus which occurred constantly, and which, injected into mice, produced the disease; and, from the pneumonic lungs of these mice, the organisms could be recovered, and the disease reproduced by their introduction into other mice.

The occurrence of epidemic pneumonia is favoured by bad ventilation and overcrowding, by sudden changes in the temperature of the atmosphere, by cold, debility and advancing years, and alcoholism.

MALARIAL FEVER.

The conditions which favour the occurrence of malarial fever, with regard to the soil, have already been entered into.

Although malarial fever is of most frequent occurrence in tropical and sub-tropical parts of the world, it is also met with in temperate zones, and at one time was prevalent in certain parts of England and Scotland, particularly in regions where the soil drainage was bad, and the soil in consequence marshy and full of vegetable organic matter.

The parasite of malaria is now well known: its life history has been carefully studied of late years, and much important information gained regarding its mode of gaining access to the human subject. Without entering into the life history of the plasmodium malariæ, and its existence in certain kinds of mosquito during a certain phase of this life history, we may say that the parasite has various forms, each having reference to a special variety of malarial fever. The parasite inhabits the red blood corpuscles.

The most usual variety occurs in the form of a somewhat indefinitely-shaped mass of protoplasm, occupying a larger or smaller area of red blood corpuscle. Sometimes the plasmodium is rosette-shaped or spheroidal, or may, under certain special conditions, be flagellated. In the malignant malarial fevers crescentic bodies make their appearance. The plasmodia may or may not be pigmented with granules of melanin.

The symptoms of malaria vary exceedingly in their nature, according as the attack of malaria is of the intermittent or remittent type, or of quotidian, tertian, quartan, double tertian or double quartan, or other type; but for a description of the various kinds of malarial fever a text-book on medicine must be consulted.

The disease is undoubtedly disseminated in many instances by mosquitoes, which convey the parasite from the infected to the healthy, and the parasites contained in dust, or rising from the surface of marshes into the atmosphere, are readily carried by winds from place to place. Malaria can also be conveyed by water-supply, where the water has been, in whole or in part, derived from a marshy source and polluted with vegetable organic contamination.

Prophylaxis is difficult to carry out. A person living in a malarious region can hardly escape being affected sooner or later. The use of mosquito nets; building the basement of houses above the general level of the ground (because the miasm rising from malarious soil is more active nearer the ground level than at a distance above it); the interposition of belts of trees between a malarious district and an inhabited non-malarious region, and the drainage of marshy soils; all these precautions will somewhat tend to lessen the dangers of malarial infection.

CONTAGIOUS OPHTHALMIA.

Under this general heading are included both catarrhal conjunctivitis and trachoma. In the former disease there is a simple conjunctivitis with mucopurulent secretion, and with a tendency for both eyes to be affected; while, in the latter, the upper lids are usually involved by granulations which tend to develop cicatrices, and to produce an affection of the cornea, called pannus. These diseases, but more especially the former variety, occur in schools, barracks, &c., when the various individuals do not use separate towels and wash-basins. Trachoma is, in Eastern countries, also spread by flies carrying the infective material from the diseased to the healthy.

TUBERCULOSIS.

The manifestations of *tuberculosis* are various, and include phthisis, white swelling of joints, tubercular meningitis, tabes mesenterica, lupus, &c. The pathogenetic organism is well known, and is a short, slightly curved rod, easily stained with fuchsin, and not decolorised by the subsequent addition of a dilute mineral acid. It occurs in the morbid tissues, and in the sputum of phthisical patients, as well as in the discharges from tuberculous joints.

Tubercle gains access to the body by inoculation, although in most of these cases the effect is purely local. It also gets access by inhalation, and by swallowing the bacillus of tubercle. The organisms are disseminated into the air by the dust of dried sputum, and are ingested in tubercle infected milk and bovine flesh. Doubtless we receive into our lungs and stomachs bacilli every day, but, except the bacilli find a weak spot wherein they may grow, no harm results; for tubercle bacilli reproduce themselves comparatively slowly, and only under conditions of temperature, environment, and moisture favourable to themselves.

The occurrence of tuberculosis in individuals and communities is favoured by certain conditions, among which we may mention the following:—Overcrowding and inefficiency of ventilation, dampness of the soil, especially if in conjunction with prevailing cold winds; want of sunlight; pulmonary irritation from inhalation of dust; occupations necessitating a stooping posture; poverty, whereby an insufficiency of food is taken; and hereditary malformations such as the narrow "phthinoid" chest.

In order to combat the spread of tuberculosis it is thus necessary to prevent so far as possible the occurrence of these conditions which tend to favour its spread. Accordingly, it is necessary to lay down certain rules of living to be adopted by those already diseased, in order that they may not infect those at present healthy.

The individual suffering from, say, phthisis pulmonalis ought to reside in a house, to which the sunlight is readily accessible, and which is freely ventilated. Phthisis is predisposed to among the inhabitants of dwelling-houses which are closely built back to back, the free circulation of air being materially interfered with when houses are so constructed. All the sputum should be burned at once, or spat into bottles containing an antiseptic. The bottles should be emptied at frequent intervals, and kept thoroughly clean. The room occupied by a person who has been suffering from phthisis has been shown to have its air laden with bacilli, and on its walls and floor bacilli have been demonstrated. The room should accordingly be completely cleansed, the wall-paper removed and replaced by new paper, and the windows left open for a considerable time, to allow of absolutely complete renewal of fresh air. The bedding should be treated with superheated steam in the fashion afterwards to be mentioned.

Persons whose occupation predisposes them to phthisis must get as much fresh air and outdoor exercise as possible. Where the occupation is one which is carried on amid dust, free circulation of air should be efficiently carried out, and the dust carried away as completely as possible.

The food supply in regard to milk and meat has also to be watched. All milk and flesh from tubercle infected cows must be discarded, and it should be a matter for stringent precaution on the part of public health authorities that such milk and flesh be denied access to the public for human use.*

The compulsory notification of cases of phthisis has been strongly advocated, and in some instances actually is carried into operation. But this is not of nearly so great value as in the case of scarlatina, diphtheria, &c., for phthisis is a more or less chronic disease, and the sufferer cannot be always kept under observation; and, moreover, a certain stigma would be made to attach to the unfortunate sufferer, who would be practically compelled to suffer social ostracism. This last fact, the shunning of the phthisical by the healthy, is to be deplored, because it tends to add an element of mental depression to the individual, tending to retard his recovery by lowering his spirits.

The establishment of sanatoria is a step in the right

---

* Quite recently, doubt has been cast on the previously accepted statement, that the bacillus of human and bovine tuberculosis is identical.

direction, whereby patients may be treated in rational fashion, and can be taught how to lead healthy lives after their restoration to health. At present there are few sanatoria for the poor, but in course of time charitable persons may be led to provide funds for this most useful and humane object.

PUERPERAL FEVER.

Puerperal fever is the direct result of septic processes occurring in the parturient canals, or pelvic connective tissues or peritoneum, during the course of the puerperium.

It is caused by the introduction of septic organisms into the maternal passages by various means. Among these we may mention the want of ordinary cleanliness on the part of the accoucheur or nurse, or infection conveyed by either of them from a previous case of puerperal fever. Unhealthy surroundings, squalor and filth, sewer air in the house or room, the retention of parts of the secundines in utero, laceration of the purturient canals, the infection of erysipelas, diphtheria, or scarlatina, may have a causal relation in certain cases.

Prophylactic measures, taken in every case of confinement, aim at the exclusion of all those sources of puerperal fever.

The occurrence of glanders, anthrax, actinomycosis, hydrophobia, tetanus, leprosy, beri-beri, may be mentioned among the diseases which are contagious, but they are of too infrequent occurrence to be more than mentioned here. The reader is referred to a work on medicine for a full description of them.

GENERAL MANAGEMENT OF CASES OF INFECTIOUS DISEASE.

Cases of infectious disease, occurring in the practice of physicians, should at once be *notified* to the medical officer of health of the town or district, as the case may be. The infectious diseases of common occurrence, which should be notified, are scarlatina, diphtheria, small-pox, typhoid fever, typhus fever, measles, erysipelas, whooping-cough, puerperal fever, and, during times of epidemic visitation, cholera and plague.

The speedy notification of infectious disease is of much real benefit, as a central authority is at the earliest possible moment made aware of the outbreak of cases, and is enabled to adopt such means as he may consider advisable and necessary, with a view to prevent further spread. The district of first appearance of the disease is indicated, and careful inquiry into water and milk supply, the state of drainage arrangements, &c., can be made. It can be ascertained if the disease has been acquired by attendance at school, or by contagion conveyed by someone resident at a distance, and appropriate measures can at once be adopted. Unfortunately it is the case, however, that an infectious disease cannot generally be recognised and reported until it has already reached an infectious stage, and consequently it often occurs that before means of prevention can be adopted, other individuals have already been afforded opportunity of acquiring the infection.

Every infectious case ought to be *isolated* as speedily and as thoroughly as possible. Where, from the nature of the surroundings, want of accommodation in poor and crowded localities, this is a practical impossibility, the patient ought to be removed to an hospital for infectious disease, and should remain there until he is well, and no longer a source of danger to the community. In houses where there are facilities for isolating the patient, a room at the top of the house should be selected for the sick-room. All unnecessary furniture, curtains, bed-hangings, carpets, pictures, &c., should be removed, and a single bed, small table, and a couple of wooden chairs should be retained. Any other room on the top floor can be used by the nurse, and should in any case not be occupied by any of the family. Outside the door a sheet should be hung, saturated with 1 in 30 carbolic acid, or Izal and water of similar strength, or fluid sanitas can be freely sprinkled over it. Without saying that such a sheet is able absolutely to keep infection from passing from the sick-room into the house, we can at least be sure that some infection is prevented from escaping into the passages, and the presence of the sheet serves to keep the other inmates of the house in mind that the patient suffers from an infectious disease, and ought in consequence to be avoided.

No communication other than that necessary for nursing purposes ought to be allowed between the sick-room and the house. Cooked food should be left at the door for the nurse to take in to her patient, and dishes used by the patient should be washed in hot water, cleansed, and then plunged into an antiseptic fluid. One set of dishes should be reserved for the exclusive use of the patient. The nurse should wear a cotton or holland overall above her dress, which ought not to be of woollen material, in order that when she comes out from the sick-room for her daily exercise in the fresh air, she may simply cast off her infectious garment and leave it behind her; or, she may change her dress completely in a room adjoining the sick-room, before she goes out through the house.

The patient ought not to use handkerchiefs, but pieces of old cotton, &c., which may be burned after use. Infectious discharges from the nose and fauces, as in diphtheria and scarlatina, should be at once burned after being swabbed away with wool, or removed by pieces of old cotton or linen. The stools, in diseases like cholera, typhoid fever and dysentery, ought to be treated with some reliable disinfectant, such as carbolic acid or corrosive sublimate solution, before being thrown down the W.C., and in certain cases the stools can be dealt with by burning or by boiling. In cases of scarlatina, where the desquamating skin is a means of spreading the disease, the patient ought to be bathed once daily at least, and a mild antiseptic can be added to the water in the bath, and afterwards he should be anointed with carbolic oil (say 1 in 40), not so much to exercise any germicidal action on the infectious skin, as to prevent by means of the oil the separation and flying about of the particles of desquamating skin.

The bed-clothing should be soaked in 1 in 20 carbolic or Izal solution before being removed from the sick-room.

Free ventilation of the sick-room should be maintained, and to this end a fire in the room is a decided advantage.

When the patient has recovered from an infectious disease, he must still be kept isolated until all danger of infecting other and healthy people has passed away; and the period of continuous isolation depends of course on the particular disease from which he has been suffering. In all cases, before entering society again, he should be thoroughly bathed in water containing some mild disinfectant, and should be supplied with new clothes.

And then there follows the necessity of rendering his sick-room innocuous, and removing all danger of infection from articles of apparel, &c., which are considered too valuable to be actually destroyed. For these purposes we make use of *disinfectants.* Before going further we may here define three terms in common use in this relation, viz. :—

1. An *Antiseptic* is a substance which has the power of inhibiting or arresting organismal growth, without necessarily killing the organisms themselves.

2. A *Disinfectant* is an agent which is able to kill living organisms.

3. A *Deodorant* is merely able to remove odours, either by absorbing the odorous substance, or by oxidising it, and thereby changing its nature.

Disinfection of the Sick-room.—In the first place the room should be freely exposed to the action of the oxygen of the air, and should accordingly have its window or windows kept widely open, so that free access of atmospheric air may be facilitated. The walls of the room should be denuded of their wall-paper, and the pieces when removed should be burned. Sometimes it is regarded as sufficient if the wall-paper is simply cleaned with bread-crumbs, but the former method is safer. The woodwork of the room should be thoroughly scrubbed, and afterwards washed with some disinfectant like 1 in 20 carbolic acid solution, or 1 in 2000 corrosive sublimate; and it is an advantage to repaint such parts as the doors, skirting, window shutters, &c. Finally, the room should have all the organisms, which may still be in it killed by means of chemical disinfection of its air. This is done by the use of some volatile chemical substance, such as *chlorine*, *nitrous acid*, *sulphurous acid*, or *formaldehyde.* Of these the most usually employed are the two last. In a room of 1000 cubic feet, 5 lbs. of sulphur are burned on a flat iron surface placed over a pail of water, and there should be sprinkled over the walls and floor a considerable quantity of water, in order that the anhydrous SO_2 generated by the burning sulphur may combine with the water vapour to form sulphurous acid ($SO_2 + H_2O = H_2SO_3$). The room ought to be completely shut, when the sulphur has been lighted, and kept sealed for several hours, after which time it should be entered, the windows thrown open, and fresh air allowed freely to enter.

Formaldehyde is potent and is inexpensive. It is put up by chemists in tabloids of 15 grains each, three of which can thoroughly disinfect 100 cubic feet of air in a room. The vapour can also be generated by heating *formaline* (a 40 per cent. solution of formaldehyde) in a special apparatus (Trillat). In this apparatus calcic chloride is added to the formaline solution (known now as formo-chlorol), and heat is applied. The formaldehyde vapour is given off, and passed into the room for a half to one hour. The gas is very irritating, and special care must be taken by persons entering the room after the process of disinfection is over.

Disinfection of Clothing.—Various means for this purpose have been employed, but all are not equally efficacious. It may be well to indicate each method individually, and, at the same time, point out its special advantages and disadvantages.

1. Air.—Exposure of infected materials to the air is a means provided by nature for getting rid of infection. The organisms are acted on by the oxygen contained therein; they are at the same time exposed to a certain temperature and dried, or perhaps, the temperature being low, they are rendered inert by the cold; while sunlight and the mere dilution by wind currents also tend to destroy their virulence. But this process is too slow and too uncertain, and must be aided by other agencies, of which the most efficacious are heat and chemical substances.

2. Heat.—Heat is a very efficient means of disinfecting, and can be made use of in a variety of ways. Small articles of little value can be simply destroyed by being *burned.* Articles which can stand *boiling* can be disinfected in a reliable fashion by this means. They are first soaked in water to remove all coarse impurities before they leave the infected room, and then are boiled. Five minutes boiling is sufficient to destroy any of the contagia, which are associated with infectious diseases.

Steam is very potent when used as a disinfectant for pillows, mattresses, blankets, clothing, &c., which cannot be boiled. Steam at a temperature of 212°F. is a disinfectant of a high degree of efficiency, and is particularly so when acting under pressure, or superheated. Steam *penetrates* into the interior of the fabrics exposed to it, in virtue of the fact that as it penetrates it condenses, and, shrinking in bulk thereby, it creates a vacuum into which more steam penetrates. Moreover, at the same time it gives off latent heat in condensing. Steam destroys such materials as leather goods, because it shrivels them and renders them useless.

Dry Heat must be applied for a longer time to articles intended to be disinfected by it, and is not to be depended on if used at a lower temperature than 220°F., at which point there is some risk of scorching the article. It is deficient in penetrating power, and rarely reaches into the interior of such things as bedding, bundles of clothes, &c. Hot air is therefore greatly inferior to steam, even when there is added to it a little steam.

In carrying out into actual practice these means of disinfection, care must be taken that there is no manner of communication between articles already disinfected, and articles to be disinfected. This can be insured by having the apparatus double, and providing two doors, one for the reception of infected goods, and another for the removal of the disinfected goods. There are many varieties of apparatus in the market, some of which possess modifications more or less advantageous.

Washington Lyon's Chamber.—This has a central disinfecting chamber constructed of iron, and in section oval, having a tightly-fitting steam-tight door at either end, and around it there is a steam jacket. From an adjacent steam boiler, steam is let into the outer jacket under a pressure of 10 to 30 lbs. per square inch, and thereby the inner chamber is heated. Steam is then let into the inner chamber at a *lower* pressure, so that the steam will not condense. The steam pressure is intermitted from time to time in order to favour penetration. Ten to twenty minutes suffices for disinfection, after which time the steam is cut off from the inner chamber, and the articles are thus dried. A few minutes later the steam is cut off from the outer jacket also, the removal door is opened, and the tray holding the articles in the inner chamber is removed.

Goddard, Massey & Warner have an apparatus where the steam is generated in the outer jacket from water placed in the lower part of it, under which there is a furnace. The inner chamber is first heated by hot air drawn through it, and the steam generated in the outer jacket is then passed into the inner chamber. The steam pressure inside and outside the inner chamber is 20 lbs. per square inch. The chamber is constructed of rectangular shape in section.

Van Overbeek de Meyer Apparatus.—Here the steam is not under pressure, and yet the apparatus is of good penetrating power. The outer jacket is again the boiler also, and surrounds the inner chamber. The steam passes into the inner from the outer chamber by an aperture in the top, and when the steam is not turned on, hot air is drawn through the inner chamber, and acts as an efficient drying agency.

The Equifex Disinfector is a cylindrical chamber surrounded by a coil of piping containing steam at high pressure. There is no outer jacket. Steam is blown into the chamber intermittently, so that penetration of the articles is secured, and condensation of the steam in the cylinder is prevented by the steam coil outside the cylinder. Hot air is used subsequently to dry the disinfected articles.

Reck's Disinfector.—This is a simple apparatus consisting of a single chamber into which steam is passed at a low pressure and at a temperature of about 105°C. The articles are exposed to the steam for an hour. The steam is rapidly removed after disinfection by a shower of cold water let into the chamber, but not on the disinfected articles, which are sheltered under an umbrella-like covering or shield. This shield receives the cold shower, and so distributes the water and insures speedy condensation of all steam.

Thresh's Stove.—Steam is generated from water containing calcic chloride in solution; the boiling point of this solution is lower than that of water. A temperature of 105°C. is obtained *without pressure*, and the steam is allowed to escape continuously from the inner disinfecting chamber. Penetration is good, and the whole process of disinfecting is complete in an hour. The articles, after being disinfected, are dried by hot air drawn into the chamber.

3. CHEMICAL DISINFECTANTS.—These act best in watery solution. Many of the so-called disinfectants are really deodorants and nothing else, while others are reliable disinfectants when used in certain strengths, and if allowed to act for a sufficiently long time. Certain articles of clothing can be thoroughly disinfected by these agents, but should first be carefully soaked in tepid water to remove dirt and organic soiling, which, if left on the clothes put into the disinfectant solution, become permanent stains on the fabric. Among these chemical agents we may mention the following, viz., carbolic acid 1 in 20, Izal 1 in 20, chloride of lime 2 oz. per gallon, perchloride of mercury or corrosive sublimate 1 in 1000, and chloride of zinc (Burnett's Disinfecting

Solution). Articles to be disinfected should be left in these solutions for 12 to 24 hours.

Condy's fluid, a solution of potassium permanganate, is merely a deodorant. Sanitas, Jeyes' fluid, terebine, eucalyptus, thymol, and boracic acid have all a mild antiseptic action, but are hardly efficient as disinfectants.

CHAPTER VIII.

FOOD AND ITS RELATION TO DISEASE.

IT seems to be unnecessary in a volume of this nature to enter into a classification and description of the various foods and food-stuffs used for human consumption, but it is necessary to say a few words about the diseases which man may acquire from them.

Excessive amount of Food.—Persons who habitually consume an excessive quantity of certain kinds of food render themselves liable to certain diseases.

Excessive amount of *proteids* in the diet is liable to produce gastric catarrh, constipation, headache, hepatic enlargement, and albuminuria, while in certain individuals it may produce gout.

An undue consumption of *fats* leads to obesity; while, if *carbo-hydrates* be excessively indulged in, the individual may develop gastric catarrh, flatulence, constipation, and possibly glycosuria, which may ultimately terminate in diabetes mellitus. When a young child or infant is fed on too exclusively a farinaceous diet, there is a great tendency for rickets to occur.

Deficiency of Food naturally produces thinness, weakness and lassitude, bodily and mental, quickening of the pulse, ultimately terminating in a fatal issue. Scorbutus has long been recognised as due to an insufficiency of fresh food, especially of fresh milk and vegetables. In adults, scurvy or scorbutus occurs, particularly among sailors, and in comparatively recent times the partial want of fresh food is compensated for by the use of lime juice or of citric acid. Children brought up on tinned foods without a sufficient addition of fresh milk are very liable to suffer from scurvy, and care must always be taken in the case of hand-fed children that this serious disease is not allowed to occur. Preserved meat, vegetables, and milk are of great service under certain conditions, but should only be used in combination with fresh foods. If the preserved food should become at all decomposed, it should on no account be used, as otherwise severe gastro-intestinal symptoms are liable to be set up.

Tinned meats and fruits may be contaminated to some extent by salts of tin, but not to a poisonous extent. Preserved peas may be adulterated with copper salts to give a permanent green colour to the peas: this can be readily detected by merely placing a clean steel fork or knife into the bottle, when the copper will at once be deposited on the steel.

Animal Flesh is one of our most important sources of proteid, and great care must be exercised that it be fresh and free from disease, when used for the needs of the community.

The animal, be it a bullock, sheep, or pig, should before slaughter be healthy in its appearance, showing activity in movement, ability to rise easily, with its coat glossy and free from sore of any sort, with easy breathing, no nasal or oral discharge, and free from dulness of the eyes. It should not suffer from fever of any kind, and ought to be well nourished.

Healthy meat should be alternately streaked with lean and fat, and be of marbled or "marled" appearance. It should be firm and well set, and be well bled. No smell of an unpleasant kind should be observable, and, after the meat stands a short time, a little juice of distinctly acid reaction will escape from it. The fat should show firm and white, free from blood.

Meat which is decomposing, is soft, offensive, and pale in colour: its juice is alkaline and stinking.

Inspection of the offal should show the absence of buccal ulcers, absence of inflammatory conditions of the alimentary tract, no flukes or abscesses in the liver, and the pleural surfaces free from adhesions. When, before being exposed for inspection, a carcase has had its pleural membrane all stripped off, then suspicion should arise as to the state of the removed pleuræ; probably they have been tubercular or affected by pleuro-pneumonia.

Certain diseases are commonly recognised as rendering animal flesh unfit for human food, and among these are the following:—

1. Cattle plague.—In this disease there is pyrexia, accompanied by buccal, nasal, and conjunctival discharge, ulcers on the udders and inside of the thighs, and purging. The flesh of an animal dead of this disease is dark in colour, soft, and malodorous.

2. Pleuro-pneumonia.

3. Anthrax. (Splenic fever.)

4. Tuberculosis.—The animal so affected is thin and poorly nourished, and has not the appearance already indicated as that of a healthy animal. After slaughter, the disease is recognised as white tumours scattered

throughout the lungs, pleuræ and peritoneum, liver and lymphatic glands. The flesh may appear quite natural if the disease is early, but, nevertheless, the meat of tuberculosed animals must not be used for human food, but ought to be destroyed.

5. Rheumatism.
6. Actinomycosis.
7. Foot and mouth disease.
8. Parasites (see below).
9. Typhoid fever (in pigs).
10. Quinsy or strangles.

The following is a short account of the parasites which are more commonly transmitted from animals to man :—

1. *Tape Worms* or *Cestoda.*

These consist of a head and jointed segments called proglottides. The segments near the head are small; the distal ones are mature, and contain a hermaphrodite sexual apparatus. They have a lateral opening or genital pore. Each ovum gives rise to an embryo which possesses six hooklets. The mature segments, getting broken off, are passed from the alimentary canal of the individual affected by the parasite, and get swallowed by some animal, which constitutes what is called the "intermediate host." The capsule of the ovum is dissolved in the gastric juice of the intermediate host, and the embryo, escaping, penetrates the stomach wall, and reaches distant tissues. Here it begins to grow, gets encapsulated, and loses its hooklets, and in certain cases gets hollow and bladder-like, as in the case of tænia echinococcus. A small projection appears on this bladder, and on this four suckers and a circle of hooklets are formed. If set free, or taken into the alimentary canal of the "adult host," the head and suckers attach themselves to the mucous membrane, and the creature attains full development.

Tænia Solium is seven to ten feet long, with a head equal to the size of a pin's head, and possessing a proboscis, four suckers, and twenty-six hooks arranged in a circle. The neck is one inch long. The segments possess a genital pore placed on alternate sides of the successive segments. The ova are globular, and have a striated capsule.

The "intermediate host" is the pig, in which the parasite constitutes the bladder-like cysticercus cellulosæ, causing the flesh to have the appearance which is called "measly."

Tænia Mediocanellata. — The adult parasite is twelve feet in length, and possesses four suckers. Its uterus is very much branched, and there may be as many as three genital pores on each segment. The "intermediate host" is the ox.

Bothriocephalus Latus is seventeen to twenty feet long, and has a head on which are two longitudinal grooves. The genital pore opens on the ventral aspect of each segment. The ova are oval in shape, and possess a lid which allows escape of the embryo. The "intermediate host" is fish.

Tænia Echinococcus is a small tapeworm, and is only $\frac{1}{6}$–$\frac{1}{3}$ inch long. It consists of three or four segments, only the last of which sexually mature. Man is the intermediate host, the adult host being the dog and wolf. The intermediate stage of the creature is found manifested in the liver of man most commonly, but also occurs in the lungs, brain, and eye, and is then known as hydatid disease. The hydatid cyst may be single, or may have daughter and grand-daughter cysts inside it; it is surrounded by a capsule. The fluid in the cyst is composed of water and sodium chloride, and under the microscope hooklets can readily be demonstrated in it.

2. Among the round worms or *Nematoda*, spread by the eating of meat, the most commonly known is *Trichina Spiralis.* This parasite infests man and pigs. The worm itself is small, measuring about $\frac{1}{8}$ inch, and infests the muscles of its host. When a portion of infected muscle is eaten, the capsule of the trichina, encysted in the muscle, becomes ruptured, and the parasites escape into the stomach and exist free. Being reproductively active, they breed young embryos in seven days or so, and the embryos boring through the gastric walls find lodgment in the peritoneum and diaphragm, and, later on, in other muscles of the body. During the period when the embryos are leaving the stomach by boring through it, the patient suffers from pyrexia, abdominal pain, vomiting, cramps in the muscles, and leucocytosis has been noticed as a constant feature.

In examining suspected meat for trichinæ a lens must be employed, either by the use of a powerful small pocket lens, or a portion of the meat is subjected to microscopic examination. Under the lens there are seen small whitish specks in the meat, and occasionally they can be felt as gritty particles, owing to the presence of lime salts in the cyst wall.

When the microscope is used, a few fibres are placed in liquor potassæ and teased with needles, when the encysted parasite can be detected under a low power. The muscles most usually affected are the diaphragm, intercostals, and the muscles of mastication.

We have already noticed that *shell-fish* may under certain conditions be the means of causing outbreaks of enteric fever and cholera. But, in addition, symptoms of poisoning may be caused by mussels gathered from the vicinity of dirty water. The poison appears to be present in the liver of the mussel, and the symptoms may occur whether the shell-fish be eaten raw or cooked. The symptoms are of a *nervous* character, with rapid pulse, dilated pupils, cold surface and extremities, and tendency to fatal collapse. If the shell-fish be somewhat decomposed, then the symptoms are largely gastro-intestinal, with diarrhœa and vomiting as prominent features.

Milk.—No milk from a diseased cow should be sold for human use. Acute diseases in cows usually arrest the secretion of milk, but tuberculous cows continue to secrete milk, though of a poor watery quality. Such milk ought to be condemned.

Milk is in addition a common vehicle for the transmission of infectious diseases, such as typhoid fever, scarlatina, diphtheria (*q.v.*). Milk is very absorbent of gases and effluvia, and as organisms are found in association with these odours, they themselves are taken up by the milk and therein find plenty of pabulum. Oidium albicans, the cause of thrush in infants, easily gains access to milk, and, growing there, produces this disease, when consumed by children. The ready decomposition of milk, too, especially in summer time, favours the occurrence of gastro-enteric catarrh in infants.

Ice-cream and *cheese*, both of which have milk entering largely into their composition, may cause poisonous effects when consumed, the symptoms being of the nature of vomiting and diarrhœa from gastro-intestinal irritation.

CHAPTER IX.

VITAL STATISTICS.

VITAL Statistics are those having reference to population, births, deaths, and disease, especially disease as a cause of death.

1. *Population.*—Every ten years a *census* is taken of the population of the country, and returns are given of each town, county, and district. To estimate the population at any time during the period between the taking of the census, it is assumed that the "natural" increase will be at the same rate as during the previous decade. This estimate may, however, be far from accurate. In rapidly growing towns, or in districts depopulated by emigration, the subsequent census may show that the actual increase has differed largely from the expected or "natural" increase.

It is often of importance in estimating the population to take into account the *age distribution*, as otherwise a false idea of the health of a district may be obtained by reference to the death-rates, *e.g.*, one district (A), with a large population of children and aged people, may have a larger death-rate than another district (B) with a large proportion of adults; yet the district (A) may be the healthier of the two, but this will only be rendered apparent by comparing the *death-rates at certain corresponding ages.*

Another consideration that affects death-rates is the *density of the population.* A knowledge of this is obtained by dividing the population by the area. The unit of area may be taken as an acre or a square mile. Thus, the specific population of a district =

$$\frac{\text{The actual population.}}{\text{The number of square acres or square miles in the district.}}$$

It has been estimated that when the specific population or density is over 400 the death-rate increases with the density.

2. *Birth-rates.*—These are calculated in relation to a fixed unit of time or a fixed unit of population. The birth-rate of a district is the number of births in a year for every 1000 of population. Thus, the population (P) is to 1000 as the whole number of births in the year (B) is to the birth-rate. Expressed graphically:—

$$\text{Population (P)} : 1000 :: \text{number of births (B)} : \text{birth-rate (x).}$$

i.e.,

$$\text{P} : 1000 :: \text{B} : \text{x}$$

$$\therefore \text{x} = \frac{1000 \times \text{B}}{\text{P}}$$

$$\text{Birth-rate} = \frac{\text{Number of births} \times 1000}{\text{Population.}}$$

Sometimes it is necessary to compare the birth-rates for a week or a month or any portion of a year. The result is still stated in terms of one whole year and per 1000 of population, as if the proportion of births were the same all through the year. Then the birth-rate for one week (*i.e.*, $\frac{1}{52}$ part of a year) would be—

$$\frac{\text{Number of births in a week} \times 52 \times 1000}{\text{Number of population.}}$$

If the number of births in a week were 2 per 1000, then the weekly birth-rate would be 104, because—

$$\frac{2 \times 52 \times 1000}{1000} = 104.$$

All births must be registered within 21 days (Scotland), 42 days (England). Still births are not included in the returns.

3. *Death-rates.*—These are estimated in the same way as birth-rates.

$$\text{Death-rate} = \frac{\text{Number of deaths in a year} \times 1000}{\text{Population.}}$$

The death-rate for any particular period (say a week) indicates the number of deaths that would occur in a year (*i.e.*, 52 weeks), supposing that there were to be the same proportion of deaths throughout the whole year as in the week under examination. The "general" or "crude" or "gross" death-rate—reckoned as above—cannot be taken as a criterion of the healthiness or unhealthiness of a district, unless it be subjected to certain corrections for *age*, *sex*, and *public institutions.*

(*a*) The death-rate of children under five years, and of adults over fifty-five years, is much higher than the mean death-rate. Therefore, in a district where there is a disproportional number of young children or of aged persons, this must be taken into account. (*b*) Again, the average death-rate of males is appreciably higher than that of females. In certain districts, therefore, this has also to be taken into consideration.

The correction of death-rates for age and sex for any district is made as follows:—

The age and sex distribution of the city or district must be known from the last census. What the mortality for the district is, ought to be reckoned according to the average mortality for the different ages and sexes over the whole country (say of England

and Wales). The result gives what is termed the "standard death-rate" for the district. Different districts and towns have different standards. The "mean" death-rate for the whole country divided by the standard death-rate for any locality, town, or district, gives what is called the "factor" for such town or district. The death-rate multiplied by the "factor" gives the corrected death-rate.

The death-rates are important when calculated in relation to disease, especially zymotic disease. The connection also between mortality and *occupation* is of importance from a legislative point of view.

(*c*) Deaths, occurring in hospitals, prisons, and other public institutions, of persons who do not belong to the district, must be accounted for, by deducting the number of persons in the institution from the population of the district, and by deducting the deaths of persons not belonging to the district (often called "country deaths") from the number of deaths in the district, and calculating the result in terms of deaths per 1000 of the corrected population.

Life Table.—A life table is necessary, as the basis on which the probability of life is estimated, usually for the purpose of life insurance, and the procedure is as follows. A million births are imagined to take place simultaneously. By reference to the census returns for different ages, and the corresponding death-rates for corresponding ages, it can be calculated how many will survive at the end of the first year, how many at the end of the second year, and so on till the whole million are accounted for.

Expectation of Life.—This is the average length of time any person at any given age may be expected to live, and it is calculated from a life table. The following factors must be known in making the calculation :—The total number of persons alive, as shown by the census returns, the ages of these persons, the total number of deaths, and the number of deaths at the different ages, making at the same time allowance for such extraneous modifying factors, such as emigration and immigration.

It must be remembered, however, that expectation of life tables constructed in this manner may not hold true for the individual, but are a good and fair indication of what may be expected on the average, when many persons are being taken into consideration.

CHAPTER X.

CLIMATE.

WHEN we speak of the "climate" of a place we mean the sum total of the particular soil, air, temperature, and other conditions, studied in relation to their effects on vegetable, and, more especially, on animal life. The classification of climates will be referred to later, when we have examined the various considerations which, in the aggregate, constitute a climate.

The physical conditions which go to make up a climate are the following, viz.:—Temperature; humidity; purity; density; winds; electricity; and the general relationships as to geographical position; propinquity, or the reverse, to the sea, lakes, mountain ranges, plains; the nature of the subsoil and soil; drainage; vegetation; and the aggregation of human beings. To most of these general relationships we have referred in previous chapters, and they need, therefore, no further mention.

The *temperature* of a place depends on its position with regard to the equator. At and near the equator the sun's rays fall practically direct on the surface of the earth, and the further from the equator we go, the more obliquely do the rays descend. Therefore, at the equator the temperature is highest; and the more remote we are from it, the lower does the temperature become. When the air is pure, and free from foreign bodies and moisture, it is practically diathermic—that is to say, the sun's rays fall through the air *without heating it*, and the heat passes directly on and into the surface of the earth. The surface of the earth, after becoming heated, parts with its heat again, and warms the air which comes into contact with it. Land gives off heat more quickly than it absorbs it; so also does water, but water takes longer to absorb and to give up its heat than does soil. Consequently, water is the great medium for modifying the temperature conditions of localities, and keeps up a more or less equable temperature. When the sun is strong and hot, as during the day and in summer, the land is speedily heated, while water, absorbing the heat more slowly, remains cooler. The air which comes into contact with the water is therefore comparatively cool, in contradistinction to the air over land, which gets very much more heat imparted to it by the land. For this reason the air in the vicinity of an expanse of water, be it sea or lake, is much cooler during the day than the air over a considerable area of land. Conversely, during the night and in winter the air over land is cold, because of the readiness with which land gives off its heat, while near water expanses the air is not nearly so cold, owing to the fact that the water is more retentive of the heat which it has acquired. Land, therefore, in the neighbourhood of a large lake or on the sea coast, is of much more equable temperature, its air never being excessively hot nor excessively cold, in summer and winter, by day and during the night respectively, but maintaining a fairly even level.

On the sea coast a pleasant and cooling *sea breeze* is produced during the day, by the land taking up heat so readily and then warming up the air in contact with it. This air becomes lighter, expands and rises, and, to take its place, cool air flows in from the sea, because the water, absorbing and parting with its heat more slowly, remains colder and the air in contact with it is also kept cold. This colder air of course does not rise, and therefore flows in towards the land to take the place of the heated and displaced land air. At night the reverse occurs; for the sea, retaining its heat longer than the land, has the air over it warmer and lighter than the air in contact with the cooled land. Accordingly the lighter sea air rises, and the colder land air flows outwards to the sea, and constitutes a *land breeze.*

Heat passes slowly upwards through the various strata of air, and the lower air strata possess, as a consequence, the greatest amount of heat from the soil already warmed by the sun's rays. Conversely, lowering of temperature of the strata of the air in cold weather occurs more quickly near the surface of the earth. Hence, in summer and during the day, the air of hills is cooler as a general rule than the air of plains, and in winter and during the night is somewhat warmer.

Humidity.—Temperature has a very important relationship to the *humidity* of the atmosphere, because the higher the temperature of the air, the more water-vapour can the air take up.

Absolute humidity is the term employed to signify the actual amount of water-vapour in the air at a given time.

Relative humidity refers to the amount of water present in the air, relative to that amount which is just sufficient to saturate the air with water-vapour.

If the relative humidity be high, any increase in the amount of water-vapour taken up by it will cause condensation, constituting dew, mist, or clouds. When the temperature of air is increased, a degree of humidity, amounting to saturation of the air with moisture, will cease to cause saturation, because of the fact, that the warmer air is, the more water it can take up. On the other hand, when air gets *cooled* to a certain point, the aqueous vapour it contains, not originally causing saturation, may come to be sufficient to saturate the air, and further loss of heat will entail condensation of the water-vapour in it. Hence it is, that, when warm air, containing a fair amount of aqueous vapour, comes into contact with mountains, it is cooled and deposits its moisture on the surface of the hills as rain or snow. When extensive ranges of high hills exist, it may happen that the windward side of the hills is very damp and rainy, while the leeward side possesses a fine dry climate. This of course infers that there is a prevailing wind coming in a certain constant direction for considerable periods of the year.

Rainfall is caused then by warm air heavily charged with water-vapour coming into contact with cold air or winds or mountain ranges. It is therefore more prevalent in places where there are hills or mountain ranges, which cool the air and condense its moisture, than in such places as broad plains. Rain is also more abundant along the sea coast than far inland, because of the greater abundance of water in the air coming in from the sea.

The purity of the atmosphere is a factor of considerable importance in relation to climate. The air of mountains, of the sea coast, and places remote from aggregation of human beings is free from organic impurities of all descriptions, and is very fresh and pleasant. It contains a normal standard amount of oxygen and a minimum of carbonic anhydride, while it is comparatively rich in ozone. Ozone (O_3) is an allotropic modification of oxygen, is powerful as an oxidiser and deodorant, and is a stimulant to animal and vegetable life.

Atmospheric Density or Pressure is measured by means of the barometer, an instrument constructed on the knowledge of the fact that the weight of a column of air, of, say, one inch in thickness, and extending to the height of the atmosphere, is equivalent to the weight of a column of mercury 30 inches high and of similar thickness to the column of air.

The variations of atmospheric pressure are due to two main causes—(1) the temperature of the air and (2) the moisture contained in it. Referring to the first cause, we know that the warmer air is, the lighter it becomes, and as it then expands and ascends, the atmospheric pressure becomes decreased. The influence of the moisture in the air in lowering atmospheric pressure is due to the fact that aqueous vapour is *lighter* than air. If, then, air contains much water-vapour, the water-vapour displaces an equivalent bulk of air, and, therefore, the atmospheric pressure is diminished. When the aqueous vapour is condensed and rain falls, the air assumes the place previously occupied by the lighter water-vapour, and the atmospheric pressure once again rises.

Winds are very largely the result of temperature conditions. We have already seen that air is heated by coming into contact with the warm surface of the earth, and, becoming thereby lighter it expands and rises upward. In the neighbourhood of the equator the sun's rays fall directly on the earth's surface, and, as we pass in the direction of the north and south poles, the sun's rays fall more and more obliquely. The temperature of the earth near the equator is, therefore, higher than at any other region, and the air there is accordingly warmer; and, as the equator is left and the polar regions approached, the earth's surface and air become gradually colder and colder. The natural result of this is, that the air in the equatorial regions rises upwards, and, to occupy the position vacated by it, cold air flows in from the polar regions. This air in its turn is heated, rises, and flows to the poles, where it falls as it cools, and returns along the surface of the earth to the equator. In this manner a constant circuiting of the air is brought about. The current of air, flowing over the earth's surface from the polar regions towards the equator, should constitute a north and a south wind in the northern and southern hemispheres respectively; but this does not exactly take place, for we must remember that a disturbing factor must be taken into consideration, namely, the movement of the earth itself. The atmosphere surrounding the earth moves with the earth, and as the earth's surface at the equator moves faster than at any other part, owing to the circumference of the earth being greatest at the equator, it follows that the atmosphere will also move with diminishing speed as we pass from the equator to the poles. Accordingly, as the air flows in from the poles to the equator, where the earth and its atmosphere are moving at the greatest speed, the more slowly revolving polar air current will not be travelling at the same rate of speed as the earth's surface at the equator. A breeze will then appear to exist, and, as the earth moves from west to east, the wind will appear to be travelling from east to west. In the northern hemisphere, then, this breeze will be north-east and in the southern hemisphere south-east, and these winds are those commonly known as the *trade winds.*

The heated air, moving in an upper stratum from the equator to the poles, flows in an exactly opposite direction, and appears to be from the south-west and north-west in the northern and southern hemispheres respectively. These winds are of course full of moisture from the amount of evaporation which occurs at the equator, and they are consequently the great source of rainfall in the lands towards which they flow. They cool as they flow from the equator, and, when they come over land or reach hills, they supply an abundance of rain. For this reason the south-west winds, which reach the British Isles and the south-west of Europe, are laden with aqueous vapour.

The force of the wind is measured by an instrument called an *anemometer,* which consists of an upright from whose upper extremity four arms radiate outwards at right angles to the upright. At the distal end of each of these arms there is attached a hollow cup upon which the wind impinges. The force of the wind causes the horizontal arms to swing round, and, as they are attached to the upright, the latter revolves also on its long axis. The upright is attached to a clockwork mechanism, and thereby a record is obtained of the number of revolutions of the horizontal arms in a given time. The instrument is made so that

500 revolutions equal one mile, and the time occupied in recording a mile equals the velocity of the wind.

The fact that *electricity* exists in the atmosphere has long been known, but its precise effects on vegetable and animal life are largely conjectural. We know little more than the fact of its existence, and that its occurrence is closely associated with conditions of atmospheric temperature. Both positive and negative electricity can be detected in the air, and an instrument used for demonstrating its presence is called Thomson's Electrometer. The contact of clouds charged with positive and negative electricity occasions a thunderstorm with discharge of heat and lightning.

Classification of Climates.—Climates have been variously classified according to what has been considered the most important feature or condition dominating the production of climate. Thus we have climates divided into warm, temperate, and cold; into dry and humid; and also into sea or insular, and inland or continental. Without saying that one classification is better than another, we may shortly indicate what is signified by each of the above terms:—

Warm climate is a climate lying between the equator and 35° latitude north and south of the equator.

Temperate climate, from 35° to 50° or 55° latitude.

Cold climate, from 50° or 55° latitude to the poles.

Mountain climate is the climate of altitudes of between 2500 and 6000 feet. These levels are chosen for convenience of description, for, while no doubt the air is fresh and pure under 2500 feet, it does not come under the category of "mountain" air. Above the level of 6000 feet the altitude begins to have secondary effects, which are inimical to animal and vegetable life. The characters of mountain air are diminution in atmospheric pressure, greater rarefaction of the atmosphere, and lowering of temperature. As regards the question whether the air of mountains is drier or more humid than the air of plains, a great deal depends on the degree of altitude of the mountain or mountain range, its configuration, the presence or absence of vegetation on it, and the nature and direction of the prevailing winds, for if the latter be of high relative humidity, they will tend to get cooled by coming into contact with the mountains, upon which they will then deposit their condensed aqueous vapour. If a certain mountain range happens to be surrounded by other high mountains, then the latter will receive all the winds and rains, and will render the air of the protected mountain free from both rain and wind. In a mountain region there is also greater abundance of sunlight and ozone than there is to be found on plains.

When an individual goes from a plain to a mountain climate, he almost at once begins to breath more quickly. His red blood corpuscles increase in numbers, probably owing to the necessity for more oxygen carriers when the air is more rarefied. After his descent to the plain again, the number of red blood cells reaches the normal aggregate in the course of a few days.

Sea or *island* climate is the kind of climate found on the sea, on the sea coast, and on moderately sized islands and capes. The air is of course very pure, and the amount of moisture in the air is comparatively great, and is more constant in quantity than in the case of inland climates. Moreover, on account of the proximity of water, the temperature of the air is more equable, there being comparatively little difference between the daily and nocturnal temperature, and the summer and winter variation is also comparatively slight. This, of course, is due to the fact that during the day and in summer the large surface of water keeps the air cooler, and during the night and in winter it keeps it warmer than it would otherwise be, did no water lie near.

Inland or *Continental* climate, on the other hand, is more subject to extremes of seasonal and daily variations, and is liable to be very hot in summer and very cold in winter. It may be said to possess characteristics the very reverse of those of a sea climate.

INDEX.

E. & S. Livingstone, *Printers*, Edinburgh.

CATALOGUE

OF

E. & S. LIVINGSTONES'

MEDICAL

PUBLICATIONS, &c.

⁂

15 Teviot Place,
EDINBURGH.

6,01.

PUBLICATION

OF

Medical and Scientific Works.

THE SUBSCRIBERS are prepared to undertake the Publication of MEDICAL and SCIENTIFIC WORKS on terms advantageous to Authors.

The rapid sale of Works hitherto placed in their hands enables them to guarantee a favourable reception in the Profession, and by the Trade at home and abroad.

The Printing of their Publications is carried on within their own premises, thereby saving unnecessary expense and receiving more careful attention.

E. & S. LIVINGSTONE,

MEDICAL AND SCIENTIFIC PUBLISHERS,

EDINBURGH.

Price £2 : 2s. Super-Royal Folio, Cloth.

THE
Topographical Anatomy of the Child

By JOHNSON SYMINGTON, M.D.,

F.R.S.E., F.R.C.S.E.,

Professor of Anatomy, Queen's College, Belfast; formerly Lecturer on Anatomy, School of Medicine, and Examiner in Anatomy, University of Edinburgh.

Illustrated by 14 beautiful and correctly Coloured Plates (nearly all of which are life size) and 33 Woodcuts.

'Dr Johnson Symington has well filled a gap in our Topographical Anatomy. This department of anatomical science has been worked at most extensively and ably by Pirogoff, Braune, Luschka, and others, in the adult; but the method of frozen sections has hitherto been systematically applied to the child, in one case only, by Professor Dwight. Dr Symington has added to our knowledge by presenting us in this work with fourteen coloured lithographic illustrations, all life-size, and thirty-three woodcuts taken from sections of male and female children, aged four years and a half, five years, six years, and thirteen years, and has given us a large number of very accurate observations on the position of the various organs and viscera, and the changes which they undergo in the earlier periods of life. The horizontal sections have been taken from a girl six years of age, whilst the vertical sections (both coronal and sagittal) are from children of both sexes and various ages. In addition to the illustrations, the work is most valuable for excellent letterpress, treating very fully and minutely of the position of structures at all periods of early life, and it is evident that many of the views generally held in regard thereto will have to undergo considerable alteration. For example, Dr Symington shows that the external auditory meatus is relatively as long in the child as in the adult, when examined in the fresh state in subjects with the entire head frozen; that the spinal cord in the newly-born child ceases at much the same point as in the adult; that the child's neck is not relatively short, but that it is higher in relation to the vertebral column than in the adult. The common assumption that the position of the stomach in the child is vertical is also shown to be erroneous, and is proved by figures taken from an infant four days old, and from a girl six years of age. The portion of the book devoted to the position of the pelvic viscera in male children is of great importance to surgeons, and will be carefully studied in view of operations on the urinary organs in early life. Too much praise cannot be bestowed upon the author for the obvious care and industry with which he has pursued his investigation, and the accuracy and fidelity with which he has reproduced its results. Its dedication to Professor Braune is a most graceful compliment to an anatomist who has done more to advance the knowledge of Topographical Anatomy than any other worker in this special branch.'—*The Lancet*, 22nd October 1887.

Just published, price 4s. 6d. net.

The Conservative Treatment
OF
Tubercular Joint Disease and Cold Abscess

AS CARRIED OUT AT BRESLAU BY

Prof. J. VON MIKULICZ, LL.D.Edin.

BY

DR A. HENLE,

Chief Assistant at the Surgical Klinik, Breslau.

WITH PREFACE BY PROFESSOR J. VON MIKULICZ.

TRANSLATED FROM THE GERMAN BY

CHARLES W. CATHCART, F.R.C.S.,

SENIOR ASSISTANT SURGEON, ROYAL INFIRMARY, EDINBURGH.

'We regard this as a most important contribution to the literature of a most important department of surgery. Every practising surgeon should learn for himself what the modes of treatment are which find favour with Professor Mikulicz in a domain wherein he ranks as an authority of no undeniable weight. In this handsomely bound and well printed octavo, he will find discussed the "congestion" treatment, the "orthopædic" treatment, the "iodoform" treatment, and all the other preliminary methods of avoiding the more advanced procedures of erasion, excision, &c., which may be employed before sacrificing a whole limb. We strongly recommend this volume to the attention of every practitioner.'—*The Medical Press.*

Third Edition, in 2 vols., price 18s.

ILLUSTRATED WITH 238 USEFUL ENGRAVINGS.

Applied Anatomy

BY

JOHN M'LACHLAN, M.D., B.Sc., F.R.C.S.E., &c.

The Book includes what is usually known as—

1. SURGICAL ANATOMY. 2. MEDICAL ANATOMY.
3. OPERATIVE SURGERY.

USED AS A TEXT-BOOK IN THE PRINCIPAL UNIVERSITIES & MEDICAL COLLEGES.

'It deserves every success.'—Sir George Macleod, Professor of Surgery, University of Glasgow.

'If the medical student of to day comes to an examination unprepared, and retires without his diploma, he certainly cannot lay the blame of his failure on want of instruction. To help the student in his difficulties, to guide him in the waste wilderness of his poor lecture-room notes, and to give him a chance of learning something, the student has to find for himself men that can really teach him, and books that convey useful information, information that will bear not only on the work of the examination, but also on his future professional life. Dr M'Lachlan is such a teacher, and his book is of the kind we mean. It is a successful attempt to show how the facts of Anatomy are necessary as a groundwork both of Surgery and Medicine. If mastered it will do the student more good than acres of MSS. dealing with theory and fad, for it makes his anatomy interesting, and the bedside or the operating theatre intelligible, and, except where vested interests in fees come in, it is pretty generally acknowledged now that the dissecting room, the laboratory, and the hospital are the real places of study.'—*Edinburgh Medical Journal*

'The text is copiously illustrated with well executed engravings, numbering altogether 238 as against 74 in the former edition. The author has produced a work which is more fitted to meet the wants of the student and the practising surgeon in the application of anatomy to practice, than any other which has come under our notice.'—*Hospital Gazette.*

'The book is written specially with a view to the requirements of students preparing for the higher examinations; and its successive editions have, in this regard, been each one more perfect than the last. In this issue much new matter and many new illustrations have been added. The work may be cordially recommended to students as a complete and practically useful text-book.'—*Scotsman.*

Just Published, Fifth Edition, price 10s. 6d. net.

The Students' Handbook
OF THE
PRACTICE of MEDICINE

Designed for the use of Students and
Junior Practitioners.

BY H. AUBREY HUSBAND, M.B., C.M.,
B.Sc., F.R.C.S.E., M.R.C.S., L.S.A.,
FORMERLY LECTURER ON MEDICAL JURISPRUDENCE AND PUBLIC HEALTH
IN THE EXTRA-ACADEMICAL SCHOOL, EDINBURGH.
MEMBER OF THE GENERAL COUNCIL OF THE UNIVERSITY OF EDINBURGH;
EXTRAORDINARY MEMBER OF THE ROYAL MEDICAL
SOCIETY, EDINBURGH;
AND CORRESPONDING FELLOW OF THE MEDICO-LEGAL SOCIETY
OF NEW YORK.

Illustrations, Tables, Prescriptions, and Glossary.

'The book before us is an excellent example of its class; the whole of medicine is digested and tabulated, and in fact served up ready prepared at infinite pains to render it easily assimilated.'—*Lancet.*

'The distinguishing features of Dr Husband's handbook are condensation and clearness of diction—qualities which are certain to ensure for the book a favourable reception by those for whom it is intended. We have pleasure in recommending it to our readers as a most useful work to peruse immediately before presenting one's self for a Medical Examination.'—*Students' Journal.*

'The book is not put forth as a systematic treatise upon diseases and their treatment, but under each section will be found a brief statement of the main points connected with all the diseases enumerated in the nomenclature of the Royal College of Physicians, London. From the point of view of the uses to which this Manual is designed, we know of no work that can be put in comparison with it.'—*Provincial Medical Journal.*

'Whether as a handbook for use as an introduction to the systematic study of disease, or for the purpose of refreshing the memory on the eve of an examination, the work is equally to be commended, and one may safely assert that it will retain its well-earned popularity.'—*Hospital Gazette.*

Sixth Edition, Revised and considerably Enlarged.

Illustrated by Coloured Plates, price 10s. 6d. net.

THE STUDENTS' HANDBOOK
OF
Forensic Medicine, Toxicology, and Public Health

By H. AUBREY HUSBAND, M.B., C.M.,
B.Sc., M.R.C.S., L.S.A., F.R.C.S.E.,
Author of 'Student's Handbook of the Practice of Medicine,' etc.

Used as a Text-book in the principal Universities and Medical Schools in Great Britain, India, and the Colonies.

'It is intended for students, and is for them very convenient. This edition fully sustains the acceptableness of the work.'—*Lancet.*

'The work is an excellent epitome of the subjects on which it treats, and contains all that the student need know to pass his examinations, or that the ordinary practitioner will require in the course of his practice. . . . As a trustworthy and readable guide to the study of forensic medicine, we can strongly recommend it to both students and practitioners.'—*Student's Journal.*

'The book is one which can be commended, and will in the future, as in the past, doubtless smooth the passage of many medical students through the difficulties of the examination room.'—*Public Health.*

'The work has long enjoyed a pre-eminent reputation as a book useful to students about to proceed to examination in the subjects of which it treats; and men have been known to boast of having secured academic degrees by no more than a cursory perusal of its pages. They toiled not; but, being possessed of this handbook, neither were they spun. The new edition gives the book in an improved shape. The text has been revised, new matter has been added; and some professionally beautiful illustrations now appear in the work. For the rest, this edition keeps the handbook well abreast of its reputation.'—*Scotsman.*

JUST PUBLISHED.

Price 10s. 6d. net.

ELEMENTARY TEXTBOOK OF ZOOLOGY

BY

ARTHUR T. MASTERMAN,

M.A.(Cantab.),

D.Sc.(Lond. and St And.), F.R.S.E.

LECTURER ON ZOOLOGY AND BIOLOGY IN THE
SCHOOL OF MEDICINE OF THE ROYAL COLLEGES, EDINBURGH;
JOINT-AUTHOR OF
"THE LIFE-HISTORIES OF THE BRITISH MARINE FOOD-FISHES";
EXAMINER IN BIOLOGY TO THE
ROYAL COLLEGE OF PHYSICIANS, EDINBURGH, ETC.

PROFUSELY ILLUSTRATED.

Second Edition, price 6s.

THE STUDENTS'
Handbook of Chemistry

By H. LEICESTER GREVILLE,

F.I.C., F.C.S., &c.

This book contains a large amount of information condensed into Tables; also the most important Chemical Calculations and Illustrations.

'The tabulation of facts, containing groups of elements and compounds, is a good feature in this book, and likely to prove very useful to the student. The chapters dealing with Organic Chemistry are clear and succinct.'—*Nature.*

'This book has many merits. It is clearly and pleasantly written, is well arranged, and contains a great deal of useful and important fact, much of it embodied in Tables.'—*Lancet.*

'A concise and useful Manual. The work has been revised and made more valuable by the addition of several Tables and much new matter in the text. The calculations are very useful.'—*Scotsman.*

Fifth Edition, Revised and Enlarged, price 6s.

MANUAL OF
Materia Medica and Therapeutics

FOR THE USE OF STUDENTS AND PRACTITIONERS.

By WILLIAM CRAIG, M.D.,

C.M., F.R.S.E., F.R.C.S.E., etc.,

Lecturer on Materia Medica in the Edinburgh School of Medicine,
Examiner at the Royal College of Surgeons, Edinburgh,
Examiner at Edinburgh University.

Used as a Text-book in the principal Universities and Colleges in Great Britain, India, and the Colonies.

'This concise little Manual, though intended primarily to assist students attending the author's own classes, possesses several characteristics which have rendered it more generally popular. Special emphasis is laid upon alterations in nomenclature which might otherwise escape attention. The volume concludes with a Posological Table, a Schedule of Poisons and their Antidotes, together with an Appendix of Contracted Terms in Common Use. It is beautifully printed, and is altogether a very handy and convenient volume for the use of students preparing themselves for examinaton.'—*British Medical Journal.*

'This being a fifth edition, calls for very little remark. The amount of condensation of material is truly surprising.'—*Lancet.*

Demy 4to., price 7s. 6d.

Illustrated with 10 Coloured Plates.

Nerves of the Human Body

BY ALFRED W. HUGHES, M.B. & C.M.Edin.;
F.R.C.S. Edin.; M.R.C.S. Eng.;
Late Professor of Anatomy, King's College, London.

'An excellent work of reference for students, quite in place in a Medical School library. The drawings are large and bold, demonstrating the distributions and connections of the cranial and spinal nerves with clearness and accuracy. The cranial nerves in particular are well represented. . . . The preparation of "Nerves of the Human Body" must have cost its author much trouble, and Dr Hughes may be congratulated on the result of his labours.'—*British Medical Journal*

'As regards the work little is left to be desired. As far as the diagrammatic and literal description of the nerves goes, this work is undoubtedly good; and there is no doubt that the anatomical details are an improvement on those usually given. It will be found a help to students in their practical work, and of equal help to the practitioner in his pathological and therapeutic investigations.'—*Provincial Medical Journal.*

Price 4s. 6d. net.

ILLUSTRATED WITH 8 COLOURED PLATES.

MANUAL OF
SURGICAL ANATOMY

BY ALFRED W. HUGHES, M.B. & C.M.Edin.;
F.R.C.S.Edin.; M.R.C.S.Eng.;
Late Professor of Anatomy, King's College, London. Author of 'Nerves of the Human Body,' &c.

Used as a Handbook in all the Universities and Medical Colleges.

'This little book contains very terse descriptions of the anatomical facts most important to students about to present themselves for their Final Examination in Surgery. Clearness sometimes, and elegance of diction often, have been sacrificed to brevity. It will recommend itself to those for whom it is specially prepared.'—*Lancet.*

'Dr Hughes evidently possesses the faculty of condensing a large amount of information into a small space in a clear and methodical manner. The student will find it a very reliable guide The work contains a number of excellent illustrations, which will greatly assist the student in learning the relative positions of various structures which he would encounter in the ligature of the principal arteries.'—*Edinburgh Medical Journal.*

Second Edition, price 6s.

Revised and Enlarged, with 12 Tinted Plates and 40 Woodcuts.

MANUAL OF THE
Minor Gynecological Operations and Appliances

By J. HALLIDAY CROOM, M.D.,
F.R.C.P.E., F.R.C.S.E.,
Lecturer on Midwifery and Diseases of Women, School of Medicine;
President of the Obstetrical Society, Edinburgh; and
Examiner in Midwifery in the University of Edinburgh and Royal College of Physicians, Edinburgh.

'The descriptions and recommendations of Dr Croom seem entirely familiar, intelligible, and wholesome. A number of well-executed lithographic plates, giving various relations of the pelvic organs, add to the value of the book.'—*American Journal of Obstetrics.*

'We are glad to see that this valuable Manual has run into a Second Edition Its arrangement is such as will commend itself both to the student and busy practitioner. We finish the perusal of this work impressed with its simplicity of arrangement and lucidity of expression.'—*Liverpool Medico-Chirurgical Journal.*

Price 10s. 6d.

THE STUDENTS'
Handbook of Medicine AND Therapeutics

By ALEXANDER WHEELER,
Clinical Assistant, Out-Patient Department, Edinburgh Royal Infirmary.
Author of "OUR UNSEEN FOES," &c.

Used as a Text-Book in the principal Universities and Colleges.

'It is distinctly designed to refresh the memory on salient points, as well as to enunciate the leading principles of treatment. These aims have been faithfully carried out, and that too with an originality for which it might be thought there could be little scope. Clear, concise, and accurate.'—*Lancet.*

3rd Edition. 5th Thousand, price 5s. net.

Illustrated by about 40 Plates (many Coloured) or 109 Figures.

Anatomy of the Brain and Spinal Cord

By J. RYLAND WHITAKER, B.A., M.B.(Lond.)

F.R.C.P., L.R.C.S.(Edin.);

Lecturer on Anatomy, Surgeons' Hall, Edinburgh; Examiner for the Triple Qualification.

Used as a Text-Book in the principal Universities and Medical Colleges in Great Britain, India, the Colonies, U.S.A., and Italy.

'The book is an excellent Manual for the use of Students and makes a good introduction to the heavier text-books. This Edition is made more valuable by the inclusion of some new matter in the text, and by the addition of many new figures and tables.'—*Scotsman.*

Price 4s. 6d. net.

Notes on Pathology

By J. RYLAND WHITAKER,

B.A., M.B.(Lond.), F.R.C.P., L.R.C.S.(Edin.);

Lecturer on Anatomy, Surgeons' Hall, Edinburgh;
Examiner for the Triple Qualification.

Vol. I.—GENERAL. Vol. II.—SPECIAL (*in preparation*).

Used as a Handbook in the principal Universities and Colleges.

'These "Notes," which traverse the whole range of General Pathology, have evidently been compiled with great care. Together, they form an outline of the subject of which it will not be difficult for the student to fill in such details as he gathers from his lecturer or his text-book. The author himself recognises this as the main object of his publication, and we may say at once that he has done his work well, and that it should prove of much utility. In these days of "compendia" of knowledge, where the aim often seems to be to condense into as small a space as possible the facts of science, so that the student may be saved the trouble of learning them step by step, it is gratifying to find a writer who takes a higher view of the kind of assistance that the student needs. The information he conveys in his little work is considerable, and also accurate; in parts even—*e.g.*, in the sections dealing with Inflammation and the Parasites—it is almost, if not quite, as full as is to be found in many a text-book. But it would be difficult for the student to use the work simply for the purpose of "cram." We believe, moreover, that teachers also may be glad of so concise a summary of the subject as Mr Whitaker has given.'—*Lancet.*

Demy 8vo, price 4s. 6d. net.

Vaccination Eruptions:

ORIGINAL RESEARCH.

By THOMAS DOBSON POOLE, M.D.,

Master in Surgery, University of Edinburgh; Fellow of the Obstetrical Society.

'The title of this very interesting work concisely indicates its contents. A good acquaintance with the literature of the subject is shown on every page, and the cited cases are of great interest, especially those in connection with the subject of generalised vaccine eruption (*vaccine généralisée*). The differential diagnosis between vaccination, ulcers, and primary chancres, also between vaccination eruptions and secondary syphilitic manifestations, is given *in extenso* from Portalier's summary of Fournier's lectures. In conclusion, this work deserves perusal by all who are interested in the subject of vaccination, therefore by all medical practitioners.'—*British Medical Journal.*

Second Edition. Price Two Shillings net.

Revised in accordance with the British Pharmacopœia, 1898.
96 pp. Crown 8vo. Bound in Cape Morocco.

The Students' Practical Materia Medica

BY

G. HAXTON GIFFEN,

L.R.C.P.E., L.R.C.S.E., L.F.P. & S.G.;

'Bathgate' Gold Medallist in Materia Medica, Royal College of Surgeons.

'We recommend this little book.'—*Dublin Journal of Medical Science.*

'It contains a vast amount of information in small compass and is likely to become popular with students preparing for an examination.'—*Edinburgh Medical Journal.*

'This is a very concise and practical manual, a summary and resumé of the principles of pharmacology, and the nature and uses of drugs with their doses. The method of the arrangement of the chapters is simple and intelligible and the doses of officinal preparations are stated under a system of classification which prevents reiteration and more readily impresses the memory.'—*Glasgow Herald.*

'It is at present the most succinct, lucid, and suggestive of all the manuals on the subject.'—*Scotsman.*

'It contains much useful information.'—*Medical Press.*

Quarto. Price Sixpence net.

SCHEDULES FOR

PLANT DESCRIPTION

(ILLUSTRATED)

By JOHN WISHART,

Lecturer on Zoology and General Biology in Robert Gordon's College, Aberdeen; Herbarium Medallist of the Pharmaceutical Society of Great Britain.

USED IN ALL UNIVERSITIES AND COLLEGES.

'The use of these Schedules by pupils will train their powers of observation and reasoning, and prevent them from being contented with book knowledge.' —*Dublin Journal of Medical Science.*

'These tables are admirably adapted and arranged on a scientific principle for building up an instructive record of plant examination.'—*Aberdeen Daily Free Press.*

BY THE SAME AUTHOR.

Price Two Shillings net.

THE

Botanists' Vade Mecum.

'A very handy little pocket guide to the classification of plants, intended for use during botanical excursions. The matter is very concise and well arranged, and the value of the book is very materially enhanced by an ingenious and novel form of index.'—*Guy's Hospital Gazette.*

'This little manual, of a size suitable for the pocket, will form a useful companion to students of botany in their field-days. Its arrangement is concise, and its information conveniently scheduled. A useful ledger-index adds to the convenience of the manual.'—*Glasgow Herald.*

'We commend this Vade Mecum as a very useful guide to all botanical excursion students, who will find it an invaluable aid to recognising the characters of the various divisions and natural orders.'—*British and Colonial Druggist.*

Price 2s. 6d. net.

THE ROTATORY MOVEMENTS
OF THE
HUMAN VERTEBRAL COLUMN
AND THE
SO-CALLED MUSCULI ROTATORES.

By ALFRED W. HUGHES,

M.B. & C.M. Edin.; F.R.C.S. Eng.; F.R.C.S. Edin.;

Late Professor of Anatomy, King's College, London; Author of 'Nerves of the Human Body' and 'Manual of Surgical Anatomy.'

'The entire work bears evidence of careful observation, and forms a useful contribution to the mechanism of the human skeleton.'—*Edinburgh Medical Journal.*

NEW EDITION.

Revised in accordance with the British Pharmacopœia, 1898.

Price One Shilling net.

POSOLOGICAL TABLES;
Appendix on Poisons; Index of Diseases; and Medicines arranged according to their Actions.

By WILLIAM CRAIG, M.D.,

C.M., F.R.S.E.,

Lecturer on Materia Medica, Edinburgh School of Medicine; Examiner in Materia Medica, Edinburgh University; Examiner, Royal College of Surgeons.

Being a Tabular Arrangement of all the Medicines contained in the British Pharmacopœia, with Dose, &c.

'This is a useful little book, containing a tabular arrangement of all the Pharmacopœial preparations, with their doses and methods of administration. A table on Poisons and an Index of Diseases with Appropriate Remedies are included.'—*Lancet.*

Price 1s. 6d. net.

Materia Medica Tables.

Designed for the Use of Students.

By A. HERBERT BUTCHER,

L.R.C.P., L.R.C.S. & L.M.,

Honorary Surgeon to Birkenhead Borough Hospital.

'This is a small work intended to supply a long-acknowledged want, and will be found to contain much information arranged in an admirably simple manner.'—*Publisher's Circular.*

Price 2s. 6d. net.

THE STUDENTS' HANDBOOK

OF

Diseases of the Skin.

Illustrated by Coloured Plates and Wood Engravings.

'It is clearly and systematically arranged, and the student who masters its contents will have acquired a useful general knowledge of the pathological classification, course, and methods of treatment of all but the rarest diseases of the skin.'—*Manchester Guardian.*

'It will prove of service to the young practitioner, and also to older men in country practices, whose work leaves them but little time for the study of books of greater pretensions. A number of well-executed illustrations increase the working value of the book.'—*The Publisher's Circular.*

Second Edition. Price 6d. net.

Revised in accordance with the British Pharmacopœia, 1898.

Dose Tables of Materia Medica

Containing all the Doses required for Examinations and Prescribing.

By T. HOMER, L.R.C.S., L.R.C.P.Edin.

Price 1s. 6d. in Paper Boards; or in Cloth, 2s.

THE CHILD—HOW TO NURSE IT;

Or the Management of Children and their Diseases.

BY ALEXANDER MILNE, M.D.

'Dr Milne not only describes how the Child should be managed from the hour of birth, but he notes the distinctive characteristics of all the ailments to which Children are liable, and gives instruction as to their proper treatment. A great many works have been published of late years, but there is certainly not one which is more likely to be of use to inexperienced or conscientious parents.'—*Scotsman.*

'This little work will be found to contain copious details on the management of infancy, expressed in language singularly free from technicalities.'—*Courant.*

'We heartily recommend the careful study of Dr Milne's invaluable work.'—*Ladies' Own Journal.*

'To emigrants and others who are at a distance from medical aid, we believe the book will be a "present help in time of trouble."'—*North Metropolitan.*

Price Threepence.

The Monthly Nurse:

A FEW HINTS ON NURSING.

BY H. AUBREY HUSBAND, M.B., C.M., B.Sc., &c.

'It can scarcely be said that a handbook of this kind is not required, and it is certain that a more clearly-arranged little work of the kind could not be found.'—*Scotsman.*

'A little Manual written in the simplest possible style, but containing invaluable advice and instruction for those who have to act as midwives. District visitors who should distribute copies of this pamphlet to poor mothers would save them much unnecessary misery.' —*Literary World.*

'We have very great pleasure in bearing testimony to this excellent little pamphlet. Monthly nursing, as it at present exists, is not at all in a satisfactory condition, and it is a relief to be able to get at some sensible advice and suggestions—Dr Husband supplies them here.'—*Medical Review.*

We supply the above two Works on special terms to District Visitors and Institutions using quantities for distribution.

Fourth Edition. Price 2s. net.

BOTANY NOTES

Specially adapted for Students preparing for Professional Examinations in Medicine and Science. The various divisions considered in accordance with the several University Syllabuses.

By ALEXANDER JOHNSTONE, F.G.S.,

AUTHOR OF 'ZOOLOGY NOTES,'

Lecturer on Botany, School of Medicine, Edinburgh; and Natural Science Master, Blair Lodge.

In reviewing 'Botany Notes,' and 'Botany—a Manual,' *The Lancet* says 'This little volume entitled "Botany Notes" traverses the same ground as the other book, but is rather more suitable for use on the evening preceding Exam. It is not too much to believe that, if the student does not receive material aid from the "Botany Notes" now before us, he has but small prospect of receiving assistance from any printed matter whatever.'

Price 3s. 6d. net.

ZOOLOGY NOTES

Specially adapted for Students preparing for Professional Examinations in Medicine and Science. The various divisions considered in accordance with the several University Syllabuses.

By ALEXANDER JOHNSTONE, F.G.S.,

AUTHOR OF 'BOTANY NOTES,'

Lecturer on Botany, School of Medicine, Edinburgh; and Natural Science Master, Blair Lodge.

'This useful little manual is divided into three parts. The first part is devoted to General Morphology, Histology, and Physiology, and to the Protozoa and Vermes; the second part treats of Vermes, Mollusca, and Arthropoda; and the third is occupied with Classes from Arthropoda to Man. The plan pursued is that a brief account of each class is given, then in succession the sub-classes and divisions are described, and finally a detailed account of some animal, as the anodonta amongst mollusca, and nephrops amongst crustacea. The descriptions, though short, are accurate.' —*Lancet.*

THE CATECHISM SERIES.

(NEARLY ALL THE PARTS ARE ILLUSTRATED.)

Price One Shilling net, each Part.

ANATOMY.

Part 1—Upper Extremity.
„ 2—Lower Extremity.
„ 3—Head and Neck.
Part 4—The Abdomen.
„ 5—The Thorax.
„ 6—Bones and Joints.

BOTANY.

[TWO PARTS.]

CHEMISTRY.

Part 1—Inorganic.
Part 2—Inorganic and Organic.

FORENSIC MEDICINE.

[ONE PART.]

MATERIA MEDICA.

Part 1—Mineral Waters, Foods, and Inorganic.
„ 2—Inorganic.
„ 3—Orders and Plants and Vegetable.

'The reading of these books just before going in for an examination will be of considerable use in recalling the most important points to memory.'—*Illustrated Medical News.*

'The arrangement of questions and answers seems to be admirably adapted for fixing the facts in the mind of the student, and for a busy man preparing for examination nothing could be handier than these booklets.'—*Glasgow Herald.*

THE CATECHISM SERIES.

Price One Shilling net, each Part.

SURGERY.

Part 1—Hæmorrhage—Repair—Inflammation—Suppuration—Ulceration—Mortification—Erysipelas—Wounds—Burns.
" 2—Fractures and Dislocations of the Upper Extremity.
" 3—Fractures and Dislocations of the Lower Extremity—Diseases of Blood-Vessels and Lymphatics.
" 4—Tumours—Diseases of Bones—Diseases of Joints.
" 5—Injuries and Diseases of Muscles and Nerves (Club-Foot, Whitlow, Ganglion, &c.)—Venereal Diseases.—Regional Surgery: Injuries and Diseases of the Head.
" 6—Regional Surgery: Face, Nose, Mouth, and Tongue; Œsophagus, Hare-Lip, Neck, Tracheotomy, &c.; Thorax and Mamma.
" 7—Regional Surgery: Vertebral Column, Abdomen Rectum, Urinary and Genital Organs, &c.

SURGICAL ANATOMY and OPERATIONS.

[TWO PARTS.]

TOXICOLOGY.

[ONE PART.]

ZOOLOGY.

Part 1—Invertebrata. Part 2—Vertebrata.

'They cannot fail to be popular with students.'—*Hospital Gazette.*

'We recommend these little books to students, for we feel sure they will help to refresh the memory, specially if about to pass an "exam."'—*Journal of Microscopy.*

'We must commend the general accuracy and clearness of the descriptions.'—*Glasgow Medical Journal.*

THE CATECHISM SERIES.

Price 1s. net, each Part.

Examination Questions

IN

Practice of Medicine

WITH ANSWERS.

Part 1.—GENERAL DISEASES.
Part 2.—SKIN DISEASES.
Part 3.—FEVERS.

Adapted for those who are Preparing themselves for the Final Examination.

'These little books are very valuable in refreshing the mind of the student.'—*Daily Free Press.*

[*Other Parts will follow.*]

THE CATECHISM SERIES.

Price 2s. 6d. net, each Part.

PATHOLOGY.

Part 1. GENERAL. Part 2. SPECIAL.

Price 2s. 6d. net. Illustrated.

PHYSICAL TRAINING:

ITS THEORY AND PRACTICE.

Being an Elementary Treatise on the necessity and effects of exercise.

By H. RIPPON SEYMOUR

Gymnastic and Fencing Master, George Watson's College, Edinburgh.

With an introduction by
WILLIAM TAYLOR, M.D., F.R.C.P.E.

'It gives so much instruction in anatomy and physiology as is necessary for an intelligent understanding of the useful series of exercises it enumerates, and sets forth in a clear and interesting way the advantages that come of a scientific study of physical culture.'—*Scotsman.*

'I can heartily recommend this book to all athletes. It will well repay perusal.'—*The Athletic Times.*

'This is a very praiseworthy attempt to connect the theoretical and practical physical training in one book, and it easily succeeds in being both concise and intelligible.'—*Publishers' Circular.*

Second Edition, price 12s. 6d.

THE
Principles and Practice of Midwifery

By ALEXANDER MILNE, M.D.,

Ex-Vice-President of the Edinburgh Obstetrical Society.

'The very favourable reception accorded to the first edition was well merited, the work being thoroughly practical, and very readable—not too diffuse nor exhaustive, yet containing sufficient details for all examination purposes. The Second Edition has been carefully revised, and such additions made as were rendered necessary through recent advances in the obstetric art. We have no doubt that the Second Edition of Dr Milne's Manual will be more popular with medical students than the first.'—*Student's Journal.*

'Dr Milne has contrived to condense a great amount of obstetric doctrine, both physiological and pathological, into his book.—*Lancet.*

'I estimate highly the thought, the labour, and the courage expended in the work.'—Dr J. Matthews Duncan, London.

'A very excellent and comprehensive Manual.'—Professor Graily Hewitt, London.

'An admirable digest of the subject.'—Professor A. R. Simpson, Edinburgh.

Price 4s. net.

YELLOW FEVER

By JAMES W. MARTIN, M.D.

ILLUSTRATED.

'It gives a very clear and concise account of the chief facts about yellow fever and its congeners among the malarial fevers of the tropics, and discusses its etiology and treatment at some length.'—*Lancet.*

TEMPERATURE CHARTS:

Suitable for Hospitals, Dispensaries, or Private Cases.

SPECIMEN COPIES FREE ON RECEIPT OF TWO STAMPS.

Special Sizes or Kinds produced to order at Moderate Rates.

Third Edition. Greatly Enlarged and Improved.

Price One Shilling net.

THE URINE

In Health and in Disease, together with its Chemical Examination.

BY H. AUBREY HUSBAND, M.B., C.M.,
B.Sc., F.R.C.S.E., etc.,

Formerly one of the Medical Officers of the Royal Dispensary, Edinburgh.
Author of the 'Students' Handbook of the Practice of Medicine,'
'Students' Pocket Prescriber,' &c.

WITH NUMEROUS PLATES.

Price 1s. 6d. Illustrated by 26 Woodcuts.

THE PHYSIOLOGY OF THE EYE,

With an Introductory Chapter on Optics.

BY H. CAMPBELL, M.B.,
B.Sc. Lond., M.R.C.P. Lond., M.R.C.S. Eng.

New Edition. Revised and Greatly Enlarged.

Price 1s. 6d. net.

The Students' Pocket Prescriber

BY H. AUBREY HUSBAND, M.B., C.M.,
B.Sc., etc.,

Author of 'The Students' Handbook of the Practice of Medicine,' 'The Urine, in Health and in Disease,' etc.

This Book is intended for Students and young Practitioners, and contains much useful information. The Prescriptions are arranged thus:—Alteratives, Antacids, Antispasmodics, Aperients, Cathartics, and Anthelmintics, Astringents, Caustics and Counter Irritants, Diaphoretics and Diuretics, Emetics and Expectorants, Gargles and Inhalations, Lotions, Liniments and Ointments, Narcotics and Sedatives, Refrigerants and Salines, Stimulants, Tonics, and Uterine Therapeutics; with an Index to the Prescriptions.

Price One Shilling net.

Puberty and the Change of Life.

A BOOK FOR WOMEN.

By J. C. WEBSTER, M.D., M.R.C.P.E.,

Assistant to the Professor of Midwifery and Diseases of Women in the University of Edinburgh.

'It should be read with profit by both mothers and daughters; its teachings are sound, and always on the side of that educated common sense which is but another name for science itself. The author's remarks on the evils attending the educational competition among girls deserve the attention of mothers especially. The health directions set forth in this manual, if followed out, cannot fail to avert much of the preventible pain and misery so characteristic of our modern civilisation.'—*Glasgow Herald.*

'The book is well written; some parts of it unquestionably are calculated to do good to suffering womankind.'—*Birmingham Medical Review.*

Price One Shilling and Sixpence net.

DISEASES OF THE EYE.

A Manual for Senior Students and Young Practitioners.

By J. ARTHUR KEMPE, F.R.C.S.,

Late Senior Demonstrator of Anatomy, Surgeons' Hall, Edinburgh.

USED IN THE EDINBURGH MEDICAL SCHOOLS.

'It is a book for those who now require to show a knowledge of the more common eye diseases before passing the final examinations. The arrangement is good, the information explicit, and after the student is done with it as an examination guide he will find it very useful in general practice.'—*Glasgow Herald.*

'This book gives a pithy digest of the symptoms and diagnosis of the commonest diseases of the eye with practical hints as to treatment.'—*Daily Free Press.*

Price Sixpence net.

Case-Taking Book for Hospitals;

With Hints on Case-Taking, Normal and Abnormal Temperatures, Weight of Adult Organs, etc.

The Synopsis used in the Royal Infirmary, Edinburgh.

Price One Shilling net.

REFERENCES TO NERVES:

Being Tabular Views of the Motor Nerves to Muscles, the Nervous Supply of the Principal Articulations and of the Skin, the Deep and Superficial Origins of the Cranial Nerves, etc.; with the most important effects following Solution of Continuity of Nerves.

INVALUABLE TO THE ANATOMICAL STUDENT.

Price One Shilling net.

MORPHOLOGY OF THE VERTEBRATA;

DOG-FISH, COD, PIGEON, AND RABBIT;

WITH DEVELOPMENT OF THE DOG-FISH.

BY D. KNIGHT,

OF THE MUSEUM OF SCIENCE AND ART, EDINBURGH.

ILLUSTRATED.

Part I.—Price Sixpence net.

ATLAS OF CHEMISTRY:

Inorganic and Organic,

Designed for the use of Medical and Science Students, and Science Teachers in Schools and Evening Classes.

BY VICTOR V. BRANFORD, M.A.

Third Edition, Revised, price Sixpence net.

HANDBOOK OF ANIMAL CLASSIFICATION

For the Use of Medical and Science Students.

BY VICTOR V. BRANFORD, M.A.

Price One Penny.

ALCOHOL: Its Action on the Body in Health.

BY ALEXANDER WALKER, M.D.,

Late Medical Officer of Health, Putney.

Price Two Shillings net.

Handbook of Deductive Logic:

Designed specially for the use of Medical Students preparing for their Preliminary Examination.

By Rev. DUNCAN STEWART, D.D.,

Minister of Spott, Dunbar.

'Brevity and simplicity are the cardinal virtues in this book, because it has been designed specially for the use of young men intending to study medicine and preparing for their Preliminary Examination. A new feature in it is that not a few of the illustrations are medical, but the fundamental principles of logic being the same the world over, it is adapted to any other class of students. Brevity has been aimed at, but not to the detriment of perspicuity, and whatever help has been had from other writers on logic is mainly due to Jevons. As the work has been confessedly prepared for a purpose, the student is recommended not to pass over any of the questions on the several sections given at the end of the book till he is able to answer them. The questions and exercises are numerous and searching, and fitted to acquaint the student with the likely subjects of examination.'—*Glasgow Herald.*

Price One Shilling net.

A Manual of Dental Education

With some General Notes upon the Modern Curriculum of the Dental Student.

By ARTHUR TURNER,

Licentiate in Dental Surgery of the Royal College of Surgeons, Edinburgh; Dental Surgeon to the Buckinghamshire General Infirmary; Fellow of the Chemical Society.

'We can recommend it as affording much valuable information to those who think of studying dentistry.'—*Manchester Guardian.*

This is an epitomized guide for those about to enter upon the study of Dental Surgery with a view of obtaining the diploma, and will be found useful.'—*Edinburgh Medical Journal.*

'A manual such as we have now before us will be found most useful for intending dental students. It is a welcome and useful guide.'—*Glasgow Herald.*

NOW READY.

Second Edition, price 2s. 6d. net; post free, 2s. 10d.

Walter Crighton

OR

Reminiscences of George Heriot's Hospital.

By JAMIESON BAILLIE.

PROFUSELY ILLUSTRATED.

With Portraits, Sketches, and Wash Drawings

By J. R. Abercromby, and Others.

'The descriptions are exceedingly good. . . . Such an institution as George Heriot's Hospital with all its ancient customs lent itself to a book of this kind, and this volume is one of the best books of school life we have seen.'—*Edinburgh Evening News.*

NEARLY READY.

Memories of a Modern Monk

OR

Reminiscences of George Heriot's Hospital.

By C. B. GUNN, M.D.Edin.,

With a Descriptive and Critical Account of the Architectural Features of the Hospital by

Hippolyte J. Blanc, R.S.A., F.R.I.B.A.,

And a Short Sketch of the late Dr Bedford (House Governor)

By his son, Captain Charles Henry Bedford,
D.Sc., M.D.Edin., M.R.C.S.Eng.;
Indian Medical Service; Professor of Chemistry, Calcutta University, &c.

PROFUSELY ILLUSTRATED.

ILLUSTRATED WITH OVER 100 CHARACTERISTIC SKETCHES & PEN & INK PORTRAITS.

Price 2s. 6d. net.

[An EDITION DE LUXE, printed on Dutch hand-made paper and bound in half-morocco, price 5s. net—only 100 copies printed.]

CHEAP EDITION—(Words only)—Price 3d.

The Awful and Ethical Allegory OF DEUTERONOMY SMITH

Or, The Life History of a Medical Student.

'This excellent series of University sketches are a sort of Pilgrim's Progress of Edinburgh University studentdom, recording the gradual development of the medical, from the crude and chrysalis stage to that of his full-grown and perfect butterfly existence, and the moral of the tale lies in this, that it is of universal application; and the medical of to-day can read in it lessons for himself just as sound as the generation for whom it was written. The humour of the narrative lies largely in this, that it is written in the Biblical style, which gives to the incidents related a *naivete* that is often irresistible.'—*College Column.*

Crown 8vo., 411 pp., price 3s. 6d.

CLAUDE GARTON

A Story of Dunburgh Student Life.

BY THOMAS J. HENRY, F.R.C.S.E.,

AUTHOR OF 'DEUTERONOMY SMITH.'

'This highly interesting story by the author of "Deuteronomy Smith," itself an excellent testimonial, deals with the life and adventures of a medical student. We are introduced to many whose names are curiously familiar. The story is interestingly written, and will be read with avidity by Edinburgh men in particular and medical students in general.'—*The Student.*

'Mr Henry has given us a very striking book, even more powerful, in its way, than George Moore's masterpiece, "Esther Waters." It describes the experiences of a medical student in Edinburgh, from his entry to the day when he is "capped" for his diploma, and each scene stands out distinct and clear, a triumph of detailed and effective realism. To read these chapters is never to forget them; it is as though we had been present at the scenes described. Conan Doyle has done nothing better. Mr Henry has done for the Medical School of Edinburgh what Tom Hughes did for Rugby.'—*Sheffield Daily Telegraph.*

'The story is one of extraordinary fascination and dramatic power.'—*St James Gazette.*

PUBLISHED ANNUALLY.

Crown 8vo, price 2s.; by post, 2s. 3d.

Medical School Calendar

FOR SCOTLAND

Is the only book that contains all the information required for Graduation in Medicine, Surgery, and Public Health at Edinburgh, Aberdeen, Glasgow, and St Andrews Universities; Fellowship, Licence, and Licence in Dental Surgery of the Royal College of Surgeons; Fellowship, Membership, and Licence of Royal College of Physicians; Faculty of Physicians and Surgeons of Glasgow; Triple Qualification of Scottish Conjoint Board; Classes in the Universities and Schools of Medicine, with short Syllabus of each Class; Classes and Schools for Women; Dispensaries, Students' Societies, &c.; also the

Preliminary and Professional Examination Questions

set by the Universities, Educational Institute of Scotland, Royal College of Surgeons, Royal College of Physicians, and the Triple Board, for several years past.

* * *

'It is full of the most useful information. It ought to be a most valuable work of reference for the medical student.'—*Edinburgh Medical Journal.*

'Much time and money may be saved by a careful perusal of this book.'—*Medical Press and Circular.*

'The Medical School Calendar maintains its reputation for comprehensiveness and accuracy of information.'—*Scotsman.*

The book is crammed with information on all subjects which a student requires to know in piloting his way through a course of medical study. A page of well-compiled advice to the student as to the most advantageous method of study is given. A glance through the pages of the Calendar shows the extensive provision for medical education in Edinburgh, and is itself the most convincing argument for the necessity of the publication.'—*Edinburgh Evening News.*