Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

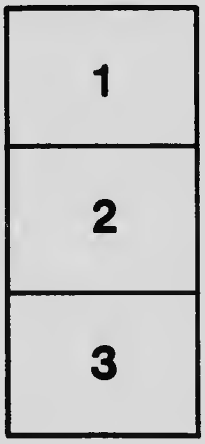
- ☐ Coloured covers / Couverture de couleur
- ☐ Covers damaged / Couverture endommagée
- ☐ Covers restored and/or laminated / Couverture restaurée et/ou pelliculée
- ☐ Cover title missing / Le titre de couverture manque
- ☐ Coloured maps / Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black) / Encre de couleur (i.e. autre que bleue ou noire)
- ☑ Coloured plates and/or illustrations / Planches et/ou illustrations en couleur
- ☐ Bound with other material / Relié avec d'autres documents
- ☐ Only edition available / Seule édition disponible
- ☐ Tight binding may cause shadows or distortion along interior margin / La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure.
- ☐ Blank leaves added during restorations may appear within the text. Whenever possible, these have been omitted from filming / Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- ☐ Additional comments / Commentaires supplémentaires:

- ☐ Coloured pages / Pages de couleur
- ☐ Pages damaged / Pages endommagées
- ☐ Pages restored and/or laminated / Pages restaurées et/ou pelliculées
- ☑ Pages discoloured, stained or foxed / Pages décolorées, tachetées ou piquées
- ☐ Pages detached / Pages détachées
- ☑ Showthrough / Transparence
- ☐ Quality of print varies / Qualité inégale de l'impression
- ☐ Includes supplementary material / Comprend du matériel supplémentaire
- ☐ Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image / Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.
- ☐ Opposing pages with varying colouration or discolourations are filmed twice to ensure the best possible image / Les pages s'opposant ayant des colorations variables ou des décolorations sont filmées deux fois afin d'obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below /
Ce document est filmé au taux de réduction indiqué ci-dessous.

10x		14x		18x		22x		26x		30x	
	12x		16x		20x	✓	24x		28x		32x

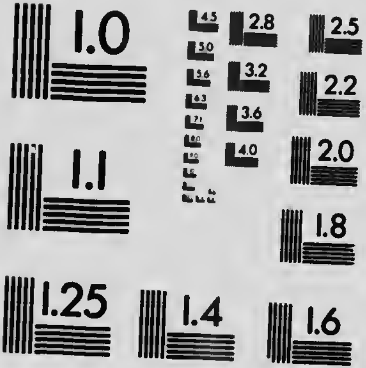

1
2
3


1
2
3


1
2
3
4
5
6

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



Practical or Applied Hygiene

AND

Descriptive Catalogue of Hygiene Museum

BY

T. A. STARKEY, M.D., D.P.H., (LOND.), ETC.
FELLOW ROYAL SAN. INST.
PROF. HYGIENE McGILL UNIVERSITY

McGILL UNIVERSITY

JANUARY 1915

MONTREAL:
DESBARATS PRINTING COMPANY, LIMITED
23 BEAVER HALL HILL

PREFACE

My object in writing this book is to bring before the student of hygiene the practical application of the important theoretical principles underlying the science.

No attempt has been made to go beyond this idea, and the work is not intended in any sense to supplant regular treatises on the subject, but rather to be considered as supplementary.

As the Museum is fairly complete, and contains either actual specimens, or working models, of everything relating to practical hygiene, it was thought advisable to incorporate with the text the Descriptive Catalogue of the Museum.

As regards the Museum it will be noted that in the choice of the various exhibits, the chief idea has been always to make each specimen a "type" of a class. This has been done for two reasons—first, in order to keep the collection within reasonable limits, and, secondly, to avoid repetition as far as possible.

This method of dealing with "types" of classes, will, I think, prove of more value to the student of hygiene, than the individual consideration of numberless specimens of each class—for in studying the "type," special attention must be paid to the "working principles" of the class—which principles can be applied to any particular specimen.

In this way, I think, a more lasting and serviceable impression is created in the mind, than by a cursory examination of a multitude of specimens, all exhibiting the same working principles with slight modification in each case.

With this in view, explanatory diagrams of the more important, or complicated, apparatus have been enclosed in the catalogue.

The Decimal System has been adopted throughout in classifying, and numbering, the exhibits.

The different sections of the Museum are indicated by large numbers, corresponding to the sectional numbers in the catalogue.

My best thanks are due to Dr. R. St. J. Macdonald for the kindly, and extensive assistance, which he has given in the work.

T. A. STARKEY.

HYGIENE DEPARTMENT,
McGILL UNIVERSITY,
MONTREAL.

January 1st, 1915.

SECTION I—DISINFECTANTS.

As regards the practical disinfection of a room, and its contents, particular attention must be paid to the nature of the internal finish of the room, and also the materials of which the various objects in the room consist—that is, furniture, etc. ; this is very essential because such knowledge directly governs the choice of the disinfectant to be used.

The following hints may be found useful in carrying out disinfection of a room, and its contents. Everything which is of no value, and can be burnt, is best destroyed directly by fire. All objects which can be boiled, or steamed, (e.g. culinary utensils, bed clothes, and such like) should be treated by these methods of disinfection. Boiling is a form of disinfection which can usually be carried out on the premises ; an application of steam involves the use of some form of steam sterilizer, and as this is usually a Municipal concern, the articles to be disinfected by this means must necessarily be transported to the Municipal plant. For this purpose all such articles should be freely sprinkled with Carbolic Acid solution, 1 in 20, or Izal 1 in 100, and wrapt in tarpaulin. (Exhibit 1.91.) This is to prevent the spread of infection by the dissemination of dust and germs from the infected articles during transit. The usual things treated in this manner are bedding, mattresses, and certain articles of clothing. The remaining articles in the room, together with the room itself, now call for treatment. I don't think there is any question about the superiority of the liquid disinfectants when they can be applied ; they are certainly more thorough, and penetrate better than a gaseous disinfectant ; for this reason I always recommend the use of a liquid disinfectant wherever it is possible. The nature of the surface, and materials, to which the liquid disinfectant is to be applied must be such as will not be injured by the liquid.

The matter resolves itself into walls, floors, and woodwork composing articles of furniture, (like chairs, tables and bedsteads).

The liquid disinfectants in common use are a solution of Perchloride of Mercury (1 in 1000), Carbolic Acid solution (1 in 20), and Izal (1 in 60). Of these Carbolic Acid and Izal are much to be preferred, because they will stick to greasy surfaces, whereas Mercury solution will not adhere. All articles of furniture, which are handled by people, necessarily become greasy on their surface.

The various objects, having become wetted with the liquid disinfectant, should be allowed to remain untouched for about twelve hours. The remaining objects in the room which do not allow, by their texture of the application of the liquid, must be treated by some form of gaseous disinfectant. These articles usually consist of carpets, tapestries, various ornaments, pictures, and certain articles of fine clothing.

The only gas which we need consider, from a practical standpoint, is Formaldehyde.

Before applying the gas however, the room must be prepared to receive it, as we wish to attain a certain concentration of the gas in the air of the room. We must therefore render the room as nearly air-tight as possible ; all cracks and crevices in the floor, walls, around windows, and doorways, must be plastered up with strips of paper, 2 inches wide, stuck on with common flour paste—the various articles must be spread out, such things as bundles of clothing, etc., must be freely opened up, and are usually hung over lines, so that the gaseous disinf[illegible] can be brought into contact with all surfaces. It is necessary to observe this precaution, because as mentioned before, these gaseous disinfectants have very little, or no penetrating power, and it can be realized how easily imperfect disinfection may arise when these precautions are not observed.

It is for this reason that I recommend so strongly a liquid disinfectant, as giving better results all round, and insuring a more perfect disinfection; for any individual can see at a glance if a surface has been dosed with a liquid disinfectant, whereas in the case of a gaseous disinfectant no one can tell by the ordinary sense of sight, whether or not a surface has escaped disinfection. It may be as well to note that all those places which have been plastered over with the paper strips are of such a nature as to allow of an application of a liquid disinfectant; and it should always be applied before the paper is pasted on, otherwise an infected surface covered up with a pasted strip is protected from the gaseous disinfectant, and when the paper is stripped off again, the underlying surface remains still infectious.

As regards the generation of the Formaldehyde gas, two methods are in popular favour:—

The first, and better method, is by placing in a bowl, or regular receptacle sold for this purpose (Exhibit No. 1.39), a certain quantity of Permanganate of Potash crystals, and then adding a definite quantity of Formalin solution; a double chemical decomposition takes place with a rapid liberation of Formaldehyde gas. Of course as soon as the operator has completed the mixture, he will have to leave the room quickly, and paste up the door through which he has made his exit.

In the second method, the gas is generated by boiling the Formalin solution in a copper boiler (Exhibit No. 1.36); the gas, and accompanying steam, are conducted through a rubber tube leading from the boiler; this tubing can be passed through the keyhole of a door, so that the boiling process can be controlled outside the room. The drawback to this method is that where the room to be disinfected is very large, it takes a long time before the requisite strength of Formaldehyde gas can be obtained in the air of the room; and if the room be not air-tight, one may go on indefinitely introducing the gas into the room without it reaching the requisite strength—resulting in imperfect disinfection.

The requisite proportions for the generation of Formaldehyde gas, are, by the first method, 1 pint of Formalin to 1 lb. of Permanganate crystals, and by the second method, 1 pt. of Formalin for every thousand cubic feet of space in the room.

Although Formaldehyde is the gaseous disinfectant most commonly used, still there are two others of which mention must be made, viz., Chlorine and Sulphur Dioxide.

In former years before the introduction of Formaldehyde these were the only two gaseous disinfectants known. They are very powerful germicides when properly applied, and undoubtedly have their uses, even at the present day, where the surroundings will permit of their application. The great disadvantage of these two gases is their powerful bleaching properties, and their corrosive action on certain metals. For this reason their use is practically precluded in disinfecting ordinary living rooms; but for such places as out-houses, dairies, milk shops, stables, etc., these gases are eminently suitable—and besides, they are cheap and easily applied. The rooms must be prepared, in the sense that they must be rendered as air-tight as possible, so as to concentrate the gas in the atmosphere. In the case of both these gases, moisture must be present in the air of the room, otherwise no disinfection takes place. The necessary amount of moisture is easily obtained by boiling water in a kettle, or suitable pan, placed in the room; the steam issuing from the kettle permeates the air of the room, and when the walls appear damp, the generation of steam may be stopped, as quite sufficient water vapour will then be present.

Chlorine is generated by placing a definite quantity of Chloride of Lime in a bowl, covering it with a little water, and then adding crude Hydrochloric Acid, when the gas is produced in large quantities. The operator then retires quickly from the room, pasting up the door behind him. The proportions are 1 lb. of Chloride of Lime and 1 pint of Hydrochloric Acid for every thousand cubic feet of space. The disinfecting action of Chlorine is due to the formation of nascent Oxygen when Chlorine comes into contact with water vapour.

Sulphur Dioxide is obtained from the burning of Sulphur, made into blocks with wicks for this purpose (Exhibit No. 1.21). It may also be obtained from liquid Sulphur Dioxide —for when this liquid is placed in an open vessel it rapidly volatalises into the gaseous state. This latter method is by far the better of the two, because it not only involves less trouble, but it also avoids the risk of fire, which is always present when the first method is employed. The strength in which the sulphur is used is 1 lb. of Sulphur, or 1 pint of the liquid gas, for every thousand cubic feet of space in the room. The disinfecting action is due to the combination of Sulphur Dioxide gas with moisture forming Sulphurous Acid.

A reference has already been made to the use of Steam Sterilizers.

Besides the actual manipulation of the machines, details of which are given in subsequent pages, it is essential to understand fully various physical facts relating to the action of steam in its different forms.

Steam may be either Current or Confined, that is to say, it may be allowed to flow freely from the boiling water through the disinfection chamber quite devoid of any added pressure, this is termed Current Steam,—or it may be Confined in the chamber under pressure.

Under ordinary atmospheric pressure, water boils at 100° Cent., and the steam arising from that water will also be at 100° Cent.

The boiling point of water may be raised either by adding some mineral salt, thereby increasing the Specific Gravity, or by applying pressure.

Calcium Chloride is the salt most commonly used, a 2% solution possesses a boiling point of about 105° Cent., but obviously a limit to this method of raising the boiling point is soon reached ; the application of pressure is much more preferable in practice, on account of the ease with which varying ranges of temperature can be obtained.

Under 5 lbs. pressure water boils at 109° Cent.
" 10 " " " " 115° "
" 15 " " " " 121° "

There is likewise another important point to note,—whatever the boiling point of water may be, the temperature of the steam arising therefrom is the same, and in all such cases the steam is said to be Saturated.

Now if this Saturated Steam be introduced to a body of lower temperature, even though it be only one or two degrees lower, it will at once condense, and at the moment of condensation will give up its Latent Heat, which is largely imparted to the cooler body.

Again, if steam from boiling water be conducted through some kind of pipe which can be heated externally, the temperature of the steam contained in the pipe, can be raised to any temperature ; but steam so treated no longer behaves as ordinary steam, it is really a dry gas, and it will not condense until its temperature is lowered below that of the boiling point of water from which it was originally obtained. Such dry steam is known as Superheated Steam.

It has been found that Saturated Steam is far more efficacious than Superheated Steam for disinfection work, and this depends upon the fact that the latter has no penetrative power when applied to thick bundles of clothes, etc.

The explanation of this penetrative power possessed by Saturated Steam is briefly as follows:—when saturated steam is introduced to a bundle of clothing of lower temperature than itself, it penetrates the outer layers for a short distance, and at once condenses, imparting its latent heat to the outer layers. At the moment of condensation a vacuum is formed, and more steam rushes in to occupy the place of the condensed portion ; this in turn penetrates a deeper layer of the bundle, there to undergo the same condensation process ; and so on, in successive stages, penetrating deeper and deeper into the bundle until the centre is reached, when disinfection is completed.

1.1 Disinfectants.

A disinfectant, or germicide, is an agent which is capable of killing or destroying micro-organisms, especially the pathogenic varieties. To attain this result the disinfectant must be applied in a certain definite strength ; when used in weaker proportions it may only inhibit the growth, and not actually kill the organism.

A complete list of disinfectants would include, besides those enumerated below, such agencies as fire, heat (moist and dry), sunlight, and oxygen. The subjoined list, however, comprises all the more common disinfectants in ordinary use, and of these Carbolic Acid, Perchloride of Mercury, Sulphur, Chlorine, Iodoform, Potassium Permanganate, and Formalin, are most employed, and the strengths are given in which they may be relied upon to disinfect completely all organisms, both spore-bearing and non-spore-bearing.

Carbolic Acid, Perchloride of Mercury, Sulphur, Chlorine, and Formalin, are described more in detail later on.

1.11 NATURAL DISINFECTANTS.

1.111	Turpentine.	Applied pure.
1.112	Eucalyptus.	
1.113	Eucalyptol.	
1.114	Camphor.	

1.12 COAL TAR PRODUCTS.

1.121	Carbolic Acid, 5%.	
1.122	Izal, 2%.	
1.123	Creosol, 4%.	
1.124	Salicylic Acid.	
1.125	Thymol.	Solution in Alcohol, 1%.
1.126	Menthol.	
1.127	Resorcin.	
1.128	Iodoform.	Applied pure.
1.129	Formochlorol.	Formalin and Calcium Chloride.
1.120	Formalin, 3-10% solution.	

1.13 INORGANIC DISINFECTANTS.

- **1.131** Lime. (1 Slacked Lime, to Water, 4 parts.)
- **1.131a** Chlorinated Lime, 5%.
- **1.132** Boric Acid, 5%.
- **1.133** Borax.
- **1.134** Chromic Acid, 1%.
- **1.135** Corrosive Sublimate, 1%.
- **1.136** Zinc Sulphate.
- **1.137** Iron Sulphate.
- **1.138** Copper Sulphate.
- **1.139** Potassium Permanganate, 1%.
- **1.130** Sulphur. (SO_2 1%.)

1.14 PATENT DISINFECTANTS.

- **1.141** Specimens of Jeye's patent disinfecting fluids and soaps.
- **1.142** Glyco-Thymoline.

1.2 Disinfectants Commonly Used.

1.20 LIQUID SULPHUR.

1.21 SPECIMENS OF SULPHUR BLOCKS.

1.22 SPECIMEN OF CHLORINATED LIME

ordinarily used for the generation of Chlorine Gas. This is made up in 1 lb. tins for convenience.

1.23 SPECIMEN OF FORMALIN.

This is a 40% solution of Formaldehyde in water. "Formalin" is the technical or trade name for this solution.

It deteriorates rather quickly, and after being kept a month or two usually contains about 33-36% of Formaldehyde.

The Formaldehyde Gas is generated from this in one of the special generators.

1.24 SPECIMEN OF PARAFORM TABLOIDS.

This is a polymer of Formaldehyde. Chemically, it consists of three molecules of Formaldehyde, and can be obtained from a solution of Formaldehyde by the addition of dilute Sulphuric Acid.

When heated it is dissociated again into Formaldehyde gas.

This is one of the original methods of generating Formaldehyde.

1.25 SPECIMEN OF CARBOLIC ACID.

1.26 IZAL.

1.27 PERCHLORIDE OF MERCURY.

1.3 Formalin Machines.

1.31 HAND SPRAYING MACHINES.

A portable machine for spraying disinfecting solutions, such as Formalin, or Carbolic Acid, upon walls, etc.

This machine is the one usually employed by municipalities.

1.32 HAND SPRAYING MACHINE.

This is on the same principal as No. 1.31, but a cheaper variety, being made of common tin.

1.33 HAND SPRAY.

A small hand spray for Formalin.

1.34 ALFORMANT LAMP.

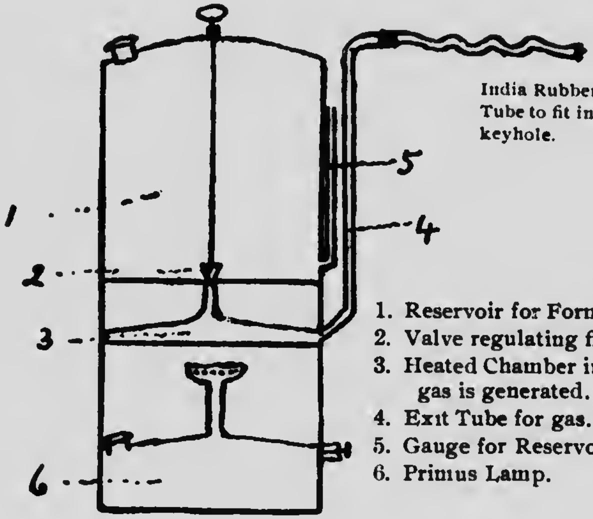
This Lamp is for the use of Paraform Tabloids. The Tabloids are placed in the iron cup above the spirit lamp; the heat from this causes the Formaldehyde Gas to be evolved from the Tabloids.

A minimum of 20 Tabloids to the thousand cubic feet of space is to be recommended.

1.35 FORMALDEHYDE GENERATOR.

The Formalin Solution is placed in the copper boiler above ; the heat is supplied from a spirit lamp or primus lamp, the gas coming off through the funnel-shaped nozzle when the solution boils.

1.36 FORMALDEHYDE GENERATOR.



India Rubber Tube to fit into keyhole.

1. Reservoir for Formalin.
2. Valve regulating flow.
3. Heated Chamber in which gas is generated.
4. Exit Tube for gas.
5. Gauge for Reservoir.
6. Primus Lamp.

The construction is practically the same as No. 1.35, but, in addition there is a long India rubber tube attached to the gas nozzle, so that the apparatus can be used outside the room.

The India rubber tube is inserted through the keyhole, or some other suitable aperture, and the gas, as it is evolved, is conducted into the room by means of the tubing. This is an advantage over the preceding generators, for the reason that the whole operation can be watched and regulated from the outside, whereas, in the preceding ones, the lamps are placed in the room, and, after having been started, are left there without further supervision.

1.37 Formaldehyde Generator.

This has a tubular boiler in place of the simple copper boiler, as in the preceding specimens.

1.38 Robinson's Formalin Lamp.

This lamp is for use with Methyl Alcohol.

1.39 Formaldehyde Generator.

Gas produced by mixing Formalin and Permanganate of Potash.

✓ **1.30** Trillat's Formo-Chlorol Generator.

This machine is in all respects similar to an ordinary autoclave. The Formalin Solution is placed in the inner chamber, quantities recommended being not less than a litre, and not more than three and a half litres. The cover is screwed down and heat applied below by means of the ordinary primus lamp.

When the manometer registers a pressure of three atmospheres, the stop cock is slowly turned on. The temperature at this pressure is generally about 135°C., and it is not desirable to take it beyond this. The gas which comes through the stop cock can be conducted into the room through a hole, or some other aperture, by means of an India rubber pipe.

1.4 Steam Disinfecting Apparatus.

1.41 Simple Apparatus for Pasteurizing Milk.

Water is placed in the can to a depth of about three inches ; the bottles, after having been perfectly cleansed, are filled with milk to within about an inch of the neck. One bottle is filled with water and a thermometer inserted through the cover so that the temperature of the water in the bottle can be registered. The bottles are then placed in the rack, the corks being lightly inserted to allow of the escape of steam, the whole placed in the water and the cover adjusted. Heat is applied below, and the temperature of the milk inside the bottles is carried to from 70-80°C. for 15-20 minutes. It is then allowed to cool down.

The cover is then taken off, and the corks quickly pressed tight into the necks of the bottles.

If necessary this procedure can be repeated at the end of 12 or 24 hours so as to give the milk a double pasteurization, but this is not commonly practised.

1.42 RECK'S STEAM DISINFECTOR.

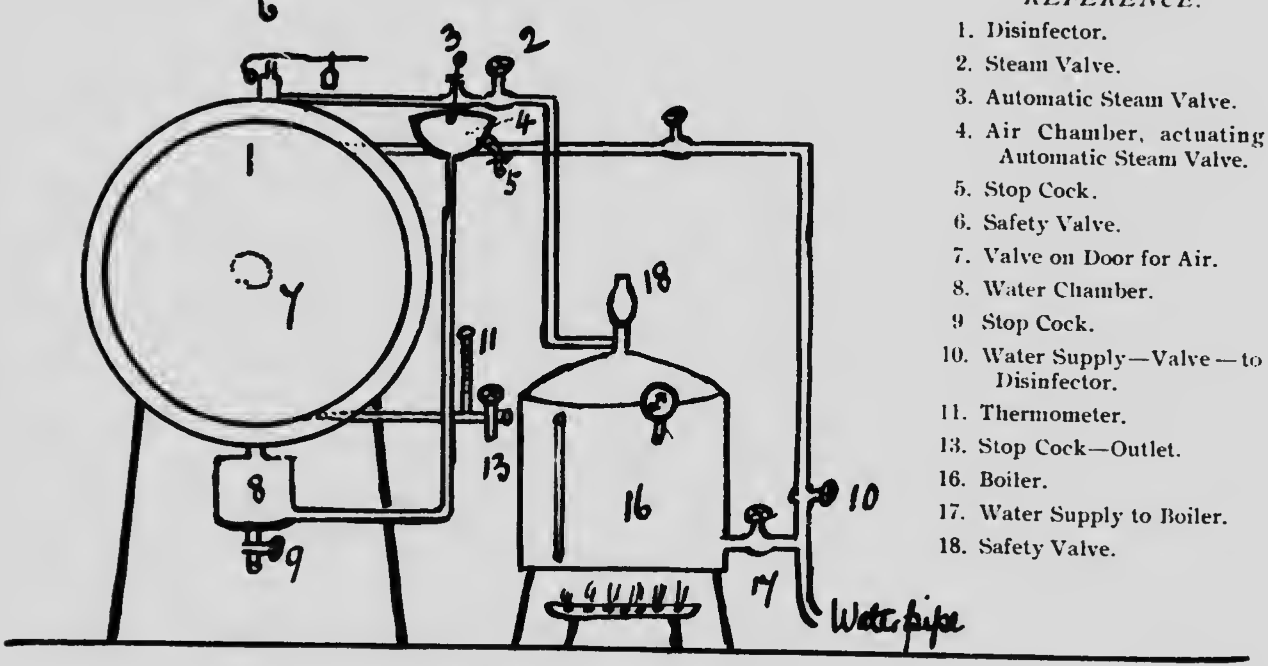
To work this apparatus the first step is to warm up the chamber. This is done by opening the outlet (13) and then admitting the steam slowly through the valve (2).

The next step is, to place the articles to be disinfected inside the chamber on a rack, spreading them out so that the steam can penetrate thoroughly. It is now closed and steam valve (2) opened slowly, the outlet valve (13) being kept fully open; the little air valve (5) is also opened.

The steam is allowed to pass through until all the air from the inside of the chamber has been completely driven out. When this is accomplished the thermometer (11) will indicate 100°C. The valve (13) is now closed and the pressure begins to rise. This pressure forces the water from the chamber (8) into the ball (4), and when the water begins to run out of the little stop cock (5) the latter must be closed.

This ball is the reducing valve which automatically shuts off the steam, when the pressure has reached two-thirds of a pound. The process is allowed to go on for 20 minutes. The steam valve (2) is then shut off, the outlet (13) opened, and cold water admitted by opening the tap (10). This cold water condenses the steam in the disinfector.

The delivery door of the disinfector is now opened, the carriage drawn out, and emptied. The different articles must be shaken in the open air to remove the steam and to dry them.



REFERENCE.

1. Disinfector.
2. Steam Valve.
3. Automatic Steam Valve.
4. Air Chamber, actuating Automatic Steam Valve.
5. Stop Cock.
6. Safety Valve.
7. Valve on Door for Air.
8. Water Chamber.
9 Stop Cock.
10. Water Supply—Valve—to Disinfector.
11. Thermometer.
13. Stop Cock—Outlet.
16. Boiler.
17. Water Supply to Boiler.
18. Safety Valve.

1.42. RECK'S STEAM DISINFECTOR.

The diagram of the steam boiler explains itself, but, before commencing the disinfection, the pressure guage should always record 6 lbs.

1.43 Model of Kny's Steam Disinfector.

This is in full working order with Formalin Injector.

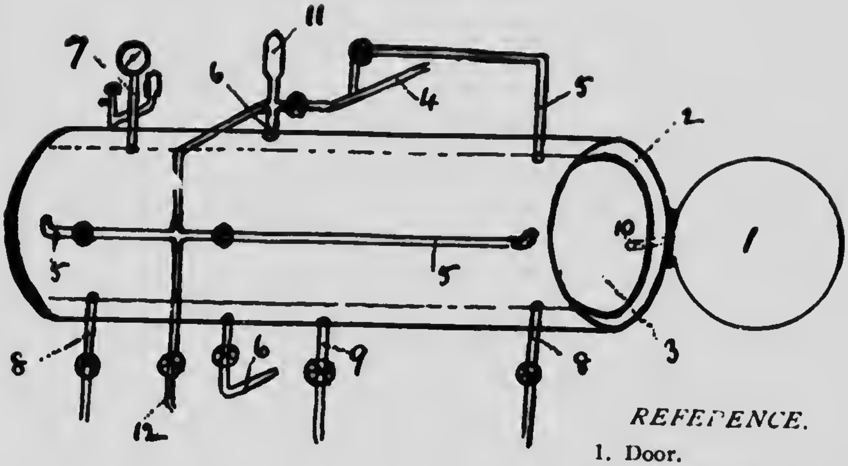
Directions for Working.

The clothes or articles to be disinfected, are placed on the rack within the chamber of the disinfector through the opening marked (1). The doors are then tightly closed, valves (8) are opened to allow of the escape of air; valve (9) is also opened, and the steam is then allowed to circulate within the jacket by means of valve (6). After a few minutes, that is, until the chamber has been thoroughly heated, valve (9) is closed ; the steam is thus under pressure in the jacket, and is allowed to remain so for ten or fifteen minutes. This is done with the object of warming up the contents of the inner, or disinfecting, chamber, in order that no condensation may take place when the live steam is admitted around the infectious articles. Valves (5) are then opened and the steam rushes in to the inner chamber, displacing the air through openings (8). In a few minutes it will be seen that the whole of the air has been displaced, when valves (8) can be closed and the live steam left in contact with the articles to be disinfected for about one-half to one hour.

It is exceedingly important that the whole of the air inside the disinfecting chamber shall be displaced before valves (8) are closed, otherwise efficient disinfection does not take place.

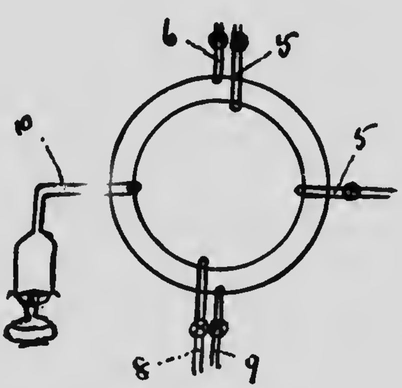
If desired, at this point, Formalin vapour can be driven into the inner chamber, to aid in disinfection. This is done by placing a pint of Formalin in the little boiler by the side, adjusting the flame beneath, and when the solution boils the vapour forces its way into the inner chamber.

1.43. KNY'S STEAM DISINFECTOR.



REFERENCE.

1. Door.
2. Outside Chamber or Steam Jacket.
3. Inside Chamber into which articles to be disinfected are placed.
4. Main Steam Pipe from Boiler.
5. Steam Pipes to Inner Chamber.
6. Steam Pipes to Outer Chamber or Jacket.
7. Pressure Gauge with Safety Valve, communicating with Inner Chamber.



8. Outlets for Air, Condensed Steam, etc., from Inner Chamber.
9. Outlets for Air, Condensed Steam, etc., from Jacket.
10. Pipe from Formalin Injector to Inner Chamber.
11. Safety Valve.
12. Waste Pipe for Steam.

When sufficient time has elapsed for disinfection, the steam to the inner chamber is cut off by closing valves (6), and valves (8) are opened so as to admit air. The jacket is still kept working, and in this way the articles in the interior are quickly dried. This requires only about ten to fifteen minutes. At the end of that time the steam to the jacket is cut off by closing valves (6), the door at the opposite end of the sterilizer opened, and the articles taken out into the next room, for, as will be seen from the model, the ends of the sterilizer project into different rooms, one being reserved for infectious articles, the other for the disinfected ones; in this way contamination is avoided.

1.44 Model of Thresh's Steam Disinfector.

This consists of a boiler jacket, the space enclosed being the disinfecting chamber.

The articles to be disinfected are placed in the cage in the interior, the door closed, the steam turned on, and allowed to pass through the chamber under the ordinary atmospheric pressure.

The boiler is a simple boiler, except that the water conconsists of a 2% solution of Calcium Chloride. This is used in order that a temperature of 105°C. may be imparted to the steam as it comes off the boiling solution. Hence the articles in the interior are sterilized by means of current steam at about 105°C. The process lasts about 40 minutes, to an hour.

This disinfector is usually mounted on wheels, and is one eminently suitable for poor rural districts where it is impossible to establish one central disinfecting station.

1.9 General.

1.91 Samples of Tarpaulin Used in Disinfection.

Infected clothes and material generally can be sprinkled with some disinfectant, wrapped in these tarpaulins and safely conveyed to the public, or private, disinfecting station.

1.92 Specimen of Canvas Bucket Used in Disinfection.

SECTION II—HEATING AND LIGHTING.

HEATING.

In the consideration of heating from a practical standpoint, the aim, or object, is obvious, viz., to keep the room warm. The best all round temperature is in the vicinity of 66 or 68 Fahrenheit; this will be found to be the most serviceable, both for working and resting purposes; a higher temperature induces a feeling of lassitude, and is not favourable to intellectual activity.

The heating appliances at our disposal are comprised in the following list: Fireplaces, stoves, hot-air system, hot water, and steam radiators. The methods by which heat is transmitted are—(1) Radiation, (2) Conduction, (3) Convection.

In radiation the heat travels through the air in the form of waves, radiating in straight lines from the source of heat—in practice this is usually an open fire. The remarkable thing about radiant heat is that in its passage through the atmosphere, it does not unduly warm the air, but the heat rays warm up any surfaces on which they may impinge.

Conduction means the transfer of heat from one body to another lying in contact—for instance, the air lying in contact with a hot stove, or pipe, is warmed by conduction, the heat passing directly from the iron surface to the air next it.

Convection applies to fluids only. When any portion of a liquid, or gas, has been warmed, that part is of lesser density than the remaining cooler portion, and will therefore have a tendency to rise, at the same time carrying with it the contained heat; we thus have a transference of heat from one place to another.

In the study of heating from the hygienic standpoint, attention must be paid to the method by which the heat is transmitted, and to note any effects upon the air of a room, either in the way of abstracting a portion for combustion purposes, or adding something to it in the way of products of combustion. Acting on these lines, the various simple heating arrangements may now be reviewed.

FIREGRATES.—These work on the principle of radiation as far as the heating of a room is concerned. They warm up the surfaces of all objects presented to the source of radiant heat, but surfaces which are screened from the heat waves are not warmed at all. The heating effect on any object is inversely as the square of the distance between the object and the source of heat. Looking at it in this light, an open fire does not seem to be the best form of heating; one frequently hears the complaint from a person sitting in front of a fire, that they are roasted in front and frozen behind. As a heating arrangement an open fireplace is decidedly not economical, for on a rough estimate three-quarters of the heat goes up the chimney. Open fires, however, have two great advantages which outweigh to a larger extent the disadvantages just mentioned. They are —(1) the air in the room is not unduly heated, and (2) the chimney flue attached to the fireplace acts as a very powerful exhaust, so aiding ventilation. (See Exhibits Nos. 2.13 to 2.15.)

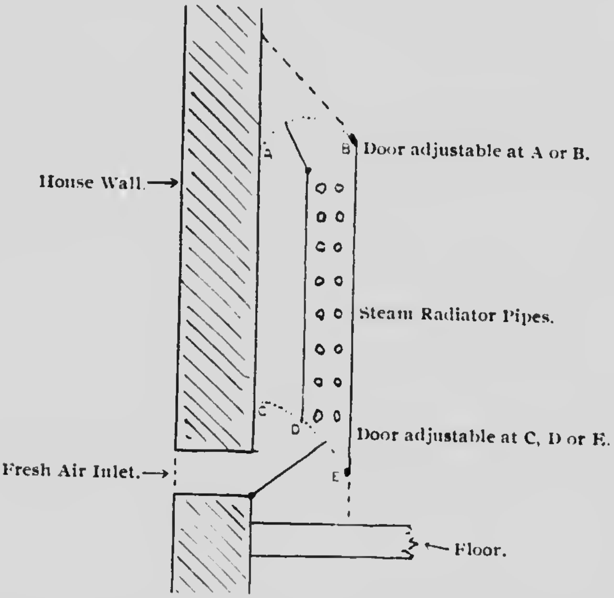
STOVES.—These appliances have for combustion material oil, wood, coal, coke, or gas. They are usually very simple in construction. In some very simple forms where oil, or gas is used, they are really nothing more than large lamps (Exhibit No. 2.11), the products of combustion escaping freely into the air of the room. Both oil and gas when burnt produce fairly large quantities of "Carbon Dioxide" which is extremely undesirable in the atmosphere to be breathed by the inmates; besides this, however, in the case of coal-gas, we have certain sulphur compounds formed when the gas is burnt. These products are extremely irritating to the respiratory tract, and unhealthy. All the other kinds of stoves are practically on the box principle, that is, the fire inside a metal casing; the products of combustion are conducted up a chimney, and the heating of the room is effected very largely by Conduction and Convection,—the air in contact with the heated surface of the stove becomes warmed by Conduction, and then rises owing to its lessened density, carrying with it the contained heat; the heat being thus transferred by Convection. These stoves possess certain advantages and disadvantages. In view of having a chimney flue attached, they aid in ventilation, which is a point to the good. The heating by Convection causes the relative humidity of the atmosphere to be markedly lowered, producing a disagreeable sensation of dryness. The most important drawback connected with stoves, however, is the power some of them possess, of enabling Carbon Monoxide to be manufactured in small quantities, and adding it to the air of the room. The actual manner in which this Carbon Monoxide is formed is not well understood, and is thought by some to be due to the Carbon Monoxide inside the stove permeating the red hot cast iron constituting the sides of the fire box. Personally I am more inclined to the theory that it is due to the production of Carbonyl compounds (probably that of iron), which would be split up again with formation of Carbon Monoxide; however this gas may be accounted for, there is no question about it being formed in some cases where stoves are used, and on account of its very poisonous properties it would be extremely dangerous to the inmates.

HOT WATER RADIATORS work on the principle of Convection, (See Exhibit No. 2 31), the heat being applied at a central point, is carried by means of the pipes to the various radiators, where the water is cooled, and owing to its increased density falls down again towards the furnace. This system has the advantage of being under full control as regards the heating, that is, the pipes can be made hot, or luke warm, according to the degree of stoking.

In STEAM RADIATORS, steam is forced under slight pressure from the boilers, situated in a convenient part of the building, into the radiators in the various rooms. The one disadvantage of this system lies in the fact that there is no means of obtaining a moderate degree of heat. The steam is either full on, or entirely cut off.

We may consider both these types of radiators from their hygienic aspect together. The method of heating is by Convection, the air lying in contact with the radiators becoming warmed, rises in the room, carrying with it its heat, and so, by a process of circulation, the temperature of the room is raised. The term radiator seems to be a misnomer, because radiation hardly enters into the question at all. The air of the room, under these systems, may become unduly heated, thus producing a marked reduction of relative humidity, which, as we have already seen, is not very healthy. These appliances do not add anything to the air in the way of combustion products, neither do they take anything from it, nor do they aid in ventilation ; on the contrary, the maximum effects would be obtained from the radiators in the room, if the apartment could be made perfectly air tight ; and in the modern dwelling where these arrangemeets are usually employed, and where we rarely find such a thing as an open fireplace, rooms are actually kept as air tight as possible. It is extremely probable that this condition of affairs in modern dwellings is answerable to a certain extent for such ailments as catarrh of the respiratory mucous membranes, and explains why the older generations, who used simple stoves and open fireplaces, did not suffer from these complaints so much.

Of recent years a combination of heating and ventilation has been favoured. The principle involves bringing the fresh air into the house, but warming it before being admitted to the rooms. Many of the heating arrangements which have been considered already, may be adapted to meet the requirements of the case ; for instance, an open fireplace may have an air shaft behind it, along which the fresh air travels on its way to the room. Immediately behind the back of the fireplace is a series of heating flanges, which warm up the air as it passes by. This is a very satisfactory arrangement, for it utilises the waste heat from the open fire, and does not warm up too much the incoming fresh air. The same idea of warming incoming fresh air can be carried out in connection with steam radiators, by means of a suitable box conduit shown in the accompanying diagram.



This arrangement gives very good results, and has the additional advantage of allowing the air to be moistened by permitting a little steam to escape from the radiators through the pet-cock.

As regards ventilating stoves we are virtually being introduced to the system of HOT AIR HEATING. The stove, or fire box, is surrounded by an air space, formed by the outer jacket, where the contained air can be heated. The cold air is led to the air jacket by means of a conduit, and the heated air is conducted away by suitable flues to the various rooms. Two different methods of supplying these air jackets with air are in vogue. In the first system, the air in the room, when cooled, is conducted from thence to the furnace, where it is again heated up and returned to the room once more ; in this way a veritable circulation of air is set up, but it is important to note that the air of the room is not renewed, except by what takes place through leakages, and so eventually we have to deal with an atmosphere which is decidedly vitiated by the inhabitants of the house. The economy of this arrangement cannot be questioned, but the hygienic results are very far from perfection. Under the second system these defects are to a certain extent remedied, because the air which is brought to the furnace is fresh air, conducted through a conduit directly from the outside; after this air is heated, it is led along the air shafts to the various rooms, when, after being used, it is allowed to escape through ventilation openings, so that the vitiation products, due to respiration, etc., are disposed of, and are not sent back, so to speak, to the furnace to be re-heated, and served up over and over again to the inmates of the room, as really takes place under the first system.

In all arrangements of heating purely and simply by hot air, the necessary warmth has to be distributed by the air itself, none being furnished from open fireplaces, or radiators ; under such conditions, in order to maintain an agreeable temperature, the incoming warm air must be heated up to quite a high degree, thus causing a tremendous lowering of the relative humidity, and the production of a very dry atmosphere. Various attempts have been made to supply the requisite moisture for mitigating the dryness of the air, but so far without much success. The usual arrangement is by installing a shallow pan over the top of the furnace, keeping the pan filled with water, and allowing the steam produced to mix with the air ; the amount of steam generated from these pans is totally inadequate to meet the requirements of the case.

2.1 Stoves.

In this Section are exhibited various kinds of stoves and grates used for heating purposes. It will be noted that the exhibits are worked by gas, but it is to be borne in mind that, although the heating agent is gas, the same remarks apply with equal force to any other agent, such as oil, coal, coke, or wood.

2.11 SINGLE BURNER GAS STOVE.

This apparatus can be placed in any part of a room ; the products of combustion are conducted straight into the apartment, there being no flue connected with a chimney, or other outlet. The heating is accomplished by simple convection; the air in the room comes into contact with the heated portions of the stove, and by virtue of being heated, rises and diffuses itself into the apartment generally.

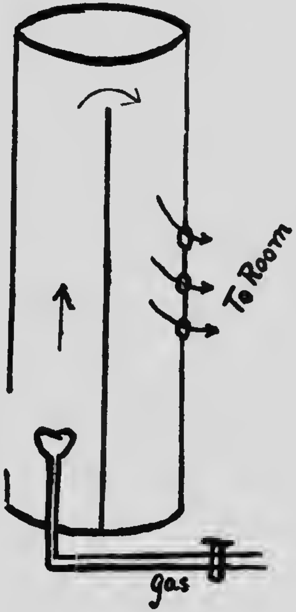
The principle is a bad one, seeing that the inmates of such a place would be breathing the air vitiated by the products of combustion.

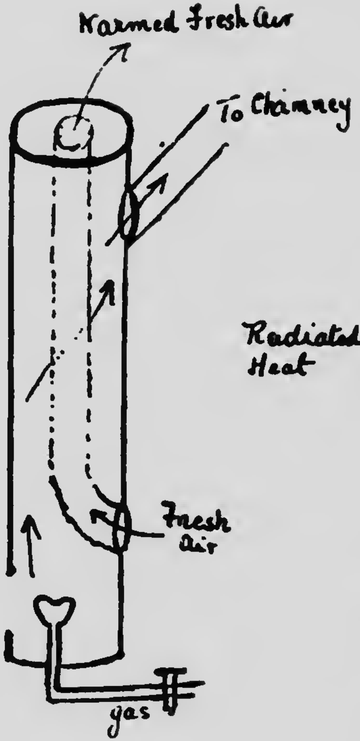
2.12 HEATING STOVE WITH SIX GAS JETS.

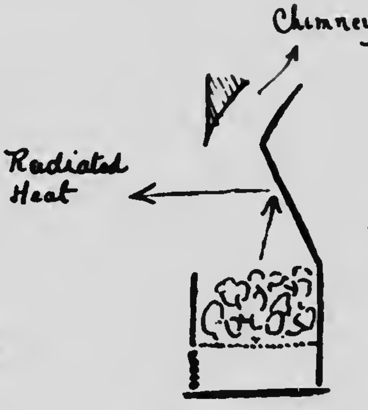
The principle of heating with this apparatus is much more preferable to that of 2.11. The products of combustion are conveyed by means of a flue to a chimney, and so into the outside air. Again, fresh air, from the outside, is conducted, by means of tubes, through the heated portion of the stove, and so allowed to have free access to the apartment. In this way the stove acts as a good ventilator, admitting the fresh air from the outside, and at the same time warming it, if the outside air be too cold.

2.13 GAS FIRE GRATE.

This is supplied with patent non-strike-back Bunsen burners. The flame from the burners plays onto an iron fret-work, which becomes red hot, and radiates its heat into the room just like an ordinary fire. The products of







Coal or gas fire.

combustion are conveyed by means of a flue to the chimney, and so to the outside air. The stove is enamelled with patent silicate enamel, which is not affected by heat.

The chief point about this stove is the large heating surface presented to the room, and, with a given consumption of gas, throws out far more heat than the ordinary gas fire.

2.14 BALL FIRE GAS GRATE.

This has patent non-strike-back Bunsen burners, and the principle of heating involved is that of simple radiation, exactly similar to 2.13, but the amount of heat given off from this fire with the same amount of gas consumed as in 2.13, is very much less.

The products of combustion are conveyed to the chimney; the grate is enamelled with patent silicate enamel.

2.15 BALL FIRE GAS GRATE.

This has the patent non-strike back Bunsen burners, and is the same in every respect as 2.14, except that ordinary Japan black is used as the enamel. This Japan black when heated, gives rise to a very offensive odor.

2.2 Gas Burners (Heating.)

2.21 SPECIMEN OF DOUBLE RING BUNSEN BURNER.

2.22 SPECIMEN OF SINGLE RING BUNSEN BURNER.

2.23 SPECIMEN OF PATENT SAFETY BUNSEN BURNER.
As used in laboratories, etc.

2.3 Radiators, and Appliances.

2.31 WORKING MODEL OF SYSTEM OF HEATING BY HOT WATER RADIATORS.

This model illustrates the circulation of hot water through pipes, radiators, and coils; the principle involved being that of convection, and radiation to a much less extent.

The hot water rises by virtue of its lessened density, but as it passes through the coils it becomes cooled, and its density thereby increased, the latter causing it to sink to the boiler, where it is again warmed up, and so the process of circulation continues.

2.32 WORKING MODEL OF ORDINARY HOT WATER SYSTEM USED IN A HOUSEHOLD.

This model illustrates the circulation of hot water in pipes. It is fitted with glass tubes, and expansion joints, boiler, gas burner, circulating tank, bath and sink supplies.

2.33 SMALL WATER TUBE BOILER.

This is heated by means of a Bunsen burner. It is connected up with an ordinary radiator, and is a very compact form of hot water heating. It is suitable for heating small houses, green-houses, etc.

The specimen shown is capable of heating 80 ft. of 2 in. pipe, the water inside being kept at a temperature of 50-55°F., according to the weather. A boiler, one and two-thirds the size of this, is capable of heating 200 ft. of 2 in. pipe to the same temperature.

2.34 MODEL OF JOHNSON'S THERMO-REGULATOR.

This can be applied to hot water, or steam radiators, and to hot and cold air conduits. It is an automatic apparatus, the automatic machinery being actuated by means of a thermostat, which is placed in the wall of the apartment. The power is supplied by compressed air, which is conducted through pipes to the working valves attached to the heating apparatus of whatever kind. When the temperature reaches a given point, a lever attached to the thermostat opens a small valve, and allows the compressed air to reach the regulating valves, which it closes, and so cuts off the heat supply until the temperature in the room falls again, when the compressed air valve is once more closed and the hot water or steam is allowed to circulate. So the process goes on automatically.

2.5 General.

2.51 Gas Distributors.

2.52 Specimen of Gas Cooking Oven.

This is a cheap and handy form of small oven, capable of cooking, and also for being used for boiling pans, etc. The feature about it is, that the products of combustion have very free exit, and so do not tend to contaminate the food in the interior of the oven.

2.53 Specimen of Polishing Iron.

The heat is supplied by a Bunsen flame in the interior of the iron.

2.54 Specimen of Primus Brazing Lamp.

LIGHTING.

There are two kinds of lighting to be considered—

Natural and Artificial.

Natural Lighting is derived from the direct sun rays, or diffuse daylight. It is admitted into dwellings through windows, and as it is so essential to the maintenance of health, a certain window space is required in all habitable rooms by municipal authorities. The law usually provides for an amount of window space in its relation to the area of the floor of the room, and in most places decrees that for ordinary dwellings the window space shall be at least one-tenth of the floor space; this is in reality little enough, and if we examine the lighting of a room where this relationship exists, we shall find it very indifferently lighted up. In most well-designed private houses, the area of window space is usually much larger than this, and is more often in the vicinity of one-fifth of the floor space, or even more. In special buildings, like hospitals and schools, the window space is, by common agreement, about one-fourth of the floor space ; it having been found that the inmates in these institutions do better in a well-lighted building, than in one less well provided.

In regard to the manner in which human beings react when they live under conditions where the necessary amount of daylight is not admitted, they behave very much like plants ; where green plants are deprived of daylight they turn white, and so it is with human beings under similar circumstances—they become pale, anæmic, and their bodily resistance is distinctly impaired. Besides being healthful, direct sunlight is undoubtedly a germicide and purifier ; for these reasons dark living rooms have proved, by experience, to be very unhealthy quarters for people ; their general health suffers, thus paving the way for the onset of any disease ; and besides such dark rooms are invariably dirty.

Special bye-laws are usually directed against cellar dwellings, and rooms situated in the middle of a block, where daylight cannot be directly admitted to them on account of their situation. It is a curious fact, but nevertheless true, that no amount of artificial illumination can take the place of natural light.

The means for introducing daylight are windows, skylights, etc. There is nothing worthy of note concerning the working of these appliances : the light is simply admitted directly to the apartments ; but there are outside conditions which call for special mention, because they interfere with the direct admission of light, even though ample provision exists in the way of window space ; for instance, in the case of tall buildings on each side of a narrow street—it is obviously impossible for the direct sun rays to penetrate into the lower rooms, it being shut off by the building opposite. Under circumstances of this description, Reflectors, or Refractors, are placed outside the windows at an angle of 45°, or in such a position that the light rays coming from above, are deflected in a horizontal direction into the room. For this purpose perfect Reflectors would give us the best results, because they do not absorb so many light rays as Refractors; but experience proves that Reflecting materials, such as mirrors, would not be able to withstand the ravages of wind, rain, etc. Refractors, which are nothing more than a series of glass prisms, are unaffected by the weather, and so have come to be used almost exclusively. A specimen of the material commonly employed is shown in Exhibit Nos. 2.71 and 2.75.

Realizing to the full how buildings situated close together can cut off the daylight from one another, many municipal authorities have instituted the "building angle." It mostly applies to residential property where space around houses can usually be obtained; it hardly ever pertains to the business section of a city, because it is impossible to provide space, owing to the high value of land.

The building angle is 63.5°, and its application is as follows: where a new building is to be erected near one already in existence, no portion of the new building (not counting the chimney) must project above a line drawn at an angle of 63.5° from the wall of the older house at ground level. This is to insure an access of direct sunlight through the lower windows of the dwelling.

Basement rooms in houses or shops, abutting on the main thoroughfare, are very difficult to light, because they are situated below the street level, and windows could only be installed where light wells could be provided; light wells are obviously impossible in a public sidewalk, and so other means for the admission of daylight must be instituted. The method most practised is the employment of heavy glass prisms (see Exhibit No. 2.75) fixed in a strong iron framework, the whole being able to bear the weight of the foot traffic, which passes along the sidewalk. The action of the prisms is very simple; vertical rays from above are refracted by the prism into a horizontal direction, and so shot into the basement room. The arrangement is not very satisfactory however, even when the prisms are new; the amount of light absorbed in its passage through the prism constitutes at least 50% of the whole; moreover the upper surface of the prism on which people walk, quickly becomes scratched, thus almost entirely preventing the passage of light.

ARTIFICIAL LIGHTING.—The ordinary materials, or agents, used for artificial illumination are comprised in the following list :—candles, oil lamps, gas, and electricity. Our chief concern in these lighting agencies is to ascertain how far they affect the atmosphere in rooms ; and as a minor consideration, to note the effects produced on the eyesight. The action on the atmosphere may be looked at from a twofold point of view. 1st—As to how much oxygen each agent requires for combustion purposes, and 2nd—What products of combustion deleterious, or otherwise, are given off. In comparing the hygienic values of the different illuminants, it is always distinctly understood that lights of equal candle power are used, and a 16 candle power light is the usual standard for comparison. Where actual combustion takes place, Carbon Dioxide is the chief product, and as this is formed in volume proportionate to the amount of the oxygen consumed, the oxygen consumption can be gauged directly from the figures representing the Carbon Dioxide production.

	Carbon Dioxide per Hour
16 Standard Candles (1740 grains)	6.8 cubic feet
16 Candle Power Oil Lamp (1000 grs. oil)	4.8 " "
16 " " Gas Jet (5 cub. ft. gas)	2.5 " "
16 " " Incandescent Electric Lamp	0

From this list the electric light is undoubtedly the most hygienic, because it does not consume any oxygen from the atmosphere, nor does it add anything in the way of products of combustion. Apparently candles and lamps vitiate the atmosphere more than gas ; this is quite true in respect to Carbon Dioxide, but coal gas gives off other compounds of an ammoniacal and sulphurous nature. The latter particularly are very irritating, and make their presence felt far more than a considerable quantity of Carbon Dioxide. Candles and oil produce Carbon Dioxide only, and so it comes about that although they produce larger volumes of this gas, they are really more healthy on the whole than coal gas.

The action of the artificial light rays upon the eyesight depends very largely upon the amount of violet rays which an illuminant gives off; these rays are very apt to cause irritation of the eye, and where people are subjected for a prolonged period to the action of these violet rays, their eyesight frequently suffers. Cases of this description are fairly common amongst people working in offices where daylight cannot be admitted in necessary quantity, and artificial illumination has to be resorted to during the day time. The illuminants which seem to be the most irritating are those which produce a bright white light; and it is found that on examining these white lights through a Spectroscope, they are particularly rich in violet rays. Yellow lights, such as we obtain from candles, oil lamps, etc., produce very few violet rays, and for this reason are pronounced more restful by people who have to work under this form of illumination.

Among the various exhibits will be found specimens of the different types of gas jets, and oil lamps, in common use. Attention may be drawn to the use of the Colza oil lamps—Colza oil possesses the advantage of being non-explosive, and so effectively prevents accidents, which not infrequently accompany the use of common coal oil lamps, owing to their receptacles becoming overheated.

A passing note may with advantage be made, concerning the use of water gas, owing to its attendant dangers. This gas contains a large percentage of Carbon Monoxide, which is deadly poisonous; any leakage of water gas is therefore particularly dangerous. As this water gas possesses no distinctive odor, a leakage can take place without the occupants of the house being aware of the fact, until poisoning ensues. In this respect it differs markedly from coal gas, which possesses a very characteristic odour, and is readily detected when it escapes even in small quantities.

2.7 Reflectors, and Refractors, for Daylight.

2.71 SPECIMEN OF REFRACTOR,

placed outside an ordinary window at such an angle that the light rays, coming from above, are refracted horizontally into the room.

These are particularly useful in large buildings where the windows, lighting the lower rooms, look out on to a small alley-way between large buildings, and where it would be quite impossible for the direct rays of sunlight ever to find their way into the room.

2.75 SPECIMENS OF PRISMS,

used for refracting vertical rays in a horizontal direction.

These are useful for illuminating cellars, and such like, where the source of light can only be obtained from the ground level, such ground surface being utilized at the same time for traffic purposes. These prisms of glass are very strong, and are capable of bearing large weights, so that considerable traffic might take place over them without causing material damage.

2.8 Artificial Agents.

2.81 CANDLES.

2.811 Sample of common tallow candle.
2.812 Paraffin wax candle.
2.813 Sperm candle.

2.82 LAMPS.

2.821 Specimen of common paraffin lamp.
2.822 Colza oil lamp.
2.823 Incandescent oil lamp.

The incandescence is caused by mixing the atomised oil with a large amount of air, which, on combustion, gives a non-luminous flame exactly like a Bunsen burner. This flame is intensely hot like the Bunsen flame, and is capable of producing incandescence in a silicate mantle.

2.83 GAS.

2.831 SPECIMENS OF ORDINARY GAS JETS.

These are constructed so as to allow of a certain amount of gas being consumed per hour, and are sold under such standardization, a given amount of gas producing a certain intensity of light, and they are usually designated as 8, 10 or 16 candle power, and so on.

2.832 SPECIMENS OF ARGAND BURNER.

It is claimed for this burner that, with an equal amount of gas consumed, a brighter light is produced than by the use of an ordinary burner,

2.833 SPECIMEN OF INCANDESCENT LAMP.

This is produced by the action of the Bunsen flame on an incandescent mantle and causes a very white light.

2.837 SPECIMEN OF ACETYLENE GAS LAMP.

The flame produced by the use of this gas is very intense and white, though much smaller in size than the ordinary gas jet. The same remarks, about its effect upon the eyesight, apply to this specimen of lighting with rather more force than the ordinary incandescent gas light.

2.84 ELECTRIC LIGHTING.

2.841 SPECIMENS OF INCANDESCENT LAMPS.

These are of varying candle power, the common ones being 8, 10, 16 and 32. They give a very agreeable light, though, for reading purposes and such like, they are not so comfortable to the eyes as an ordinary lamp.

2.842 TUNGSTEN LAMP.

This produces a very white light.

2.846 SAMPLE OF ARC LAMP.

The arc lamp, which gives a tremendously powerful light, is used practically only where large areas have to be lit up, such as streets, very large working establishments, and the like. The effect produced by arc lamps is much the same as that of ordinary sunlight.

SECTION III.—WATER SUPPLIES.

All available water supplies are originally derived from rain which falls upon the earth. Ignoring evaporation, this rain water either runs off the surface of the earth, or sinks into the soil; from the former, all brooks, rivers and lakes are derived; the portion which sinks into the soil goes to form vast reservoirs of "underground" water.

As RAIN WATER has to be collected and used for drinking purposes, in some localities, where, owing to unfavourable natural conditions, the local waters are not available, a few practical details may be noted concerning collection, storage, etc. In circumstances of this description the roof is nearly always employed as the catchment area; and the roofing materials may, in some instances, prove to be dangerous where rain water is concerned, owing to its remarkable solvent properties. Attention must be given to the nature of the roof. The common materials, wood, slate, and iron are not apt to give rise to any trouble, but there are two metals not infrequently used, copper, and lead, which are partic[illegible] dangerous. Rain water can dissolve quite an apprec[illegible] quantity of these metals, and although never very large in amount ($\frac{1}{20}$ of a grain per gallon), nevertheless consumers of such drinking water are very apt to develop lead, or copper poisoning, as the case may be because these metals accumulate in the system, being known as cumulative poisons. Sometimes roofs are made of some pitch preparation; such roofs when new are apt to impart a "tarry" flavour to rain water collected on them. This objection gradually disappears after a time.

A practical point may be noted regarding the collection of the rain water from the roof. Before a fall of rain, every roof will show on it a collection of dust, to a greater or less degree; the first washings are unsuitable for use, for this very reason, and therefore it is usual to employ some form of apparatus which will permit of the first washings from the roof to be discarded, and the succeeding clean portions of the water to be conducted to the storage tank. Storage tanks are best placed beneath ground, for that is the coolest situation to be found around a house, and it is necessary to keep the drinking water from being unduly heated, as would be the case if it were stored in metal tanks inside the house. In installing these "under ground" storage tanks, particular care should be taken to guarantee against the entry of any polluting liquid which may lie in the soil; these tanks should be made perfectly water tight. The over-flow from the tank should never under any circumstances, be connected up with a drain or sewer.

SURFACE WATERS:—Considering the formation of rivers and lakes, it is necessary to realize that these have their beginnings in the rain water draining from the country side. As these catchment areas, on which the rain is deposited, are elevated country, so to speak, usually in the wild state, they are often referred to as "upland surfaces," and the waters which are collected from these areas, either in the form of rivers, or lakes, are spoken of as upland surface waters. In barren rocky countries the rain falling on such areas has very little opportunity of dissolving mineral, or vegetable matter, and so an upland surface water in these cases is very near to rain water in character; in those uplands, rich in vegetation, the rain water collected from them is usually impregnated with vegetable matter, imparting to it a brownish tinge; they also are usually very free from mineral matter, and soft in consequence.

Where these upland waters are utilized as a source of drinking supplies, they must be impounded in reservoirs, either natural, or artificial.

A lake is a natural reservoir, and is the one most commonly adopted in this country.

The possibility of pollution of upland waters is of primary importance, and obviously such pollution must be of a superficial character, that is, relating to the surfaces of the earth. Virtually these surfaces are contaminated with material derived from human habitations, situated within a catchment area; the habitations are of necessity very few in number, for a tract of land thickly dotted with houses would be totally unfit as a catchment for rain water, because the ground would be so fearfully polluted. In practice, therefore, the contamination nearly always originates from a solitary house, and reaches the lake by means of a small brook, or something of that nature. These small pollutions are really the more important, because they are so often overlooked; gross pollutions are usually patent to everybody.

These catchment areas have to be guarded very closely by the sanitary authorities, and a common practice amongst municipalities using these upland waters for drinking supplies, is to buy up the whole of the catchment area, so preventing habitations being erected thereon. It is a frightfully difficult matter, however, under any circumstances, to absolutely prevent pollution, and although things may go on favourably for a time, trouble eventually occurs when the countryside becomes fairly well populated. The dangers attendant upon pollution of these upland surface waters will be fully appreciated if it be remembered that these waters are nearly always used in their raw, or unfiltered state.

When we come to deal with rivers as sources of drinking water, the possibilities of contamination are greatly increased, because they traverse long stretches of country, receiving on their way the drainage of the land on each of its banks.

Nearly all rivers have at intervals towns, or villages, situated on them, and as these communities usually adopt the common practice of taking their drinking water from the river above the town, and of pouring in their sewage at some point below it, the quality of the river water must deteriorate after several towns have been passed. In all countries the story of river pollution has been the same, commencing with a river flowing through an uninhabited region, the waters are naturally pure, but as the country becomes settled, the accretion of polluting material becomes annually greater, and it is only a question of time when the contamination becomes so pronounced as to render the river water unsafe. Apart from controlling the pollution, to which all surface waters are liable, by some method of treatment, these waters, more than any other, call for some form of purification to render them safe to the consumers; purification methods will be dealt with under their own section.

UNDERGROUND WATERS.—As the earth may be said to consist of a series of layers, some permeable, and some impermeable, to water, that portion of the rainfall which percolates into the earth will sink down through the permeable soil until, eventually, it strikes an impermeable stratum, which will cause it to be held up in the interstices of the permeable soil. These strata, roughly speaking, alternate, first a permeable layer, and then an impermeable one; the impermeable layers are usually composed of clay, or very hard rock, both of which are more or less water tight. The underground water lying in the first permeable stratum (constituting the surface of the earth), is that portion of the rainfall which has travelled directly down from the surface, and the extent of its journey is hardly ever more than a few feet.

The water lying in the first layer is termed Superficial Underground Water, and any well, or spring, which is derived from this source, is known as a Superficial Well, or Superficial Spring. The superficial layer of the earth in the vicinity of dwellings is always more or less polluted, either with material on the surface, or just within the soil, such as manure heaps, privies, leaky cesspools, or leaky drains, etc. The liquid portion of these contaminating materials naturally sinks down through the porous soil, and joins the main body of Superficial Underground Water. It is for this reason that Superficial Underground Waters are so very often badly contaminated.

As we proceed downwards in the earth we shall come across other permeable layers deeply situated, and lying beneath one or more deep impermeable layers. (See Diagram Exhibit.) Any permeable layer situated beneath the first impermeable stratum is designated a deep layer. They usually contain water, and this water is therefore termed Deep Underground Water, in contradistinction to that contained in the superficial permeable layer; and any well, or spring derived from this water is known as a Deep Well, or Deep Spring, respectively. Now in the case where a deep permeable stratum underlies the superficial impermeable layer, it is obvious that the rain water did not trickle directly down from the surface, that is to say, it did not permeate the superficial impermeable stratum; but it must have reached the deep layer by some other route. These deep strata do not go on indefinitely lying at the same depth from the earth's surface, but at points break out through the superficial layers, owing to corrosion, or some natural convulsion of the earth, and it is at these very points—termed "out-crops"—that the rain water finds its way into the deep layers.

Having once gained access, the rain water sinks down through the deep permeable layer, and may travel many miles before coming to a stop, if the stratum has a suitable inclination, and all the time getting deeper and deeper from the earth's surface. If a boring be made into this deep layer containing the underground water, many layers, permeable, and impermeable, may have to be traversed before the boring reaches it from the surface.

Any pullution to which these deep underground waters may be subjected, in nearly all instances, passes along the same route by which the rain water gains access to the deep layers, that is, at the outcrop; and, as we have seen, this pollution would have to pass through long distances of soil, or whatever material constitutes the deep stratum; where soil is the material, it practically constitutes a huge natural filter, in some cases ten or twenty miles in extent, and the liquid containing the germs, having to run the gauntlet of this vast filter, is deprived of the Bacteria. On this account most underground waters are very pure from a Bacterial standpoint. Occasionally we may meet with a stratum full of fissures (clay or chalk), and these fissures, communicating one with another, allow the water to pass along much in the same way as it would through a system of ramifying pipes; if the water contained germs from some polluting point, it would not be subjected to any filtration, and so the Bacteria might eventually reach a well, or spring, which was used as a source of drinking supplies. Another way in which deep waters may be contaminated is through a defective boring; polluting material from the surface may travel down by the side of a pipe, lining the boring; this does not often occur, but it is useful to remember it as a possibility, and serves to impress upon us the necessity of rendering the boring, and its tube, quite tight, so as to exclude the entry of any liquid contained in the strata near the surface.

All underground waters are of a hard character, the deep ones especially. This is only natural, when it is remembered that the rain-water in traversing vast masses of soil dissolves as much mineral water as it possibly can, and that the farther it has to travel, and the longer its sojourn, the harder will the water be. The nature of the stratum through which it passes also affects the degree of hardness. Such substances as chalk, or limestone, render water very hard; on the other hand, a stratum of pure sand would not impart a great deal of hardness, owing to the insoluble character of the sand.

The level on which the underground water stands in the interstices varies from time to time; after a period of excessive rainfall, the level naturally rises; and likewise after a period of drought, the water level falls. There is thus a natural up and down movement, and in addition there is a side movement in the whole body of underground water towards its natural outlet. This side movement is very important in the case of Superficial Underground Water, because of the effects which pollution may produce upon a well, or spring. If the polluting material were carried by this side movement of underground water towards a well, or spring, the latter would be inevitably polluted, whereas if the polluting material were carried away from the well, there is quite a likelihood of the latter not showing signs of contamination. Excessive pumping from a well lowers the level of the underground water in the immediate vicinity to a very marked extent, and in those cases where side flow is not very rapid, the underground water may be sucked into the well from all sides, and so may even reverse the flow of the underground water away from the well; a course which would be naturally adopted if the well were full, and not being overtaxed. This is well shown in Diagram Exhibit and Exhibit No. 3.01, which is a working model, shewing the effect of pumping on the level of the underground water in the soil.

PURIFICATION OF WATER.

All waters requiring purification are dealt with either on a large scale by Municipal Authorities, or on a small scale by householders.

PURIFICATION ON A SMALL SCALE.—Where the water supply to a community is of a dangerous, or suspicious quality, and is not purified on a large scale, it devolves upon individual householders to adopt their own means for procuring a safe drinking water. There are several methods which may be adopted for this purpose—(1) Boiling is a well known, and efficient, form of sterilizing water; as an emergency method it is one of the best, but as a permanent procedure it is not very satisfactory, because people in general dislike the taste of boiled water; furthermore, the boiled water has to be cooled down in some form of receptacle, and the storage opens the way to risks of contamination. (2) Filtration is probably the most popular method of household purification, and for our purpose it is convenient to divide domestic filters into two classes;—the plain, or ordinary filter, and the biological filter.

The plain or ordinary filters may be described in a group. The arrangement consists in every case of an upper and lower compartment separated by the filtering medium.

Unfiltered water is placed in the upper compartment, and forces its way through the filter medium by gravity ; the lower compartment serving as a storage reservoir.

In this class of filter, the filtering medium consists of one of the following substances :—Sponge, flannel, asbestos, sand, charcoal, lime and charcoal, manganese dioxide, and iron oxide.

The filtration effected by these substances is but crude ; they are capable of straining off only the larger suspended particles ; germs can pass through them freely, so that as a protection against disease germs they are useless, in fact some actually form a good growing medium for organisms which may be caught upon them, and so after a time the water that comes through may actually contain more organisms than the original unfiltered water. Charcoal possesses the property of decolourising waters tinted with vegetable matters ; under these circumstances a very clear sparkling water is produced, its clearness rendering it highly attractive, but at the same time this clearness is absolutely no criterion of its bacterial content.

The principle of the biological, or germ-free filter, is that water is made to pass through some very fine porous material capable of straining off all suspended matter, including micro-organisms. The material usually employed consists of some preparation such as unglazed porcelain, kisselguhr (powdered diatom shells), or very fine artificial stoneware. The water may be forced through by pressure, or drawn through by vacuum.

In all varieties of this filter, it is found that a slimy layer collects on the outside of the filtering medium, and, after a time, becomes so thick as to prevent any water passing through at all. The filtering block has then to be cleaned, which is done by scraping off the slimy layer, and sterilizing the cylinder, either by boiling, or by steam in an autoclave.

It is to be noted that in all these filters the filtrate is not permanently sterile. This depends upon the fact that the organisms in a few days grow through the interstices of the filtering medium. It is an actual process of "growing through," for no amount of pressure can force organisms through, and this being the case, the period when the filter "gives out" varies with different materials according to the size of the interstices, *e.g.*, unglazed porcelain generally lasts about five or six days, giving sterile filtrate with continuous filtration; kisselguhr four to five days; fine unglazed stoneware from one to three days.

PURIFICATION ON A LARGE SCALE applies to the water supplies of Cities or Towns; these are usually derived from upland lakes, or rivers; and, as we have already seen, these two classes of water are very liable to pollution from the surface of the earth, necessitating some form of purification.

The methods of purification on a large scale in present day use are either—Disinfection, or Filters.

DISINFECTION consists in adding a certain quantity of a solution of Chloride of Lime to the water; the Chlorine effects the disinfection. Only small quantities of chlorine are required to bring about the destruction of Bacteria in the water, but the amount required varies with different waters; those containing vegetable organic matter requiring more than those which have none; the organic matter uses up for its oxidation the chlorine, or to be more precise the nascent oxygen which the chlorine liberates, and when dealing with such a water, sufficient chlorine must be added not only to satisfy this organic matter, but also to kill the Bacteria. In a water free from vegetable material very small quantities of chlorine are required to destroy the germs—one part of chlorine to a million parts of water being sufficient to render it sterile. In the case of any particular water, the amount required for disinfection can only be ascertained by trial and this explains the reason why it is so important to keep watch upon the disinfecting process, which may be applied to the town water supply; for the constituents in water usually vary from time to time, and so the amount of chlorine must be varied too.

Although chlorination is a cheap method of purification, and, when properly supervised, gives good results from the Bacterial aspect, nevertheless it has one or two little drawbacks. In many instances the people complain of the odour of Chlorine in the water, and again the sterilization may, from time to time, be defective. For these two reasons chlorination should be resorted to, or recommended, more in the nature of a stop gap, when dealing with a Town's water which has become polluted, and pending the erection of a permanent filtration plant.

FILTRATION ON A LARGE SCALE :—There are two types of Filtration Plants—the Slow Sand Bed Filter; and the Rapid, or Mechanical, Filter.

The Slow Sand Bed Filter is an old institution, in fact the first form of water filter adopted, and has given very good results; when the filters are not overtaxed, a purification of 99 to 100% on the Bacterial Content can easily be obtained. The constitution of a Sand Bed Filter is well shown in Exhibit No. 3.41 where the different layers of sand and gravel are seen. Virtually the lower layers are simply a support for the uppermost layers of fine sand. This sandy layer supports a gelatinous film, which forms from the fine debris contained in the water, and the filter does not become efficient until the gelatinous layer is formed —in the case of a new filter this usually takes about two days. The film is really the active agent in eliminating germs from the water, as it passes through; the underlying fine sand only aiding in this respect to a small extent. The filter will continue to work until the gelatinous layer becomes so thick as to stop the passage of the water through it; the filter then requires cleaning, and this is accomplished by skimming off the gelatinous layer from the surface of the sand; the filter is then in the same condition as a new one. The intervals between cleaning vary with the state of the water to be filtered; in the case of very clear water the intervening period may extend to three, or four months, or even more; on the other hand, a muddy water will quickly block up the filter, and hence these filters are not suitable for the purification of muddy water, unless some preliminary treatment in the way of clarification is resorted to. The great advantage, or recommendation, of slow sand filters is their permanent character ; there is so little to get out of order in the way of wear and tear, and the attendant labour is very small indeed.

The Rapid, or Mechanical, type of filter, when closely examined, can hardly be said to involve the principle of filtration, but is based upon the principle of coagulation. It depends upon the formation of a flocculent mass, when a coagulant is added to the water ; the basis of almost all coagulants consists of either lime, or alum, or iron sulphate, or a combination of one or more of these three. All these salts when added to water produce flocculent precipitates. These precipitates form around suspended particles contained in the water, so that when the flocculent masses settle down, they carry with them all the suspended matters, even including germs, which for this purpose can be looked upon as suspended particles. If now by any process of filtration these flocculent masses are separated from the water, the filtered water will show a freedom from germs, and mud, commensurate with the perfection of the process ; so far only does filtration enter into the scheme.

Defective results can be obtained from the imperfect working of this scheme in two ways—(1) If the amount of coagulant be not sufficient to enmesh, and carry down, all the germs in the water ; (2) if by any means the flocculent masses containing the germs be broken up, the imprisoned germs are liberated once more, and appear in the filtered water. In practice this smashing up of the flocculent precipitate may take place by attempting to rush the water through too quickly. Very good results however as regards purification (99 to 100%) can be obtained by this system if the working is carefully supervised, but owing to the highly technical nature of the operation, skilled attention is very necessary. The working principles of this type of filter are well seen in Exhibit No. 3,42.

A passing reference may be made to one or two other schemes of water purification on a large scale, which have been tried in different places, but without very satisfactory results. The Electrolytic process was tried ; this involves the production of nascent oxygen by Electrolysis of water. The treatment by ozone is of a similar nature, the ozonised air (virtually nascent oxygen) is blown through the water. In both these schemes dependence is placed upon the disinfecting properties of nascent oxygen ; there is no question about the power of nascent oxygen as a germicide, but in both schemes the gas is introduced in the form of bubbles, and it can only disinfect that portion of the water with which it is in absolute contact. It is for this very reason that the schemes have proved unsatisfactory, because the disinfection of the water is incomplete, the portion of the liquid between the bubbles, so to speak, escaping the disinfection process. Perhaps at some future time this mechanical difficulty of insuring complete admixture of the gas with every part of the water may be overcome, and then these schemes may give quite satisfactory results.

Electric treatment is occasionally heard of, that is the passage of a current of electricity through the water, not involving Electrolysis at all. The germs are supposed to be killed by the passage of the electric current ; as a matter of fact electricity pure and simple, does not seem to have the slightest effect on germ life, no matter what the current may be, or the time of application.

3.0 General.

3.01 Large Working Model Illustrating Movements of Underground Water.

This consists of a mass of sand about 18 inches deep, 18 inches wide, and six feet long, representing the superficial permeable layer. The floor of the tank in which this sand is contained, represents the first impermeable stratum. The interstices of the lower part of the sand are filled with water, representing "ground water" ; in the centre is a hole, representing an ordinary superficial well, and, extending in a straight line on each side of this well, is a series of observation tubes. The well, and tubes, are connected to gauges on the front of the box, so that the level of the underground water in any of these borings can be seen at a glance.

When water is pumped out of the well, the level of the underground water is indicated on the manometers, and takes the form of a curve, which is very steep near to the well, running away into the ordinary level of the ground water at a very short distance from the well.

This is instructive, showing how the level of the underground water is depressed in the vicinity of a well which is being used ; and so it follows, that any contaminating material, situated in the vicinity of the well, can be, so to speak, drawn into it. In cases where the well is not used, the contaminating material would be carried away in the direction of the side flow of the underground water.

The side movement of the ground water can be illustrated, and its bearing to public health, by pumping the water out of one end of the box. In this way the whole of the underground water takes on a side movement towards the end from which the pumping takes place. It can be shown that any point of pollution on the far side of the well from the seat of pumping, will actually contaminate the underground water which flows from the pollution point, past the well, to the place where the water is being pumped out. This can be beautifully illustrated by introducing some chemical, which may be easily detected, at the point where pollution is supposed to take place.

3.02 BORING TOOL.

3.03 MODEL ILLUSTRATING THE SUCTION ACTION EXERTED BY LEAKY WATER PIPES.

This consists of an ordinary piece of lead pipe, as used in water connections, placed inside a glass cylinder ; connected with the interior of the glass cylinder is a manometer, to indicate any difference of pressure. The lead pipe is punctured with a small hole, such as is usually made by an ordinary wire nail.

If water be allowed to run through the lead pipe, (the bigger the pressure the better), it will be found that air is sucked in through the small hole, the lessened pressure inside the glass cylinder is indicated by the manometer. If the manometer is taken out, and the cylinder filled with coloured water, it will be noticed that this water is sucked through the small hole, in the same way as the air in the first experiment. Thus contamination by ground air, and ground water, can be demonstrated.

3.04 WATER METER.

3.05 WATER TAPS.

3.06 CASE FOR WATER ANALYSIS.

3.1 Water Pipes, etc.

3.11 SPECIMEN OF ORDINARY HEAVY LEAD PIPE.

This pipe is used for ordinary water connections for high pressure. With an intermittent water supply of low pressure, a lighter variety of lead pipe is used.

3.12 SPECIMEN OF LEAD PIPE LINED WITH TIN.

Used for water, mineral water, beer, etc. ; it is designed to prevent lead poisoning.

A drawback to this kind of pipe is the fact that, when the tin coating is broken, a galvanic action is set up between the tin and the lead, causing a very appreciable solution of lead.

3.13 SPECIMEN OF IRON PIPE COATED WITH ANGUS SMITH'S PREPARATION.

The coating is a kind of coal tar varnish, is very durable, and can be used for large and small pipes.

3.14 SPECIMEN OF IRON PIPE, TIN LINED.

This is used under the same conditions mostly as 3.12, the drawback being that the iron pipe cannot be bent in the same fashion as lead.

3.15 SPECIMEN OF IRON PIPE, GLASS LINED.

This was invented with a view to the prevention of the absorption of metal.

The great disadvantage to this pipe is that the glass lining is broken whenever the pipe is bent.

3.16 SPECIMEN OF GALVANIZED IRON PIPE.

The durability of this is not very great, the zinc coating wearing off and corroding.

3.17 SPECIMEN OF 5/8TH GALVANIZED IRON PIPE.

This shows the lumen almost occluded by the defective coating.

3.18 SPECIMEN OF OLD WOODEN CONDUIT.

This was used in ancient times for the distribution of water supply. The specimen was excavated in Montreal, somewhere in the region of Craig Street. Date uncertain.

3.19 SPECIMEN OF ORDINARY LEAD WATER PIPING

in which a hole was gnawed by rats.

3.2 Ordinary Filters.

3.21 MODEL OF ORDINARY DOMESTIC FILTER.

3.22 SPECIMEN OF MAIGNEN'S TABLE FILTER.

3.23 FIVE SAMPLES OF MAIGNEN'S PORTABLE FILTERS.

These vary in size from a little pocket filter up to a large camp filter. The principle involved is precisely the same as in 3.21.

3.24 SPECIMEN OF MAIGNEN'S IRON CYLINDER FILTER.

This is for permanent attachment to a water pipe, and is on the same principle as stated above.

3.25 SPECIMEN OF CARBO-CALCIS.

This is used in Maignen's filters.

3.26 SPECIMEN OF DAVIS'S FILTER.

This is for permanent attachment to a water pipe, and the process of filtration here is through flannel, carbon, and a mixture of lime and charcoal.

The results of filtration are the same as in the ordinary domestic filter.

3.27 SPECIMENS OF MATERIAL USED IN DAVIS'S FILTER.

3.3 Biological Filters.

3.32 BERKEFELD FILTER WITH ROTARY PUMP

adopted for use in country houses where water supply is derived from wells.

3.33 BERKEFELD FILTER, PERMANENT ATTACHMENT.

3.34 BERKEFELD FILTER.

Detachable union ; filter medium, finely powdered diatom shells (Kisselguhr).

3.35 LARGE SIZED "ECLIPSE" FILTER.

3.36 THE PASTEURIZING FILTER.

The filtering medium consists of a plate, or disc, of patent composition, held firmly between two iron slabs. The water is forced through the filtering plate by the usual main pressure, and is sterilized in its passage through. The recommendation for this filter lies in its extreme simplicity, and especially in the changing of plates.

No sterlizing and cleaning of the old plate is required, a new plate being used each time, and the old one discarded. The disc needs to be changed every four days.

3.37 PASTEUR FILTER.

Permanent attachment. Filter medium fine unglazed porcelain. The rate of filtration is slow as compared with the others, but this filter remains sterile longer than any other, namely five to six days.

3.4 Municipal Filtration Systems.

3.41 WORKING MODEL OF ORDINARY SAND-BED FILTER.

This, as used for municipal purposes, is a sand-bed composed, from above downwards, of the following materials :—First, fine sand 18 in., coarse sand 3 in., fine gravel 3 in., coarse gravel 5 in., and broken brick 10 in.

3.42 MODEL OF MECHANICAL RAPID FILTER.

3.43 MODEL OF FISCHER'S SYSTEM OF WATER FILTRATION.

This consists of a series of hollow blocks made of artificial stone. The water under its own pressure, is allowed to flow into the interior of these stone blocks, and it then percolates through the stone, during which process it is subjected to filtration.

This filter is not a germ-free filter, and the system has not met with any great amount of success.

SECTION IV.—BUILDINGS AND SOILS.

The practical application of Hygiene to the structure of buildings is concerned chiefly with the prevention of dampness, the entry of ground air to the interior of the house, and the internal finish of the various rooms.

PREVENTION OF DAMPNESS.—Besides such things as leaky pipes, defective water spouts, defective roofs, etc., dampness is frequently caused by water in the soil rising up through the foundation into the walls, which are usually composed of brick work. It is astonishing how much water a common brick can hold ; Exhibit No. 4.76 shows that an ordinary brick can hold in its interstices nearly a pound of water—exactly on the same principle as a sponge sucks up water. It is not surprising therefore that the wall of an ordinary house, when thoroughly well soaked, can retain within it a vast amount of water.

Damp walls are proverbially cold, and so exert their inimical influence on the health of the inmates. Dampness can be prevented from rising through the foundation into the wall above by the interposition of a layer of Bitumen, or Glazed Tile (damp-proof courses), in the brick work just above ground level. (Exhibits 4.61 to 4.65.) This applies to houses without cellars, that is, all above ground ; in the case of a house with a basement, the wall of a basement room, next to the earth, can be kept free from dampness by having it built double, with an air space in between, in which free ventilation is arranged for ; damp-proof courses must be put in this double wall just above the actual footing of the foundation, and at the top of the wall above ground level.

The entry of GROUND AIR into a house is bad for the health of the inmates, not only on account of the noxious gas it may contain, but because it is saturated with moisture. It can readily be understood that the ground air from a sewage polluted soil, or from "made land" (land made up from house refuse), is very deleterious to health. Such ground air can be kept out of the house by covering the soil, lying within the four walls of the house, with a layer of asphalt, or of well packed pitch and cinders. This furnishes an air tight, and water tight, covering to the soil; over this is usually laid concrete, four to six inches in thickness. This forms the basement floor.

Regarding the Internal Finish of the house, the Hygienist is concerned chiefly with conditions which influence cleanliness and disinfection—for instance, anything which would harbour dust and dirt, and which could not be disinfected, would be decidedly unhygienic, as regards the internal finish of the house. It should be remembered that the dust in a house may be highly infectious, as in the case of a person suffering from some infectious disease being treated in the dwelling. Briefly, the whole question resolves itself into the consideration of walls and floors. In the case of floors, all that can be said is, that they should be hard, smooth, and as free as possible from cracks and crevices. Hard wood floors for general purposes are undoubtedly the most suitable, because they have tight fitting joints, and can be thoroughly cleaned and disinfected. In places where concrete is suitable, this makes a very good floor.

Walls generally demand more attention than floors. All horizontal ledges should be avoided as far as possible in the design of interiors; this applies to cornices, friezes, and the like, because they offer good surfaces for the collection of dust, besides providing numerous corners and crevices which are hard to clean out. The ideal finish for a wall would be something that is hard, smooth, washable, and which would not give off deleterious products; this is equal to saying that it would be some material which would not collect the dust, and which could be thoroughly cleansed by a liquid disinfectant. Exhibit No. 4.81 contains types of all materials commonly used in the wall finish, ranging through common whitewash, paint, tile, and wall-papers, up to expensive fancy tapestry.

Whitewash (lime wash) is an excellent dressing where it can be used, (suitable in stables, dairies, factories, etc.,) and its general recommendation is that it is an excellent disinfectant, as well as being cheap to apply. Paints are very serviceable dressings, but are liable to give off turpentine vapours, which have a bad effect upon the respiratory passages, and sometimes upon the kidneys. Glazed tiles are also excellent in their way, where suitable ; wall papers, apart from their colour, must be judged by their ability to fulfil the ideal conditions enumerated above. A smooth hard paper, capable of being washed, would be very good ; but all crinkled, rough, and unwashable papers, are not good from a hygienic point of view. Cloths, tapestries, and such like, are worse than papers, because they afford lodgement for any amount of dust, and can never be dosed with liquid disinfectants.

A word may be said about roofing.

Corrugated Iron is a cheap roofing, and much utilised. It is very durable. The disadvantage in its use lies in the great power it possesses of Radiation. In summer it makes the room very hot ; and conversely in winter, very cold.

A bad form of Roofing is one which will hold, or retain, a large amount of moisture, and also afford facilities for harbouring vermin—the best illustration of this is Thatched Roofing.

4.1 Stone.

4.11 SANDSTONE.

4.111 Buff sandstone, Cleveland, Ohio.
4.112 Ohio sandstone.
4.113 Sandstone, New Brunswick.
4.114 Sandstone, Scotland.
4.115 Sandstone, Scotland.

4.12 LIMESTONE.

4.121 Limestone, Montreal.
4.122 Limestone, Quebec.

4.13 GRANITE.

4.131 Granite, Stanstead, Quebec.
4.132 Granite, Nova Scotia.
4.133 Gregoire granite, Quebec.
4.134 Granite, Barre, Vermont.
4.135 Quincy granite, Massachusetts.
4.136 Scotch granite.

4.2 Brick.

4.21 PRESSED BRICK.

4.211 Pressed Brick, Ormstown, Quebec.
4.212 Pressed Brick, Milton, Ontario.
4.213 Pressed Brick, Laprairie, Quebec.

4.22 PLASTIC BRICK.

4.221 Plastic Brick, Laprairie, Quebec.

4.23 COMMON BUILDING BRICK

4.231 Common Brick.
4.232 River Brick.

4.24 FIRE BRICK.

- **4.241** Fire Brick, plain, Glasgow.
- **4.242** Fire Brick, enamelled, Kilmarnock, Scotland.
- **4.243** Fire Brick, enamelled, American.
- **4.244** Silicate Brick

4.3 Wood, used in Construction.

- **4.31** Ash.
- **4.32** Oak.
- **4.33** Maple.
- **4.34** Cotton Wood or Whitewood.
- **4.35** Pine.
- **4.36** Black Walnut.
- **4.37** Mahogany.

4.4 Roofing.

- **4.41** Specimens of Slate.
- **4.42** Specimen of Roof Tile.
- **4.43** Specimen of Corrugated Iron.
- **4.44** Specimens of Wood Shingle.

4.5 Flooring.

4.51 MARBLE.

- **4.511** American Marble, Tennesee.
- **4.512** American Marble.
- **4.513** Italian Marble, Cararra.

4.52 TILE.

- **4.521** English Floor Tile.

4.53 LINOLITH.

This material is fire-proof, and almost "sound proof." When the glaze wears off, it is somewhat absorbent.

- **4.531** Glazed.
- **4.532** Unglazed.
- **4.533** Tinted.
- **4.534** Mouldings, for rounding off the same.

4.6 Damp-Proof Courses.

4.61 Glazed Tile, perforated.
4.62 Asphalt.
4.63 Slate and Cement.
4.64 Cement.
4.65 Plain Mortar.

The materials used, are given in the order of their efficiency. Glazed tile and asphalt stand in a class by themselves, being infinitely superior to any of the others; of these two, glazed tiles are preferable to, and more expensive than, asphalt.

4.7 General.

4.71 Specimens of ingredients of Mortar, and Concrete, showing proportions.
4.72 Specimen of Tile Lining for smoke flues.
4.73 Specimen of Terra Cotta Lining for walls.
4.74 Model of Building Angle.
4.75 Specimens of Expanded Metal used in plaster ceilings and walls.

4.8 Wall Coverings.

4.81 Model showing types of various materials used for wall coverings, some good, some bad.

It contains specimens of :—

White Wash,
Distemper or Calcamining,
Paint,
Common Wall Paper,
Good Wall Paper,
Plain Glazed Wall Paper for whitening,
Plain Wall Tile,
Decorated Glazed Wall Paper,
Thick Corrugated Surface Paper,
Velvet Cloth,
Japanese Rough Surface Cloths.

SOILS.

In this Section will be considered the various kinds of soil, chiefly from the point of view in its relation to health. The actual chemical composition of the different soils is of minor importance. The principal points to which attention will be paid are :

1. The permeability of the soil to water.
2. The permeability to air and gas.
3. The water holding capacity of different soils.

1. As regards the permeability of soil to water, this is of importance in relation to drainage, sub-soil water, and water supplies derived from the latter. In examining water supplies derived from the soil, of course it is of great import to have an idea of the permeability of the soil to water, with a view to the possibility of contamination by drainage, which may be in the soil. The greater the permeability, the greater the risk of pollution, in the sense that in a very permeable soil, the drainage can travel with greater ease, and, finally, in those cases, where the soil forms an impermeable layer, the water beneath that layer, for instance, would be protected, in a large measure, from pollution in the layers above.

2. The permeability of soil to gases is also of great interest, seeing that this bears specially upon the question of ground air, and the admission of that ground air to dwelling houses. The more permeable the soil to gases, the greater will be the amount of ground air drawn into the house, under ordinary circumstances. In view of the composition of ground air, and the desirability of excluding such from dwellings, this question of permeability is of importance.

Intimately associated with this permeability is the question of composition of the soils, in so far as it concerns the gases in the soil, *e.g.*, decaying vegetable matter and such like, affecting the ground air in its own peculiar fashion.

See also reference to "made land" under Final Disposal of Dry Refuse, Section 9.

3. The water holding capacity of soils. From a health point of view, this can be put in plain language, namely, is the soil damp, or not? That is, is it capable of holding water in its interstices? As will be seen from the apparatus, and tables, the soils are arranged in the order of their water holding capacity.

It may be briefly noted that all these three points, the permeability of soil to water, and gas, and also its water holding capacity, depend entirely upon the size of the grains, and also the interstices. It is obvious that the more open the soil is, the more permeable will it be to both water and gas. As regards the water holding capacity, this, too, depends upon the size of the grains, and as it depends entirely upon the question of capillarity, the smaller the grains, the greater the capillarity. This water holding capacity is not to be confounded with that of the quantity of water that one is able to pack in the interstices of a soil, it is essentially the quantity of water that the soil is able to suck up, and hold, in its interstices by capillary action, which is quite a different matter.

4.91 Samples of Soil.

4.911 Rock.
4.912 Gravel.
4.913 Sand.
4.914 Clay.
4.915 Loam, or Humus.
4.916 Sandy Loam.
4.917 Peat.
4.918 Made Soils, *i.e.*, Soils containing House Refuse.

4.92 Analytical Apparatus.

4.921 ELUTRIATOR,

or apparatus, for separating a sample of soil into its various parts, by a process of washing and sedimentation.

An idea of the composition of the soil may be obtained by the use of this apparatus, and depends upon the fact that the heavier particles sink more rapidly than the finer particles; so that, on settling, the soil separates out in its different layers, *e.g.*, rock (gravel) below, then sand, then clay, and finally humus on top. By the use of the foot rule, a rough percentage composition is thus obtained.

4.93 Permeability of Soil.

4.931 APPARATUS EXHIBITING THE PERMEABILITY OF SOIL TO AIR.

This exhibit shows very well how permeable an ordinary sandy soil is *e.g.*, to air, very slight pressure indeed being sufficient to force the air through a couple of feet of the soil. The closer the texture, the more pressure will be required, and, in this connection, it may be noted that if the interstices of the soil be occupied by water, the whole mass practically becomes impervious to air; but the interstices unoccupied by water are always occupied by air or gas.

4.932 TABLES SHOWING THE ORDER OF PERMEABILITY TO GASES in the various kinds of soils.

4.933 TABLE SHOWING COMPOSITION OF A SPECIMEN OF GROUND AIR.

The special points to be noted are the large percentage of CO_2 and of moisture (H_2O.)

4.934 TABLE SHOWING PERMEABILITY OF SOILS TO WATER.

This table simply shows the rate at which water, or sewage, can run through a given sample of soil; it is important from the point of view of polluting materials travelling through the soil and contaminating water supplies.

4.935 TABLE SHOWING THE WATER HOLDING CAPACITY OF VARIOUS SOILS.

As has already been noted, the water holding capacity depends entirely upon the capillary attraction.

4.936 Model exhibiting the different powers which various soils possess of drawing up water, and holding it in its interstices, in other words its capillarity. It shows very well that the smaller the grains, and the interstices of the soil, the more marked the capillary attraction.

SECTION V.—VENTILATION AND METEOROLOGY.

VENTILATION.

The object to be attained in practical ventilation is a rapid and efficient removal of the vitiated air, and the introduction of good fresh air to replace it. It is important at the outset to have a clear idea of the position assumed by the foul air in an inhabited room. The products of respiration in rooms vitiate the air, and render it hot, and this heated air ascends and lies in a layer against the ceiling. This can easily be proved by simply putting one's hands next the ceiling in any inhabited room, when a layer of warm air can readily be felt.

It might be as well to note that the inmates of a room occupy the lower half of the room space ; such being the natural conditions, any arrangement for effecting ventilation must obviously consist of an outlet, placed at the very top of the room, so as to provide the speediest exit for the foul air, and an inlet at the bottom to permit the entry of the fresh air in the lower part of the room, where it is most wanted by the inmates, and where it is least liable to become mixed with the foul air. The incoming fresh air is always cooler than the vitiated air

The schemes of ventilation are divided into two classes—natural, and artificial.

Natural Ventilation depends for its working upon natural agencies, or forces. These comprise movement due to difference of density, and the action of wind :—suction and perflation.

(1) Movement due to a difference of density depends upon certain physical laws which are explained as follows: Take two boxes, each exactly measuring one cubic foot, and open at the top ; then fill each with air at 0°C. Next heat one of them to 20°C. ; we shall then find that the air in this box will expand $\frac{20}{273}$ of its volume, the pressure

remaining the same. Hypothetically we may look upon this gas as expanded upwards, as it cannot expand laterally, or downwards, and the gas would rise out of the box to the height of $\frac{20}{273}$ of 1 foot, as the box is 1 foot cube. If we could imagine this expanded part of the gas, which hypothetically projects from the box, to be sliced off, leaving the box still full of air at 20°C., we should see on weighing the gas that it had lost $\frac{20}{273}$ of its weight. If now we placed these two boxes of air on the arms of a frictionless balance, the air at 0°C would be heavier than that at 20°C., and the heavier side would force the lighter one upwards.

Next take a cylinder ten feet high, divided exactly into two halves by a partition running down the centre, with an opening governed by a stop-stock at the bottom; let this cylinder be filled with air at 0°C. and let one-half be heated to 20°C., the other half remaining at 0°C.

The air in the heated section will expand upwards to the height of $\frac{20}{273}$rds. of ten feet.

This is theoretical of course, for in actual practice the expanded part would flow away; if now the stop-stock be opened, the air at 0°C. will flow through the opening to the warmer side, and force the heated air upwards until the balance is restored. In fact we have a repetition of the conditions in the preceding experiment. If it be arranged that the cold air, as it flows into the warmer section, shall be immediately raised to the temperature of 20°C., we shall have a continuous current set up—this is well exemplified by Exhibit No. 5.11.

The rate of flow can be determined by the well known physical law of falling bodies, $V=\sqrt{2gh}$.

$V=$ velocity in feet per second. $g=$ gravity, a constant 32, and $h=$ height through which the body has fallen.

As g is a constant 32, we can write the formula $V=8\sqrt{h}$.

It will be the same as if a body were allowed to fall in vacuo through a distance corresponding to the height of the expanded part, which air at 0°C. would assume if heated to the same temperature as that of the warmer air, in this case, 20°C.; we have already seen that this theoretical height measures $\frac{20}{273}$ of ten feet.

H in this case $=\frac{20}{273}$ of ten feet, and this was ascertained as we have seen from two factors—(1) rise of temperature, 20°C., (2) the height of cylinder which ten feet; so that we may now write the value of h in the preceding formula to suit all cases as follows:—

$$V=8\sqrt{\frac{\text{difference of Temp.} \times \text{Height between Inlet and Outlet}}{\text{273 for deg. C. or 491 for deg. F.}}}$$ ✓

This is the well known Montgolfier's formula, and is important, not so much as showing rates of flow of air in ventilation schemes, as to explain why, under certain conditions, we get no flow of air at all; for obviously if either of the factors under the square root sign be reduced to zero, the value of V becomes zero. These physical considerations form the key-note to the whole of natural ventilation, for if we now substitute the wall of a room for the cylinder, we practically get a repetition of our experiment.

If we have the same temperature outside and inside, or, if there be no difference in level between the inlet and the outlet, we get no movement of air, because we have reduced one of our available factors to zero, and the result of this is pointed out under Montgolfier's formula.

(2) Action of Winds—Perflation and Suction. If we have windows, or other openings, on opposite sides of a room, and the wind be favorable, we shall get a very forcible draught of air through the room. This is known as Perflation. Under certain conditions, it is a very favourite means to natural ventilation, for it enables us to sweep out the air contents of a room in a few minutes.

Suction is caused by the wind when it blows at right angles over an air opening. In actual practice it would be rather rare that the wind would blow across the opening at this precise angle, and in order to utilize the suction force of the wind, when directed towards the opening at any angle, Cowls are used. These are mechanical contrivances which will not admit of a down draught, no matter which way the wind may be blowing.

Specimens of these are seen in Exhibits Nos. 5.41 to 5.44.

As a practical point, the best made cowls always offer a certain amount of resistance to the free exit of air; due allowance therefore should be made for this by increasing the outlet opening, on which the cowl is placed, by about 15 to 20% of its sectional area.

Having dealt with the forces employed to effect an interchange of air, we next proceed to discuss openings—Outlets and Inlets.

OUTLETS are for the most part simple openings communicating with the outside, either directly, or indirectly by means of some form of conduit. On occasion this flue may be warmed, thus causing a slight exhaust in the shaft, and so aiding the exit of the foul air.

INLETS on the other hand are mechanical devices which are always intended to impart an upward tendency to the incoming fresh air. Various forms are ~~on the market~~, but all have this common characteristic. (See Exhibits Nos. 5.21 to 5.27.)

This upward direction is given to the incoming air, because it is cooler than the air inside the room. If it were allowed to enter through a plain opening, it would simply flow over the floor like so much water. By sending it upwards, we deliver it in the room at a height more suitable to the inmates who have to breathe it. The height at which the internal openings of inlets are fixed in the wall is about four feet above floor level, to obv~~iate~~ draughts directly on the inmates.

If placed higher we should be bringing it nearer to our outlet level, thus diminishing the height of our column of air, which we have seen tends to lessen the velocity of inflow. (Vide Montgolfier's formula.)

Many ventilation schemes have been rendered useless for this very reason, having been installed by people who do not understand the principles of natural ventilation, and who thought that any two openings into a room would be quite sufficient to act as inlet and outlet, irrespective of their relative heights.

THE AMOUNT OF FRESH AIR REQUIRED PER INDIVIDUAL.

Experiment has shown that the average individual gives off by respiration .6 of a cubic foot of CO_2 per hour. ✓

By experience also it has been found that if this expired CO_2 exists beyond the extent of .02% in the atmosphere of a room, that it is accompanied by a fœtid odour, due to certain organic matters in the expired air. As the amounts of these two chemical constituents go hand in hand, the amount of expired CO_2 is always taken as a measure, when testing the condition of the air in a room for ventilation purposes.

If we now take the .6 of a cubic foot of expired CO_2 and dilute it down with pure fresh air, so that it shall not exceed .02% in the mixture, we shall find that we require 3000 cubic feet of fresh air to accomplish this. This is taken as a basis of good ventilation, so that each person ought to be supplied with at least 3000 cubic feet of fresh air per hour.

SIZE OF INLETS AND OUTLETS.—The amount of fresh air to be supplied per hour, is necessarily governed by the number of inmates in a room, each one needing 3000 cubic feet. In practice we find that a rate not exceeding 5 feet per second is the most suitable to allow the incoming fresh air to enter through the inlet; otherwise sensible draughts are caused. The area of the inlet can therefore easily be calculated by the following formula:

$$\text{Sectional area} = \frac{\text{Volume}}{\text{Velocity}}$$

We should require an opening, or an inlet, 24 square inches in area, in order to permit 3000 cubic feet of air to pass through it in one hour, (or .833 cubic feet per second), travelling at a rate of 5 feet per second.

In practice it is better to distribute the incoming air through several inlets, than to bring it all through one, as better interchange is caused thereby; but it should be noticed that the cross-sectional area of these inlets should total up the same as that calculated for the single opening.

Outlets are openings very simple in character, no mechanical devices being required at all; they are simply to provide exhaust for the foul air; they should, like the inlets, be able to allow of the passage of the necessary amount of air per hour required for ventilation.

With reference to relative size of inlets and outlets, it has been found by experience to be good practice to increase the size of the inlets over the outlets by about 15 to 20%; especially is this the case where we have to deal with open fireplaces, for the chimney always acts as a powerful exhaust, drawing air from the room; necessarily an extra amount of fresh air from the outside must be brought in to supply their needs. If such provision be not made, and inlets and outlets balance one another in area, it commonly happens that some of the openings which are intended to act as outlets become converted into inlets. This is shown very well in working model Exhibit No. 5.51, which demonstrates the conditions for carrying out natural ventilation in a room.

ARTIFICIAL VENTILATION SCHEMES.

The contrast between Natural and Artificial ventilation schemes is very sharply defined. In the former we were absolutely dependent upon natural agencies, or forces, for our working power, that is to say, to cause an interchange of fresh and foul air; in the latter we are quite independent of natural forces. Under these artificial schemes the air can be either forced into a room, or sucked out of a room, or we may have a combination of the two. The motive power in nearly all instances is some form of fan or blower. The commonest type of fan is shown in Exhibit No. 5.61, and this is capable of producing a pressure of about three or four inches water. A more modern type, known as the Sirocco fan (Exhibit No. 5.63) works on the centrifugal principle, and is capable of giving a much higher pressure—eight to ten inches of water, or more. Where very high pressures are needed, as in the case of blowing air down a mine, and such like, regular blowing machines have to be employed ; however, as we have to deal mostly with houses and institutions, we employ fans for such purposes exclusively.—Nearly all fans now-a-days are driven by electric motors.

Under natural ventilation schemes, it will be remembered that we had to utilize the air which was available at the external openings of the inlet. We can readily understand that under certain circumstances the air might not be of very good quality—for instance, if the inlet opens on to a dusty street, or near any collection of refuse. In all cases the incoming fresh air is admitted into the lower part of the room, and the foul air escapes from the top part of the room.

In artificial ventilation schemes on the other hand, by the aid of these fans we can draw in our fresh air from any point we choose, and we can likewise make it enter the room, either at the top, or at the bottom, wherever we wish ; we do not depend on such things as difference of temperature, action of wind, etc. Another point of contrast is that we are enabled to treat the incoming air in many ways—it can be washed ; it can be heated ; warmed ; or cooled, etc. ; all these processes necessarily involving a great amount of obstruction to the free entry of air, which in the case of natural ventilation would, in most instances, entirely prevent its entrance. Having treated the air, it is then distributed to the various rooms of the house, or institutions, by means of suitable conduits. There are three systems practically in artifical ventilation :

(1) Extraction method; (2) Propulsion method (Plenum System); (3) Combination of Propulsion and Extraction.

The names indicate quite clearly the mechanical principles involved. In the first method the air is sucked out of the room through a conduit opening, which communicates with the general extraction shaft, at the end of which is placed a fan ; the fresh air is permitted to enter the room from a fresh air conduit, so replacing the foul air which has been extracted.

Under the Propulsion, or Plenum System, the fresh air is driven under pressure into the room, the foul air making way for it by escaping into the foul air conduit, which communicates with the outside. In both of these systems only one fan is utilized either for extraction, or propulsion purposes.

In the Combined system two fans are employed, one to extract the foul air, and the other to force in the fresh air. This system has proved to be the most satisfactory, because where only one fan is employed, the friction entailed in a long ramifying system of conduits is decidedly appreciable, and as one proceeds further and further from the fan along the conduits, the current of air gets less and less perceptible according to the distance ; briefly put, the rooms nearest to the fan, no matter whether Extraction or Propulsion, are acted upon more powerfully than the rooms further away. From experience it seems to be quite impossible to balance things by means of register openings.

If the combined system be now considered in this light, it will be seen that a very good balance is struck in the air supply to all rooms, for if we consider the Propulsion fan, we find that the rooms nearest the fan are the best supplied, and that the rooms furthest away are the worst off in this respect; but as the Extraction fan is situated on the other end of the system, so to speak, the room, which was the worst supplied by the Propulsion fan, would be the one most affected by the Extraction fan ; so we can say that what is lost on the Propulsion side is made up on the Extraction side, and an even balance is struck throughout.

As regards the Inlets and Outlets in artificial ventilation systems, as remarked above, they can be placed in any part of a room we may choose. Fashion seems to have decreed that outlets shall be placed in the lower part, and inlets in the upper part of the room. This seems to be flying in the face of natural conditions, for it was pointed out previously that foul air, by a natural tendency, accumulates in the upper part of a room. It appears, therefore, almost a physical impossibility to introduce fresh air through an opening in the upper part of a room, and bring it down to the level of the occupants, without producing a considerable admixture of the fresh air with the foul air. It is claimed by some people that owing to the Extraction openings being placed in the lower part of the room, the foul air given off by respiration would be drawn down towards these openings.

As a matter of fact this reasoning is very fallacious, for the moment the expired air leaves the body, owing to its markedly heated condition, it rises very rapidly to the ceiling, and if one desired to draw it downwards, in the face of its upward tendency, a current of air of almost hurricane violence would be required to accomplish this. By reversing the order of inlets and outlets, and placing in artificial ventilation schemes inlets at the bottom, outlets at the top, it is more reasonable to suppose that the incoming fresh air would have a much better chance of reaching the occupants of the room in a pure state, that is, without admixture with foul air, than when it is admitted at the top. There is apparently some reason for this unnatural reversal in the order of openings; we can easily understand that where a given temperature is to be maintained in a room, (say 66°), the incoming air, when fed from the inlet situated in the lower part of the room, must of necessity possess the same temperature; whereas if admitted through the openings placed near the ceiling, it could be a degree or two less, because in its passage downwards through the hotter layers of air near the ceiling, its temperature would be raised. If this point be taken into consideration, the whole question resolves itself into one of economy, and perfect ventilation becomes of secondary importance.

The economic aspect naturally demands attention, for when dealing with large schemes, the raising of the temperature of the incoming fresh air through two or three degrees, entails a perceptible addition to the coal bill, when the year's expenditure is being discussed. However, I do not think that the economic aspect should outweigh perfect ventilation.

One or two points of practical interest in connection with artificial ventilation schemes should be noticed in those installations where the incoming fresh air is washed, warmed, and moistened. The washed air passing through the spraying machine must be warmed beforehand, and during the cold weather, in order to avoid heating up large quantities of water for this purpose, a small quantity of hot water is used over and over again. Under these circumstances the wash water becomes extremely dirty; it then has to be changed ; but it surely cannot be hygienic under any circumstances, to wash the air with dirty water :—but here again in practice the economic question obtrudes itself. The second point deals with the system of conduits. Unless the shafts are efficiently and frequently inspected they are apt to be covered on the inside with large accumulations of dust and dirt. Frequent cleaning is very necessary therefore, but one not infrequently comes across installations affording very little, if any, means of access to the conduits for this purpose.

CUBIC SPACE.

Closely connected with the rates at which air is supplied to a room, is the important matter of cubic space. Experience has shown that the air in any room can be changed completely three times within the hour, without causing perceptible draughts ; in practical ventilation we have to pay particular attention to creation of draughts, because the average person will not tolerate them for a moment, and would promptly close up any ventilation opening from which the draughts issue. Taking as our basis, or standard, the changing of the air in a room three times per hour, and having established that it is necessary to supply each individual with 3000 cubic feet of fresh air per hour, it obviously follows that the cubic capacity, or cubic space as it is called, allotted to each individual in a room should be 1000 cubic feet; by changing the air in this 1000 cubic feet of space three times in the hour, we should pass through that space the necessary 3000 cubic feet of fresh air. If this ideal spacing be not allotted to each individual, we then have a condition known as "overcrowding," that is, too many people within a given space. In such circumstances we get serious interference with our ventilation schemes. Let us take an instance where an individual has only 500 cubic feet of space instead of the regulation 1000; in order to supply 3000 cubic feet of fresh air in an hour, we must change the air in the 500 cubic feet of space, six times in an hour. This would give rise to very sensible draughts, and it is very certain the average person would shut off the incoming fresh air, which would result in very deficient ventilation.

Overcrowding is seen most frequently in the poorer parts of towns and cities, particularly the slum districts, and the deficiency, or lack of ventilation, in these dwellings, consequent upon overcrowding, exerts a very deleterious effect upon the health of the inmates, particularly young children. In good class residential property the cubic space more often than not exceeds the regulation standard. In such institutions as hospitals, where ventilation is an extremely important factor, the amount of cubic space per individual is never less than 1500 cubic feet, and in Infectious Diseases Hospitals frequently exceeds 2000 cubic feet.

The measurement of the cubic capacity of any room is an easy matter to perform, involving merely a simple knowledge of mensuration. All rooms can be divided up into rectangular, triangular, conical, spherical, or cylindrical figures. In practice most rooms are found to be of a rectangular nature, and it is rare to come across dome, or gable ceilings, or any extension of rooms involving the columnar, triangular, or spherical figure. Exhibit No. 5.15 is a series of models which not only demonstrate the methods of calculating cubic capacity, but show the relationship which these various geometrical figures bear to one another.

EXTERNAL VENTILATION.

Having dealt with the ways and means of introducing fresh air to buildings, the subject would be incomplete without reference to conditions immediately outside the buildings, which might seriously detract from the good quality of the air to be taken into the houses for ventilation purposes.

The external air is at times rendered stagnant through faulty arrangement of contiguous buildings; for instance, a large light and air well, situated in the centre of a block of flats—a narrow street bordered by tall buildings, and more particulary if such a street ends blindly, that is, a "cul-de-sac"—are common conditions leading to the stagnation of the atmosphere, partly because the sun cannot get at it to warm it up, and partly because the wind cannot gain proper access to stir it up. Again there may be conditions like collections of filth and dust, the air in these cases becoming laden with noxious gases, germs from the filth, and dust particles. All these unfavorable conditions affecting the outside air, influence natural ventilation schemes more than the artificial class, because under the former we have to take the air as it exists immediately outside the external openings of our inlets, whereas under the artificial schemes we can draw the air from any point we like; we can take it from a point above the roof, if we are so minded; we may also wash and filter the air under the artificial methods, whereas such a thing is not possible in any form of natural ventilation, because the obstruction offered to the flow of the air will be so great, and the natural moving forces are so very weak even at the best, that it would result in stoppage of the incoming fresh air. As regards elimination of dust, the installation of fine gauze screens in such a position that all the incoming fresh air passes through them, will frequently produce good results.

OFFENSIVE AND DANGEROUS TRADES.

These are trades, or processes, giving off gases or particles which may be either dangerous or offensive, or both combined—they can be classified very conveniently as follows:—

(1) Offensive trades deal more particularly with the handling of animal organic matter, such as bone boilers, glue makers, tallow chandlers, tripe boilers, leather dressers, fellmongers, etc.,—all of them giving rise to very offensive fumes ; they do not seem to be poisonous however, or to be in any way definitely dangerous to health. The general principle of the apparatus designed to mitigate the nuisance is practically the same in all cases ; the noxious fumes emitted from the cauldron, or boiler, in which the animal matter is being treated, are carried away by means of a draught flue, communicating with the hood covering in the boiler ; but before the fumes are allowed to escape into the open air, they are passed through a fire which effectually cremates the gases causing the nuisance.

(2) Dangerous trades relate chiefly to occupations in which particulate matters are given off mostly in the form of dust ; but such trades as are carried on in chemical works, occasionally give rise to gases like Chlorine, Hydrochloric Acid, Ammonia, etc., which are highly irritating to the respiratory passages of the workmen.

The suspended particles are conveniently divided again into classes ; firstly, those which are irritating to the lungs, and respiratory passages, but not actually poisonous in themselves; the second division comprises all dust particles of a poisonous nature, which may, or may not, be irritating. Occupations giving rise to dust particles, comprised in the first division, are exemplified by the following:—Stone Masons, Wood Workers, Knife Grinders, Millers, Coal Miners, etc., the effect produced by these irritating, but non-poisonous particles, is a chronic irritation to the mucous membranes lining the respiratory passages and lungs, which, if continued for any length of time, eventually leads to Fibrosis of the lungs, a condition extremely favorable for the grafting on of tuberculosis.

Examples of trades producing poisonous particles, are Plumbers, Glaziers, Workers in White Lead, Earthenware Manufacturers—all liable to lead poisoning; Brass Workers, and Copper Workers, are prone to copper poisoning: Gilders, and Mirror Makers, may suffer from mercurial poisoning.

All ventilation schemes, designed to safeguard the workers in these various dangerous trades, follow one general principle; they are artificial ventilation schemes, worked on the extraction plan, the idea being to forcibly abstract the air containing the dangerous gases, or particles, and thus to prevent the workpeople from inhaling them. Obviously, in most instances, the dangerous gases, or particles, should not be allowed to escape freely outside the building, for there they may be a source of danger to other people, and therefore, in these schemes, one generally finds some suitable arrangement for abstracting the dangerous substances from the exhaust air—dust particles are usually washed out of the air; dangerous gases are absorbed by passing them over some suitable chemical, which will combine with them, and fix them.

OCCUPATION	Comparative Mortality Figure, Years 1890-92.
Normal Mortality for England and Wales.	1000
Tanners, Fellmongers	756
Corn Millers	845
Coal Miners	935
Stone Masons	1001
Plumbers, Painters, and Glaziers	1120
Copper Workers	1123
Cotton Workers	1176
Dyers	1370
Tin Miners	1409
File, Needle, and Saw Makers	1412
Innkeepers	1642
Potters, Eathenware, etc., Manufacturers	1706

5.1 Physical Apparatus.

5.11 APPARATUS SHOWING THE EFFECT OF DIFFERENT DENSITIES

on two columns of air, exactly the same size.

5.12 ANEMOMETER RECORDING THE VELOCITY OF AN AIR CURRENT.

5.13 CYLINDER FOR COLLECTING SAMPLES OF AIR, WITH EXHAUST, AND GAUGE.

The cylinder is first of all exhausted of air, the taps are then closed, and the cylinder can be transported to any point where a sample of air is desired.

One of the stop-cocks is then opened, the air rushes in, and so the sample is taken.

When it is desired to analyze the sample, the air is displaced from the cylinder by water, and collected.

5.14 WORKING MODEL SHOWING POROSITY OF AN ORDINARY BRICK.

It is astonishing what an amount of air will pass through an ordinary brick, under slight pressure.

5.15 MENSURATION MODELS.

5.2 Air Inlets.

5.21 MODEL OF TOBIN'S TUBE, ON STAND,

the wooden partition representing the wall of the house.

The long curved-up portion is the inside. Inside the tube is a small valve for regulating the amount of air.

5.22 MODEL OF TOBIN'S TUBE, DETACHED.

This possesses a small screen, otherwise the same in all respects as 5.21.

5.23 MODEL OF TOBIN'S TUBE, SHORT VARIETY.

The valve and dust screen are the same as in the preceding variety.

5.24 MODEL OF COOPER'S LOUVRE.

This slotted window is usually placed at the top of the room, the slots are so arranged as to give the incoming air an upward direction towards the ceiling. From its position with reference to the other parts of the room, experience has shown that, more often than not, it acts as an outlet, and not as an inlet.

5.25 MODEL OF HINCKS-BIRD WINDOW.

This simple arrangement, whereby the lower sash of an ordinary window is raised by means of a plug of wood, is eminently suitable for poor property, where expensive ventilators cannot be afforded. The incoming air finds its way into the room between the two sashes, and by virtue of the arrangement, is given an upward tendency.

5.26 WORKING MODEL OF ELLISON'S BRICK.

This apparatus is very useful for ventilation below floors, and in some instances for common living rooms.

It consists of a brick of ordinary size, in the centre of which, one or two holes are bored.

The holes are of conical shape, the smaller end is the outside, and the larger end is the inside.

This conical opening prevents the incoming air from impinging upon any object in the room with too great a force or velocity, for, when the model is worked, it can be seen how beautifully diffused the current of air is, and also, how much less is the velocity of the air at the inner opening than it is at the outer opening.

5.27 WORKING MODEL OF SHERRINGHAM'S VALVE.

This apparatus is usually fixed in the upper part of the room, and is intended to act as an inlet, but, by virtue of its position near the ceiling, more often than not acts as an outlet.

5.3 Air Outlets.

5.31 MODEL OF MICA-FLAP VALVE.

This is placed in the upper part of the room, and allows communication from the room to the chimney, but not vice-versa. The apparatus when new acts very well, but after it has been used for a time, the hinges of the flaps begin to rust, and become fixed, so that the valve no longer works.

5.4 Extraction Apparatus.

5.41 MODEL OF SIMPLE BI-VALVE COWL.

5.42 BOYLE'S AIR PUMP VENTILATING COWL.

The working principle of this is the same as 5.41; the chief object for which it is used being more of an extraction shaft than to prevent back drafts.

5.43 BOYLE'S IMPROVED AIR PUMP VENTILATING COWL.

The working principle is precisely the same as 5.42.

5.44 MODEL OF BOYLE'S AIR PUMP VENTILATING COWL.

5.45 DIAGRAM SHOWING PLANS OF BOYLE'S APPARATUS as applied to school rooms, houses, etc.

5.46 FULL SIZED COWL TILE FOR CHIMNEY STACK.

5.5 General Apparatus for Ventilation.

5.51 WORKING MODEL, BUILT TO SCALE,

showing rectangular room with fire-place, chimney, inlets, and outlets.

It illustrates the principles of ventilation as carried out by natural forces, and shows very beautifully the relationship that ought to exist between inlets and outlets, viz., that the inlets ought to be, in total area, rather larger than the outlets.

If this be not the case, as shown by the model, some of the outlets will be converted into inlets.

5.6 Artificial Ventilation Apparatus.

5.61 Specimen of Ordinary Fan.

5.62 Specimen of Rotary Blower.

5.63 Specimen of Sirrocco Fan.

5.64 Plan of an Artificial Ventilation Scheme, showing different apparatus incorporated.

5.9 Meteorological Instruments.

5.91 Wind Gauge.

This records in miles, and fifths of miles, up to a total of 500. It shows the movement of the air in a given time, and from this the velocity is calculated.

5.92 Ordinary Rain Gauge.

This reads down to $\frac{1}{100}$ of an inch.

5.93 Thermometers.

5.931 Maximum and Minimum Thermometer (Six's).

5.932 Radiation Thermometer.

This instrument is used for recording the direct heat of the sun's rays; it consists of an ordinary thermometer, the bulb of which is blackened, placed inside a vacuum tube; the latter is used so as to prevent any error by conduction, due to the temperature of the surrounding air. 7

5.933 RECORDING THERMOMETER OR THERMOGRAPH (7 days).

This instrument requires to be standardized by means of a good mercurial thermometer. The record is fairly accurate to within about a half a degree.

5.94 BAROMETERS.

5.941 FORTIN'S STANDARD BAROMETER.

This is an excellent instrument, where exceedingly accurate observations are required. It is very necessary always to see that the surface of the mercury, in the cup below, just touches the ivory point.

The ivory point records zero on the side scale. By means of the vernier, readings can be taken to $\frac{1}{500}$ of an inch, or $\frac{1}{10}$ of a m/m.

In very accurate observations, corrections for temperature, altitude, and expansion of brass casing must be made ; in ordinary work, the co-efficient of expansion of metal can be ignored.

Corrections for altitude may be roughly taken as an inch of mercury to one thousand feet in height.

For temperature $\frac{1}{10000}$ part of an inch of mercury for every degree F.

5.942 RECORDING BAROMETER OR BAROGRAPH (7 days).

This instrument has to be standardized by means of a mercurial barometer, and works fairly accurately to about $\frac{1}{10}$ of an inch.

5.95 SUN-SHINE RECORDERS.

5.951 CAMPBELL-STOKES' SUN-SHINE RECORDER.

This instrument records the amount of actual sunshine, not day-light. The instrument must be carefully adjusted; the lower end must point due south, and the angle of declination must correspond to the latitude of the place.

The glass ball acts as a perfect lens with 1¼ inch focus; the sun's rays are thus brought to a point on the paper, where a hole is burnt, and as the earth moves, this focal point moves, leaving a burnt track along the paper, indicating the actual time that the sun is not obscured in any way.

5.96 HYGROMETERS.

5.961 DANIEL'S HYGROMETER, direct method.

This instrument records the actual temperature at which the dew is deposited.

5.962 HAIR HYGROMETER.

This instrument is by no means accurate.

5.963 WET AND DRY BULB THERMOMETERS.

This is the indirect method of calculating the dew point, and is the one most commonly used.

It depends upon the fact that the drier the air the faster will be the evaporation, and as the evaporation causes lowering of temperature, so will the wet bulb differ from the dry.

By a series of tables, the dew point is calculated from these differences of temperature.

5.964 SLING WET AND DRY BULB THERMOMETER.

This is the most accurate instrument for determining the dew point, which can be put to practical use.

By the rapid movement of the bulbs through the atmosphere, the maximum amount of evaporation is secured; in this respect it differs radically from the ordinary stationary wet and dry bulb apparatus, as exemplified by exhibit 5.963.

5.965 HYGRODEIK PATTERN.

This instrument is virtually the same as 5.963, except that calculation tables are attached to the instrument.

SECTION VI.—FOOD STUFFS.

Food stuffs are necessary to the body, for the purposes of growth and repair, and also to supply heat, and energy.

In order to deal scientifically with all articles of diet, they must be reduced to a water-free condition, because the amount of water in fresh food materials is never a constant factor—all remarks, therefore, will apply to food stuffs in a water-free state. By many forms of experimentation, it has been ascertained that, to the average person, a certain amount of Proteid, Carbohydrate, Fat, and Salts must be furnished each day for the bodily requirements above mentioned.

DIET TABLE.

	Subsistence Diet.	Ordinary Work.	Laborious Work.
	Ozs.	Ozs.	Ozs.
Proteids	2.0	4.5	6.5
Fats	0.5	3.5	4.0
Carbo-hydrates	12.0	14.0	17.0
Salts	0.5	1.0	1.3
Total water-free food .	15.0	23.0	28.8

All stuffs are, therefore, conveniently described as containing a definite proportion of these components; a perusal of the analytical tables in the Diagram Exhibits will convey an idea of the percentage composition of all articles used as food stuffs.

In order to maintain the body in a perfect condition of health, the daily diet must contain the minimum requirement of Proteid, Fat, Carbohydrate, and Salts. The art of constructing a proper dietary is founded upon this knowledge; any combination of the ordinary articles of food may be chosen, so long as they are palatable, and contain the necessary components.

Before proceeding to consider any dangers to health, which may be connected with foods, the deleterious influences of over-eating, and under-feeding, should be taken into account; the former over-taxing the healthy bodily functions, particularly those of digestion, and excretion, eventually leading to disease, if persisted in; the effect of the latter will be patent to everybody, absence or scarcity of food, lead to wasting of the tissues, through lack of nourishment, and when carried to extremes, end in death.

When considering actual transmission, or production, of disease by food stuffs, in practice, it will be found that there are a few principal food stuffs chiefly concerned, and that it is unnecessary to wade through the possibilities connected with each separate article of diet, in every day use; for instance, vegetables, as a class, are not in this way responsible for any particular troubles; perhaps the only danger connected with them, is the germs in water with which they may have been sprinkled, to keep them fresh.

Cereals, again, are not of great practical moment, except perhaps it be noted that in the case of rye, wheat, and barley, ergotism occurs occasionally in some countries.

Flesh meats, and fish, are very important articles of diet in regard to the transmission of disease. They may be the means of conveying definite diseases, from which the animals or fish actually suffered whilst alive; or they may cause disease by some process of contamination, or putrefaction, which has taken place subsequent to the killing of the animals.

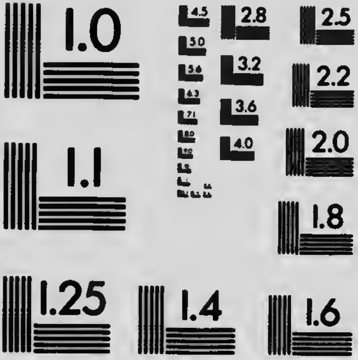
FLESH MEATS.—The prevention of disease carried, or transmitted, by flesh meats, opens up the important question of inspection of these food stuffs in all phases of handling, from the time when the animal is brought to the slaughter house, to the time when it reaches the consumer—in other words, the sanitary control of all places where animals are slaughtered, and where flesh meats are exhibited for sale. The diseases from which the living animal suffers, and which may be transmitted to man, when the meat derived from such animals is consumed, are as follows:—Tuberculosis, Actinomycosis, and various parasitic worms; the animal may likewise suffer from such diseases as blood poisoning, various forms of cattle plague, abscesses, etc., and the meat may be answerable directly for violent disturbances in the health of the people consuming it, but these illnesses are more of the nature of what we may term ptomaine poisoning, as distinguished from the actual reproduction of the disease from which the animals suffered. Again, meats may be contaminated during the process of slaughter, and while exposed for sale, by the people who conduct these operations; or from unsanitary surroundings, to which the meat is exposed during these phases; the meat in these cases may be considered as a simple carrier of the disease, it may have been healthy and sound enough to begin with, but by being exposed to these sources of infection, it may be answerable, indirectly, for the transmission thereof. For instance, it is conceivable that butchers suffering from some disease as Tuberculosis, or Typhoid, may contaminate the meat by introducing the respective germs; again, in insanitary surroundings, germs derived from defective drains, or putrefactive germs from filthy surroundings, may be introduced to the meat,—or bad conditions of keeping such articles, as want of proper refrigeration,—all of these being conditions favouring putrefaction of meat, and answerable directly for such diseases as Ptomaine poisoning.

Specimens of diseased meats will be found in Exhibits Nos. 7.11 to 7.26.

Tuberculosis is, perhaps, the one disease affecting meat, which lends itself, more than any other, to fraudulent practice; because diseased carcases can frequently be "doctored up," so as to make the detection of the presence of disease very difficult.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

Often the Tuberculous lesions are limited to lymphatic glands, and the serous membranes, more particularly the serous lining to the thoracic cavity. In such cases, by excising the affected glands, or stripping off the diseased pleural membrane, ("stripped meat"), all evidence as to the unfitness of the meat is gone. All carcases, which show signs of having been manipulated in this fashion, should be looked upon with grave suspicion. Again, it is only in places where no inspection is carried out during the process of slaughter, that such practices are possible.

Actinomycosis, a disease also connected with cows and oxen, is generally known as "lumpy jaw."

Diseases, like blood poisoning, and various forms of cattle plague, are found amongst all kinds of animals used for food, e.g., cattle, calves, sheep, and pigs.

As regards the parasitic worms, different varieties infest different animals; Liver Fluke, in the livers of sheep,—Tenia Mediocanellata is usually associated with cows; Trichina Spiralis infests pigs, likewise does Tenia Mediocanellata.

In the Tenia (tape worm), the embryos are found scattered through the carcases of the animals, and give rise to what is technically known as "measly beef," or "measly pork," the appearances presented by the meat being suggestive of these terms, the embryos existing in little white cysts, dotted throughout the meat.

Another important member of the tape worm class, connected with meat, is Tenia Ecchinococcus; this is a parasite answerable for hydatid cysts, a disease occurring both in man and animals.

All these tape worms go through a regular cycle of phases in their life history, and it is important that these phases should be well understood, in order to comprehend the results. The host in which the worm resides may be either man, or animal; the eggs from the adult tape worm find their way out with the intestinal discharges, and start upon an extra-corporeal existence; they are then introduced to a fresh human or animal body, by the mouth, and entering into the Gastro-Intestinal tract, begin to develop into the embryo stage; these embryos penetrate the intestinal wall, and find their way into the various tissues throughout the body; there they become encysted, this is known as the "cystic stage"—in most cases these cysts are small, as in "measly beef," or "measly pork," but with Tenia Ecchinococcus, the cysts are large—"hydatid cysts." When flesh, containing these cysts, is eaten by man, or animals, the encysted embryos are set free in the intestinal canal of the new host, there developing into the adult tape worm; so the cycle of the life history of the tape worm is completed.

In the case of Tenia Mediocanellata, Tenia Solium, and Tenia Bothriocephalus Latus (found in fish), the cystic stage is in the animal body, the flesh of which, being consumed by man, gives rise to tape worm in the human body.

In the case of Tenia Ecchinococcus, the tape worm stage is in the dog, and the ova voided in the dog's intestinal discharges; occasionally flesh becomes contaminated with these discharges, and so the ova may be conveyed on the meat to the intestinal tract of man, where, developing into the embryo stage, they bore their way into the tissues of the human body, giving rise to the "cystic stage"—known as "hydatid disease"; on account of these facts, relating to Tenia Ecchinococcus, dogs ought never to be allowed in slaughter houses and butcher shops.

Such being the nature of the diseases which may be communicated by flesh meat, we must consider the means by which they may be prevented from affecting human beings. Obviously this can only be accomplished by rigid inspection of all animals before slaughter, and of the carcases immediately after slaughtering, together with strict supervision of the sanitary condition of slaughter houses, stores, and places where the meat is sold. The range of this inspection work is great, and requires a large inspection staff to carry it out efficiently, even under the most favourable circumstances. The best means would consist of having one large slaughter house, or abattoir, to which all animals, to be used for food, must be brought; and wherein the inspection can be made by a minimum number of inspectors.

As frequently happens, in many places, a large number of small private slaughter houses are permitted, instead of one large sanitary abattoir; under these circumstances, a much larger staff of inspectors would be required to supervise the animals, before and after slaughter; such an arrangement would be so fearfully expensive as to render it impracticable, and, as a matter of fact, in those places where the small slaughter houses exist, the inspection of them is painfully inadequate, the result being, that loads of undesirable meat are allowed to pass, and to be sold to the public. The sanitary conditions in these small slaughter houses are, more often than not, defective, thus leading to increased risk of contamination.

The foregoing statements comprise the arguments on which the contention for central sanitary abattoirs, under municipal control, is based.

FISH.—Amongst the various kinds of fish, used for food, there is really only one disease from which they suffer that is directly communicable to man; it is a species of tape worm known as Tenia Bothriocephalus Latus. It occurs more frequently in some countries than in others, particularly in those bordering on the Baltic Sea.

Fish are known to suffer from Tuberculosis, but there is no evidence to indicate that it is transmissible to man.

As regards disease germs, which may become tacked on to wholesome fish, there are several of importance. It is popular knowledge that fish are prone to rapid decomposition, unless very carefully stored.

Mackerel seems to hold the premier place in this respect; however, whatever the type of fish may be, putrefaction entails the formation of Ptomaines, and when ingested by consumers, give rise to Ptomaine poisoning, a very common ailment.

Amongst shell fish the oyster has, within recent years, attained great notoriety as being a carrier of typhoid germs; this arises from the fact that where oyster beds are contaminated by sewage, the bi-valves are able to catch and retain typhoid bacilli, which may be in the sewage, and preserve the organisms in their virulent condition for a lengthy period. When such infected oysters are consumed in their raw state, the disease is communicated to the consumer. Sanitary supervision of the shell fish industry is therefore very necessary.

MILK.—Milk, as an article of diet, is probably more extensively used than any other; besides being consumed in fairly large quantities by all adults, it forms the staple article of diet for infants, and young children. These younger members of the community are very susceptible to illnesses of all kinds, and it is of paramount importance to insure the purity, and quality, of their main food supply.

Milk contains the natural food constituents, Proteids, Carbohydrates, Fats, and Salts; therefore, it constitutes a complete natural diet in itself. If by any process of adulteration, or sophistication, the proper quantity of one, or more, of these components of milk be deficient in value, as a diet the milk is greatly impaired; it is for this reason that the Chemical purity of milk supplies is insisted upon by all municipal authorities, with a view to prevent such practices as skimming and watering of the milk, both of which would upset the proper relative proportions of the nutritive components, so rendering it of less value as an article of diet.

In dealing with the Bacteriological condition of milk, we have the same problems confronting us as in the case of meats, that is to say, we may have germs derived directly from the cow, which would give us a milk contaminated from the very outset; again, we may commence with a good milk and have germs introduced at some period subsequent to its being drawn from the cow; these Bacteria may be actually disease germs, or simply putrefactive. The sources from which they may be derived are very varied,—from the milkers, or from the insanitary state of the cow sheds and dairies, or from polluted water supplies, conditions pertaining to the farm. After leaving the farm, the milk is transported into towns and cities, where it is handled, stored, and sold by milk dealers, in large and small ways of business. During this stage, the milk is open to contamination from the people who handle it, from insanitary conditions pertaining to dairies and shops, and, lastly, improper storage allows of Bacterial multiplication. Milk being a fine natural growing medium for germs, it is extremely important to prevent them gaining access to it at any stage, but in practice this is found to be extremely hard to accomplish.

The disease germs, which may be derived from the cow, are those of Tuberculosis. Many observers maintain that the cow is capable of suffering from Scarlet Fever, and of transmitting the germs directly to the milk ; others, again, have claimed that cows may harbour the Diphtheria Bacillus; of these two diseases there seems to be some doubt, but there is no question whatever about Tuberculosus Bacilli finding their way into the milk in many instances, where the cow is suffering from that disease, particularly when it affects the udder. The cow may also suffer from other diseases, like Septicæmia, or suppurative conditions of the udder, both of which may render the milk unfit for food, not that these two diseases are transmitted to the consumers, but the milk causes serious disturbances in their digestive tract. As regards the milkers, and all those people who handle the milk at any stage, these people may be afflicted with any of the following diseases :—Typhoid Fever, Tuberculosis, Scarlet Fever, and Diphtheria, and they may directly introduce the germs of these diseases into the milk ; epidemics have frequently been due to infections of this nature ; thus people should not only be free from diseases, but should handle the milk in a cleanly fashion, otherwise they may be the means of introducing germs of a putrefactive nature, that is, Bacteria associated with ordinary dust, and dirt. The sanitary conditions of the cow sheds, the farm, town dairy, and the various milk shops, are extremely important to note, for if defective in any of these places, germs associated with filth, refuse, sewage, etc., have easy access to the milk. It is for these reasons that all places where milk is handled or stored, should be scrupulously clean, and in perfect sanitary condition, and capable of being easily disinfected. The water supply, connected with these places, should also be perfectly good, and wholesome, otherwise disease germs associated with water supplies may be introduced in the process of washing of cans, etc. The proper storage of milk exerts a profound influence upon the Bacterial content; all milks contain a certain number of germs, some more, some less, and if the temperature be favourable, rapid multiplication of these Bacteria takes place.

By keeping the milk at an uniform temperature (36 to 42 Fahrenheit), growth of the germs is inhibited. Cold storage of such a nature is demanded, therefore, and applies not only to the dairies where the milk is stored previous to sale, but also to private houses where milk must be kept for a certain time prior to consumption. In the poorer parts of the town, this application of cold storage is frequently neglected, not only in the shops, but in the private house, with the result that the milk putrefies, or turns sour. Milks which have undergone such Bacterial processes of decomposition, produce violent gastro-intestinal disturbances when ingested; this, probably, is the most fruitful cause of those intestinal complaints so prevalent amongst infants and young children, especially during the summer months, for, during the hot weather, the absence of proper refrigeration permits of a terrific multiplication of germs, with the attendant results.

Owing to the extreme difficulty of procuring a milk containing only a moderate number of germs, the practices of Pasteurizing, and Sterilizing milk, have been greatly adopted during the last few years. This operation is usually carried out in large dairies, located in towns; these places being the centres to which the milk is sent in from one or more farms in the country.

From the remarks previously made concerning the conditions of the cow sheds, etc., usually found on the average farm, it will be gathered that the Bacterial content is rather high by the time it reaches the central city dairy,—anywhere from 50,000 to 2,000,000 germs per c.c. The object of the Pasteurization, or Sterilization, is to either eliminate, or, at all events, vastly reduce the number of the germs in the milk before it is bottled and delivered to the consumer. As a preventive measure, there is no doubt about it accomplishing a certain amount of good, but the very fact that Pasteurization, or Sterilization, is called for is, so to speak, a tacit acknowledgment of the dirty condition of the milk when it reaches the central dairy, and is good proof that the general sanitary conditions at the farm (that is, cow sheds, milkers, etc.,) are distinctly bad. Obviously the proper course is to commence with a clean milk, and it is not impossible to obtain a milk of moderate purity, say—something less than 10,000 organisms per c.c. If we start with a milk of such a quality, and it is properly cooled, and kept cool during transportation, the treatments of Pasteurization, or Sterilization, are no longer called for, and everybody admits that a clean, fresh milk, is superior to a dirty milk, which has been cleaned up by the Sterilization processes. Milk, after it has been subjected to Pasteurization, and Sterilization, not uncommonly disagrees with people, and more particularly children, whose digestive systems are delicate. However, so long as dirty milk is sent into towns, and cities, from the dairy farms, so long will these processes of treatment, in the central town dairy, be required. Proper inspection, and supervision, of all dairy farms, together with suitable education of the farmers, are the only possible means of obtaining clean milk from these sources.

Another means of enhancing the keeping qualities of milk, is the addition of Preservatives, the substances commonly used for this purpose being—Formaldehyde, Boracic Acid, Borax, Salicylic Acid, Benzoic Acid, and Carbonate of Soda. The first five are decidedly Germicidal in their action, and they are added in small proportions, just enough to inhibit the growth of Bacteria. Great discussions have always taken place over the advisability of allowing Preservatives to be used ; those in favour contending that the quantities employed are not sufficient to cause any serious trouble to the persons consuming the milk ; but it seems as if these people lose sight of the fact that there is a more serious objection, namely, that by the use of these antiseptics, milk of inferior quality, that is, of high Bacterial content, are passed off upon the public for consumption ; moreover, the contention that small amounts of these Preservatives do not injure the consumer, is hardly tenable in the case of infants, because their digestive systems are so very delicate, that they will react to small doses of these substances, if they are daily repeated.

Carbonate of Soda is employed for a very interesting reason. Milks which are deteriorating, that is, turning sour, possess the well-known odour and taste of sour milk, due to the formation of Lactic Acid ; these objectionable features can be masked very effectually by the addition of Carbonate of Soda, sufficient to neutralise the acid. This process enables unscrupulous milk dealers to foister upon the public a milk which is certainly unfit for human consumption.

BUTTER.—There are practically no definite diseases transmitted by this article of diet, but in practice we find the purity of butter is frequently called into question. This arises principally from the adulterations which are practised, not infrequently, with regard to this food stuff. As butter is one of the principal articles of food from which we obtain the fatty portion of our diet, its purity must be more or less guaranteed. The pure butter fat, which constitutes about 85% of butter, seems to be a form of fat more easily digested than any other kind ; therefore, any adulterating practice, which may substitute some other, and cheaper form of fat, cannot be countenanced, although the substituted fat may not cause any disturbance to health, and it may even have a fairly good nutritive value. Such butters made up with substituted fats are known as "Margarines," or, as some people term them, "Oleomargarines."

The fats most commonly employed for this purpose are the various forms of tallow, and certain vegetable oils like "Cotton Seed Oil" and "Cocoa Butter."

Another fraudulent practice is the introduction of an undue quantity of water into the butter; quite a large amount of water can be "worked up" with butter, so increasing the weight; but the buyer is virtually being robbed of a certain amount of butter fat, for obviously, a given weight of this "worked up" butter will contain a less percentage of butter fat than a corresponding weight of good ordinary butter. A similar practice has been resorted to, using milk in the place of water, and, within the past year or two, a process has been foistered on the public, by which 1 lb. of butter could be converted into 3 lbs., by the addition of about one pint of milk. Butters containing more than about 15% of water will not keep, but rapidly turn rancid.

The use of Preservatives is not much practised in the butter trade; the addition of 2% to 5% common salt being mostly quite sufficient to impart keeping qualities to the butter. However, one comes across other Preservatives occasionally, and the remarks made concerning these substances, under the heading of milk, apply equally as regards butter. The addition of Sodium Fluoride, for the purpose of preserving the butter, was practised to a limited extent about a year or two ago, but happily the fashion was very short lived; the Fluoride is unquestionably a germicide, but it is a villanous substance to add to butter, or any other food stuff.

CONFECTIONERY.—In this particular branch of food stuffs, the principal dangers to health are concerned with the use of colouring matters, and adulterations; an examination of the numerous specimens comprised within the series Exhibit Nos. 6.1321, etc., will reveal the extent to which these practices are carried in the confectionery line. It is true that some of the adulterations are harmless as regards the consumer, but occasionally one comes across some dangerous colouring matters, particularly in the manufacture of sweets.

Pickles, Sauces, and Condiments are articles which are much subjected to adulterations. Here, again, in the vast majority of cases, the adulterants are not poisonous in any way; for instance, the use of sawdust, as a diluent to spices, and such like articles, cannot be said to injuriously affect the health of people consuming them; the list of Exhibits, Nos. 6.1330 to 6.1359a, will give a fair idea of the extensive use of these adulterants, in the case of spices and peppers. With reference to Pickles and Sauces, one occasionally comes across specimens purporting to be a particular article (for instance, tomato sauce), wherein the true tomato is found either in very small amount, or not at all. The use of colouring matters in such cases is very common, and some of them may be of a poisonous nature.

Tinned goods, particularly if they are of an acid nature, may occasionally show signs of contamination by lead; this is derived from the solder used in sealing the tin.

Beverages.—Amongst the non-alcoholic beverages, tea, coffee, and cocoa, occupy a prominent place. Public health interest centres around adulterations practically, in connection with these articles; in the case of teas, the addition of iron filings, to lend weight, and the substitution of used tea leaves, or the dried leaves of other plants, in place of the real article, are the frauds most frequently perpetrated. (See Exhibit No. 6.1382). Coffee is sold either in the bean, or in the ground state. Artificial coffee berries (see Exhibit No. 6.1392) are extremely common nowadays, and are mixed, in certain proportions, with the true coffee bean. These artificial coffee berries usually contain no coffee whatever, and are largely composed of substitutes like burnt bread. The ground coffee may be adulterated with ground roots which have been roasted; Chicory, although sometimes added in large quantities, can hardly be looked upon as an adulterant, because many people prefer to have a little chicory in their coffee, on account of the fine colour which it imparts to the beverage.

Cocoa is adulterated with sugar and starches; pure cocoa cannot be eaten by itself, it has to be diluted down, in order to make it palatable, but on occasion, this dilution is carried to such an alarming extent, that there is precious little of the pure cocoa to be found in the finished product; such instances must be considered as adulterations.

All these adulterants affecting tea, coffee, and cocoa, cannot be looked upon as likely to cause harmful effects, but they are none the less fraudulent, and impair the purity of the beverage.

The other non-alcoholic beverages comprise the aerated waters. There is very little to be said concerning these, as regards the possible dangers to the health of the public; one occasionally comes across cases of illness caused by the ingestion of certain chemicals, which are used to lend characteristic flavours, as in Ginger Beer, Lemonade, etc. Lead poisoning has been traced, in a few rare instances, to the solvent action of certain aerated waters upon the lead fittings of the syphons.

ALCOHOLIC BEVERAGES.—Without entering into a discussion as to the use, or abuse, of alcohol, we must concern ourselves with the ailments, or diseases, which may be directly produced by the consumption of adulterated alcoholic liquors.

These beverages come under three heads—Beers, Wines, and Spirits.

Beer is supposed to be made from malt and hops, but in many countries other substances are frequently used to replace these well known ingredients—starches taking the place of malt, and some powerful bitters used instead of hops. These substituted articles may not necessarily be dangerous, but in the case of the substituted starch, the process of converting this starch into sugar may be productive of dangerous results; common Sulphuric Acid is most often used to bring about this conversion of starch, and as this acid may contain large quantities of Arsenic, epidemics of poisoning by this metal have been met with, caused by the consumption of beer so contaminated during its manufacture; occasionally Sulphuric Acid is added to the beer in small quantities, to give it a sharp taste.

Some authorities claim that they have met with instances of the addition of common salt, apparently with a view to the production of a greater thirst for the beverage amongst the consumers.

Spirits.—There is nothing to be said regarding spirits, as I know of no definite disease, or ailment, attributable directly to any substances which are used in their preparation, or even in their adulteration.

Wines seem to offer more attractions to the practice of adulteration than the other beverages; Carlyle truly said: "Wines seem to be made from everything except the juice of the grape." As Hygienists, we are not vitally concerned with the substitution of other fruit juices for that of the grape, provided the substituted juice is a natural fruit product; but there are certain cheap wines, particularly Ports and Clarets, which are made up with chemicals, and contain no natural juice of any fruit whatever. In the general mixing process, it so happens that a harmful product may be formed, and a description of it may not be out of place.

As natural wines like Port. etc., contain a fair amount of Tartrate (Crusty Port), the deposit of crust must be imitated in the manufactured articles, and this is done by adding Cream of Tartar (Sodium Potassium Tartrate). Now, as the artificial mixture containing the ingredients of the wine, results in a muddy liquor, it has to undergo a process of clarification; for this purpose, Plaster of Paris (Calcium Sulphate) is added and a double decomposition takes place between the Plaster of Paris and Cream of Tartar, with the formation of Potassium Sulphate, a rather powerful poison, and a marked depressant. The consumption of such attractive looking beverages, by enterprising youths, accounts for the uncomfortable, and sometimes painful, symptoms which supervene the next morning.

6.1 Food Stuffs.

6.11 TABLE SHOWING COMPOSITION OF VARIOUS KINDS OF FOOD.

These percentage compositions represent water-free solids.

6.12 BOX CONTAINING SPECIMENS OF ALL COMMON STARCHES.

Accompanying this exhibit is a series of slides showing the microscopic characteristics of the various starches.

6.13 SERIES OF EXHIBITS,

showing all mineral and vegetable substances used for food adulterations.

6.131 BREAD AND FLOUR ADULTERATIONS.

6.1311 Alum, adulterant for bread, flour, and baking powder.
6.1312 Magnesium carbonate, adulterant for flour.
6.1313 Plaster of Paris, adulterant for bread and sugar.
6 1314 Indian corn flour, adulterant for flour.
6.1315 Barley meal, adulterant for oatmeal.
6.1316 Bran, adulterant for oatmeal.

6.132 ADULTERANTS FOR SUGAR CONFECTIONERY.

6.1321 China clay, adulterant for peppermint lozenges.
6.1322 Barytes, adulterant for sugar.
6.1323 Verditer.
6.1324 Emerald green.
6.1325 Yellow chromate of lead.
6.1325a Carbonate of lead.
6.1326 Glucose, adulterant for sugar, honey, etc.
6.1327 Ultramarine.
6.1328 Prussian blue.
6.1329 Indigo.
6.1320 Raw umber.

6.133 Adulterants for Peppers.

6.1330 Turmeric.
6.1331 Linseed meal.
6.1332 Ground rice.
6.1333 Cinnabar.
6.1334 Red lead.
6.1335 Orpiment.
6.1336 True Brunswick green.
6.1337 Poivrette.
6.1338 Pepper shells.
6.1339 Artificial pepper mixture.
6.1339a Artificial Cayenne pepper.

6.134 Adulterants for Mustards.

6.1341 Ground rape seed.
6 1342 Ground oil cake.
6.1343 Potato starch.
6.1344 Mustard husks.
6.1345 Artificial mustard mixture.

6.135 Adulterants for Spices.

6.1350 Mustard husks, for allspice.
6.1350a Ground cocoanut shells, for allspice.
6.1351 Cassia, for cinnamon.
6.1352 Artificial clove mixture.
6.1353 Artificial allspice mixture.
6.1354 Artificial ginger mixture.
6.1355 Artificial nutmeg mixture.
6.1356 Artificial mace mixture.
6.1357 Exhausted cloves.
6.1357a Clove stems.
6.1358 Ground olive pips.
6.1358a Almond shells.
6.1359 Sawdust
6.1359a Wild mace.

6.136 Adulterants for Alcoholic Beverages.

6.1361 Boracic acid, for beer.
6.1362 Aniline violet, for wines.
6.1362a Aniline red.
6.1363 Magenta, for red wines.
6.1364 Tannin.
6.1365 Cocculus indicus, for hops.
6.1366 Catechu.
6.1367 Red sandal wood.
6.1367a Yellow sandal wood.
6.1368 Brazil wood.
6.1369 Logwood.
6.1360 Caramel, for brandy, etc.

6.137 Adulterants for Pickles, Sauces, etc.

6.1371 Venetian red.
6.1372 Blue vitriol.
6.1373 Yellow ochre.
6.1374 Cochineal.
6.1375 Verdigris.
6.1376 Sample of tomato catsup, with artificial colouring matter.
6.1377 Sample of silk dyed with artificial catsup.
6.1378 Sample of silk treated with home-made catsup.

6.138 Adulterants for Teas.

6.1381 Sample of pure tea.
6.1382 Sample of exhausted tea leaves, dried.
6.1383 Burnt umber.
6.1384 Bichromate of potash.
6.1385 Black lead.
6.1386 Green vitriol.
6.1388 Iron filings.

6.139 Adulterants for Coffee.

6.1391 Pure coffee berry.
6.1392 Artificial coffee berry, or "Process coffee."

6.139 ADULTERANTS FOR COFFEE—*Continued.*

- **6.1393** Coffee pellets.
- **6.1394** Roasted peas.
- **6.1395** Dandelion root.
- **6.1396** Chicory.

6.130 ADULTERANTS FOR BUTTER AND CHEESE.

- **6.1301** Oleomargarine.
- **6.1302** Renovated butter.
- **6.1303** Saffron—colouring matter for butter.
- **6.1304** Spanish annatto, colouring matter for cheese and butter.
- **6.1305** Fulwood's annatto, colouring matter for cheese.

6.14 ADULTERANTS FOR MILK.

- **6.141** Formaldehyde.
- **6.142** Boracic Acid.
- **6.143** Borax.
- **6.144** Salicylic Acid.
- **6.145** Benzoic Acid.
- **6.146** Carbouate of Soda.

SECTION VII.—PATHOLOGICAL AND BACTERIOLOGICAL.

The pathological specimens contained in this collection, relate to diseased meats, and should be studied in conjunction with the article on flesh meats, under Section VI., Food Stuffs.

The specimens were obtained from diseased animals which had been slaughtered in public abattoirs. But for the fact that careful inspection was made of all carcases, these diseased meats might have been passed off on the public.

The remainder of this pathological collection consists of specimens intended to exhibit the actual causative agents in certain diseases—such as some specimens of intestinal parasites, like thread worms, and pin worms ; also the series of bacterial exhibits,—for, although the diseases associated with these specimens are sometimes conveyed by diseased meats, nevertheless, it is well to remember there are other channels of communication.

7.1 Tuberculosis.

All these specimens of tuberculosis are of bovine origin, and show how this disease may occur in all parts of the animal body.

7.11 TUBERCULOSIS OF THE LUNG—BOVINE.

7.12 TUBERCULOSIS OF THE PLEURÆ—BOVINE.

7.13 TUBERCULOSIS OF THE DIAPHRAGM—BOVINE.

7.14 TUBERCULOSIS OF THE PERITONEUM—BOVINE.

7.15 TUBERCULOSIS OF THE LYMPHATIC GLANDS—BOVINE.

7.2 Intestinal Parasites.

7.21 SPECIMEN OF SHEEP'S LIVER,

showing the Liver Fluke in position.

7.22 LIVER FLUKES (FEMALE), MOUNTED.

7.23 SPECIMEN OF PIG'S LIVER,

showing cysts of Tænia Ecchinococcus.

7.24 SPECIMEN OF CYSTICERCUS CELLULOSA,

cccuring in the cystic stage in the heart muscle.

7.25 SPECIMEN OF MUSCLE,

showing Trichina Spiralis. The cysts, in which the tiny worm lies coiled up, are very small, and appear as little white dots in the muscle tissue; they are best seen in the muscle near the tendon.

7.26 SPECIMEN OF TAPE WORM—TÆNIA MEDIOCANELLATA.

7.27 PIN WORM.

7.28 THREAD WORMS: ASCARIS DUODENALE, AND TÆNIA DESPAR.

7.29 COMMON ROUND WORM.

7.3 Other General Diseases.

7.31 SPECIMEN TAKEN FROM P G SUFFERING FROM SWINE PLAGUE.

7.32 SPECIMEN OF LIVER, TAKEN FROM COW AFFECTED WITH ACTINOMYCOSIS.

7.33 SPECIMEN OF GLAND, FROM NECK OF COW SUFFERING FROM ACTINOMYCOSIS.

7.4 Bacteria.

7.41 SERIES OF TUBES, CONTAINING GROWTHS OF VARIOUS MICRO-ORGANISMS,

some of them pathogenic, some of them non-pathogenic

7.42 SERIES OF SLIDES, SHOWING MOST OF THE COMMON ORGANISMS,

stained, and mounted.

7.43 CHART.

Coloured drawings executed from slides, exhibiting various pathogenic micro-organisms, stained.

7.44 SERIES OF MODELS,

illustrating on a large scale the structure, and stages of development, of some micro-organisms representative of the more important groups.

SECTION VIII—CLOTHING.

The various metabolic processes, taking place in the body, generate a large amount of heat, far more than sufficient to maintain the body at a normal temperature of 98.4° F.; the excess, above this temperature, is very largely got rid of by evaporation of perspiration. When the water vapour, produced by this evaporation, leaves the body, it carries with it a great amount of heat, in the form of latent heat. If, however, this water vapour be condensed, the latent heat is again given up; and should this process of condensation take place in any article of clothing next the skin, the latent heat, thus rendered available, is imparted to the clothing, and so a sensation of warmth is experienced.

An ideal clothing, therefore, should be capable of permitting a great loss of heat whenever required, and should be able to prevent an under loss of heat under a different set of conditions. Take, for instance, the case of an individual undergoing hard exercise:—in the first place, the excessive heat, produced by this performance, must be got rid of by an increased production of perspiration, in other words, latent heat is taken up by the water vapour. The ideal clothing must, therefore, permit of a free escape of the water vapour thus produced in excess, and this can only take place if the article of clothing be suitably porous.

On the other hand, at the end of a period of great exertion, the production of heat in the body rapidly diminishes, and unless some means exist of preventing the rapid loss of heat by evaporation, which might take place in the moist clothing, too much heat would be abstracted from the body, and a chill result. The ideal article of clothing must be able to carry out this function also; it must possess so much absorbtive power as to enable it to retain a sufficient quantity of condensed water vapour, which will render available enough latent heat to keep the body warm, and prevent chills.

The conditions imposed on an ideal clothing are obviously very difficult to fulfil; in fact, one may go so far as to say that there is no ideal clothing in this respect; but still, a study of the various attributes possessed by the different materials used, will demonstrate how much more closely some of them approach this ideal than others. It involves a knowledge as to how far each material of clothing possesses, under widely varying conditions, physical factors necessary to produce the ideal; and this may only be gathered by ascertaining their behaviour under the following physical headings:—

1. Heat Conductivity.
2. Porosity.
3. Absorbtion of Moisture.
4. Reflection of Heat.
5. Weight.

HEAT CONDUCTIVITY.—The ideal material should be a bad conductor. An examination of the Tables of Conductivity, relating to various materials used for clothing (see Exhibit No. 8.3), will show that animal fibres conduct heat far less than vegetable fibres, and are consequently to be preferred in this respect. They are not only better adapted to prevent undue loss of heat from the body, but are likewise more efficacious in checking the effects of abnormal external temperatures.

POROSITY of an article of clothing directly governs the rate of transmission of water vapour from the body, and likewise the admission of air. It has been pointed out previously that the ideal material must admit of the free escape of water vapour from the body, under conditions where the production of heat is great, due to exercise, etc. The admission of air is also necessary, because a certain amount of ventilation of the skin is essential, to allow of the escape of effluvia, etc., arising therefrom. The presence of air in the meshes of the clothing is beneficial too, because it is in itself a bad conductor of heat.

Absorbtion of Moisture.—This characteristic is very essential in an ideal clothing, for it is on this property that the capacity to retain heat largely depends. As we have seen already, any condensed moisture present gives up a very appreciable amount of latent heat; but if in turn the material is of such a texture as to allow this condensed moisture to be rapidly evaporated, a good deal of heat is required for vaporization (latent heat taken up), and this heat must be supplied from the body, which would thus be rapidly chilled.

This property, coupled with suitable porosity to allow of a free escape of water vapour when excessively produced, forms the crucial requirement of a good article of clothing.

A perusal of experimental data (Exhibit No. 8.3), shows that animal fibres (clothes made of wool) possess this characteristic to a much greater degree than vegetable fibres (clothes made of cotton, linen, etc.).

Reflection of Heat.—The power possessed by clothing to reflect heat depends largely upon the colour; light shades being able to reflect the heat much better than dark ones. This physical attribute is only useful where the heat from the sun's rays is excessive.

Weight.—The element of weight, as regards clothing, is of some importance, because where the load to be carried by the body is excessive, fatigue necessarily results.

In all well designed clothing the maximum of warmth, and protection to the body, should be combined with the minimum of weight; in this respect the stockinet woollen goods are superior to most others.

Besides these physical properties relating to materials used for clothing, there are one or two other points, connected with garments generally, which are of hygienic interest.

Occasionally some articles of clothing are made which are injurious to the body, not on account of actual material, but of certain dye stuffs which have been used in their manufacture. Irritations of the skin, of a somewhat serious nature, have been known to arise from this cause;

some forms of black clothing, when worn next the skin, seem to have given rise to this trouble more than any other colour. Nowadays, however, cases of this kind are very rare—manufacturers having almost entirely discarded the use of dyes which are apt to cause irritation.

Correct form, or fit, of garments, or other articles of clothing, is of great importance. Anything in this line which constricts any part of the body, or limbs, or which interferes with the natural bodily functions, must be considered as unhygienic. Tight lacing is probably the commonest condition met with under this heading. Marked displacement of the Abdominal and Thoracic viscera have frequently been observed, due to this cause. The results produced in extreme cases of tight lacing, are well shown in the skiagrams and diagrams in Exhibit No. 8.2.

Garters, hats, boots, and certain forms of dress sleeves, have at different times given rise to trouble, owing to their wrong design, causing constriction of the limbs, or other parts or the body.

Within the last generation or so, some manufactured articles of clothing have been largely produced, and patronised by the public, which, owing to their texture, are highly inflammable; certain forms of cheap flannelette, possessing a highly fluffy surface, seem to be the most dangerous materials. Numerous cases have been recorded of individuals being burnt to death, owing to the material accidentally taking fire. Endeavours have been made to overcome this danger by dressing the material with chemicals, which renders the fabrics less inflammable ; Phosphate of Ammonia, Sulphate of Ammonia, and Tungstate of Soda are the chemical agents most frequently employed, the last named being the best of all.

8.0 Raw Materials.

This series of exhibits shows the natural origin of the raw material, and also the various stages through which it passes in the process of manufacture, until the finished product is reached.

The collection is a remarkably interesting one.

8.00 SILK.

8.001 PRODUCTION OF SILK ; MOTHS, ETC.

The exhibit contains beautiful specimens of all the moths, silk worms, etc., whose products are used for the manufacture of silk goods. The different stages in the life history of each moth are shown. The exhibit also contains a complete series of specimens exemplifying the manufacture of the different kinds of silk, from the raw cocoon to the finished silk cloth.

As the beautiful colours of the moths fade under strong daylight, or sunlight, it is necessary to drop the curtain after viewing the exhibit.

8.002 ARTIFICIAL SILK.

The specimens show to what a pitch of perfection the imitation of the genuine article has been carried ; there is not a particle of pure silk in any article in the case.

8.01 LINEN.

8.010 Linen.

8.02 WOOLS.

The value of a wool, for manufacturing purposes, depends upon the waviness of the hair fibre, as well as upon its length. The exhibit contains a complete collection of all known wools produced the world over, and it is interesting to note the difference in the length, and waviness, of the wool fibre derived from sheep bred under different climatic conditions. The number of scales in the structure of the fibre is also of great importance—in the highest grade wools the scales are very close together. Merino, of all known wools, combines in the highest degree these two important factors—maximum number of scales and waviness.

8.020 English wools.
8.021 Wools of varying length.
8.022 Relation between waves per inch, and diameter of fibres.
8.023 Stages in manufacture of woollen fabrics.
8.024 Manufacture of dyed and undyed silver grey.
8.025 Mixture of white and brown wool.
8.026 Manufacture of worsted fabrics.

8.03 MOHAIR.

Mohair is particularly useful where a smooth fabric of high lustre is required. For weaving purposes it is not so good as wool, because there is not much natural waviness in the hair.

8.030 Mohair.

8.04 CAMEL HAIR.

The special points about camel's hair are its durability, extreme lightness, and bad conductivity. For blankets, and outer garments, it is probably the best material of all.

8.040 Camel Hair Material.

8.05 LLAMA, ALPACA, AND GUANACO.

These are very much like camel's hair.

8.050 Llama, Alpaca, and Guanaco.

8.06 CASHMERE GOAT, VICUNA, AND ANGORA RABBIT.

These materials are very valuable, and produce cloths of extreme softness. The high price of these goods is due to the limited supply of the material.

8.060 Cashmere Goat, Vicuna, and Angora Rabbit.

8.07 YARNS.

- **8.070** Woollen Yarns, No. I.
- **8.071** Woollen Yarns, No. II.
- **8.072** Wool and Cotton.

8.08 RAMIE, AND OTHER FIBRES.

These fibres resemble linen fibre in many respects, and are used more or less as substitutes for linen.

8.09 COTTON.

The cotton plant is cultivated in many parts of the world. The fineness, and maximum number of twists in each individual fibre, together with tensile strength, are the factors by which the value of cotton is judged.

- **8.090** Cotton, from seed to finished material.
- **8.091** Typical cotton fibres, in order of length.
- **8.092** Cotton: Stages in manufacture of "Non-Flam," No. I.
- **8.093** Stages in "Non-Flam" Cotton, No. II.

The manufacture of this "Non-Flam" is designed to overcome the danger from fire, which cotton goods with a fluffy surface (like flannelette) possess.

8.1 Manufacturing Processes.

8.11 TYPES OF WEAVE.

8.12 POROSITY.

8.13 MANUFACTURE OF FELT.

This exhibit shows the stages in the manufacture of felt. The raw material is the fur derived from rabbits, hares, and otters.

8.14 MANUFACTURE OF FELT HATS.

Real felt is only used in the best grade hats—the cheaper kind of so-called felt hats are made of wool, or cotton.

8.15 LEATHER GOODS.

8.151 Gloves.—This shows the different stages in the manufacture of gloves.

8.152 This exhibit shows the different stages in the manufacture of leather.

8.153 Here are seen the different stages in the making of ladies' boots.

8.154 Ventilation of boots.—This exhibit shows how boots are provided with a scheme for ventilating the inside of the sole. It is claimed by some that such ventilation is beneficial to the feet, and that there should be a reasonable access of air to the skin of the feet, as to the skin over the rest of the body. The complaint known as "tender feet," is, in the majority of cases, due to excessive perspiration, and the inability to free the skin of this effete product, owing to its being incased in a leather boot, which is more or less impervious. Ventilation of the interior of the boot ought certainly to facilitate the removal of the moisture: and there is no question that sufferers from this complaint have derived great benefit and relief from the use of such ventilated boots.

8.2 Skiagrams and Diagrams.

These exhibits relate to Deformities due to misfitting articles of clothing.

8.3 Essential Properties of Clothing.

This exhibit is designed to bring out different characteristics, and properties, of the different materials used for clothing. The requirements of an ideal material have previously been set forth, and a careful perusal of the data, and tables, contained in this exhibit, should enable any individual to decide which article, or articles, in the collection come nearest to that ideal standard.

8.4 Evolution of Clothing.

This collection of drawings indicates the various stages in the evolution of clothing, from the earliest times of which any record is available, down to the present day. It is very interesting to see the process by which such garments as trousers, coats, etc., were gradually evolved from the primitive flowing robes.

8.5 Clothing.

In this case are exhibited specimens of most of the ordinary articles of clothing, some of them made of the best materials, and others cheap, shoddy, etc. The cheap articles, although to all appearances reasonable looking articles of clothing, are nevertheless very unsuitable for such purposes, because they do not possess the requisite properties.

8.6 Exhibits.

This draw cabinet contains specimens of all the finished products used for clothing purposes. In addition, there are some very interesting specimens showing manufacturing processes through which the finished article has passed.

8.7 Physical Apparatus connected with the Testing of Clothing Materials.

8.71 Porous Pot for Testing Conductivity, etc.

Place water at a temperature of 105° F. in the cylindrical, porous, earthenware pot, which should be so arranged that practically all the heat lost is via its curved surface ; cover the exterior with a jacket of the material to be tested. Put a thermometer in the water, ascertain the time taken for the temperature to drop from 105° F. to 95° F. The experiment records both the absorptive and conductive properties, under conditions which approximate to those of the body. The time taken for the temperature to fall may be looked upon as an index to the heat-retaining power of an undergarment made of a specified fabric.

8.72 Apparatus for showing comparative Conductivity of Fabrics.

The apparatus is based on the principle that air, when heated, expands. Turn the tap at right angles to the tube. Heat one of the bulbs by grasping it in the hand; the coloured liquid moves toward the cooler bulb. Before trying comparative tests, see that the hands are at the same temperature. Grasp the bulbs with the bare hands, the tap being at right angles to the tube: if no movement of the liquid takes place, the hands are at the same temperature.

In order to test the comparative value of two pieces of clothing, place one of these on each bulb, turn the tap, grasp the bulbs in hands. The material in the bulb towards which the liquid moves, is best suited for keeping the body at its normal temperature.

N.B.—Always place the tap at right angles to the tube when testing, and always place the tap in line with tube when not in use.

Do not allow the coloured liquid to rise into the small bulbs when testing.

Should the liquid thread split up, turn the tap at right angles, and force the liquid into one of the small bulbs by placing the hand on the large bulb on the other side, then remove hand and place tap in line with the tube.

8.73 Box of Slides, Showing Appearance of Different Fibres under Microscope.

8.74 Textile Fibres (Diagrams and Descriptions).

SECTION IX.—SEWAGE AND REFUSE DISPOSAL.

DRY REFUSE DISPOSAL.

This portion of the refuse derived from houses, consists of the contents of the familiar ash bin. It is composed of the sweepings of the house, scraps, ashes, straw, papers, bottles, etc. From its nature, part of it is decomposable organic matter, and, therefore, when placed under favourable conditions, that is, access of warmth, and moisture, a process of decomposition will ensue.

In respect to storage on the premises, between the visits of the scavenger, provision must be made to prevent scattering of this dry refuse around the yard or back area; against being blown about by the wind, and protecting it from rain, for the addition of rain gives the requisite moisture for permitting decomposition,—likewise slops of any description, should not be permitted to enter the ash bin. If dry refuse be allowed to spread over the ground, or, to come into contact with any brick work, or wood work, those materials must inevitably become foul with the organic matter contained in the refuse, and result in a decided nuisance.

Moreover, any attempt at cleaning and disinfecting such surfaces as earth, wood work, and brick work, would be quite futile.

The whole question resolves itself, therefore, into providing non-absorbent, well-covered, moveable receptacles. The most suitable material, for this purpose, is galvanized iron, and for ordinary households, a size of the capacity of two cubic feet will be found most serviceable. (Exhibit No. 9.01.)

A receptacle of such a size is not too large for the scavenger to handle; if of larger capacity, the men are unable to unload it into the cart, and frequently deposit some of the contents in the back lane, in order to render it light enough for them to lift ; this obviously results in fouling the surface of the lane. An ash bin of two cubic feet capacity is quite large enough to accommodate the dry refuse from an ordinary house, over a period of two, or three days. In cases where this is not sufficient, it is better to provide two, or more, similar bins, and not to attempt to have one large one, for the reason given above. It would be as well to note that the presence of a good tight-fitting cover not only prevents access of wind and rain, but also effectually stops the entry of marauding animals, like cats and dogs ; for these animals, when looking for savoury bits in an open ash bin, can cause considerable scattering of the contents during their search.

The responsibility of efficient removal of this dry refuse from the house premises, rests with the municipal authorities, and it is taken for granted, that this part of the work is carried out properly.

The final disposal of it is of decided hygienic importance. Municipal authorities usually adopt one of two methods ; either "dumping," or, "incineration."

By "dumping" is meant the disposal of the refuse by depositing it in some chosen place, usually a field, on the growing edge of the city. Although a very economical method of getting rid of the house refuse, it is nevertheless a very undesirable one, owing to the fact that the area of land, comprising the dump, is always utilized, in the course of a short time, as a building site.

From the nature of this house refuse, these dumps, or, "made land," are veritable reeking decomposing masses, and are certainly unhygienic building sites. Apart from the gases of decomposition, which emanate from such dumps, the material of this "made land" is naturally very rich in micro-organisms, and if this soil be worked up, and blown about, the germ-laden dust inevitably finds its way into the house, contaminating food stuffs, particularly milk. Experience has shown, that amongst the dwellers in houses built on such areas, gastro-intestinal disorders, especially during the summer time, are far more prevalent than in other parts of the town amidst healthy surroundings.

The process of "incineration" is the most rational and sanitary method of disposing of this house refuse. Briefly, the whole of it is burnt up. From the composition of this refuse, it will have been noticed that a considerable portion of it is combustible, so much so, that under certain conditions no fuel need be added to bring about complete combustion. There are two types of Incinerators in use, viz., the low, and high temperature plants.

The Low Temperature Incinerator (Exhibit No. 9.05) simply consists of a suitable furnace, into which the refuse is deposited in proper quantities from time to time. As the name implies, the temperature of the furnace is not very high, the process of incineration is, therefore, necessarily slow, and fuel must be added to the refuse, in order to make it burn. A process of distillation goes on before the stage of actual combustion is reached, and the products derived from the distillation of the various organic materials in the dry refuse are extremely foul smelling, and give rise to a grave nuisance, if allowed to escape into the open air.

Before these gases are allowed to escape by the chimney, they ought to be passed through a second fire, where they undergo an efficient form of cremation. The necessity of a second fire, and the slow rate of combustion of the refuse (two to four tons per day per cell) have led to the introduction of a High Temperature System. This consists of a fire box, or furnace, in which the fire is kept going at full blast, by means of forced draught, thus creating an intense heat; so great is this heat that the refuse needs no added fuel, the combustible components of the refuse being quite sufficient for this purpose. So complete is the combustion, that even such articles as tin cans go up in a shower of sparks.

It will be seen (Exhibit Nos. 9.03 and 9.04) that the outlet flue is placed immediately above the fire, which is situated in the front part of the fire grate; the refuse being put into the cell at the back, moves forward slowly on the hearth to the fire bars, and as this refuse approaches the very hot fire, it undergoes a marked distillation process; the only outlet for the gases produced being through the flue, which commences immediately above the hottest part of the fire; the intense heat from the blast furnace beating directly into the first portion of the flue, renders the fire-brick lining white hot, so that the gaseous products of distillation have to run the gauntlet of this white-hot section, and, during their passage, are completely cremated. Such a High Temperature Incinerator is capable of handling about seven tons of refuse per day per cell; this fact, together with the saving of extra fuel, and the absence of a second fire, gives it a marked advantage over the Low Temperature System.

There are other economical contrivances connected with the High Temperature Incinerator, which recommend it; for instance, the tremendous heat generated is not allowed to go to waste, but is utilized by being converted into some form of energy, a favourite one being the driving of an electric light installation. In some cases, the power derived being sufficient to serve for the street lighting of the town. Again there is a certain amount of hard clinker, which, when crushed, and mixed with a suitable proportion of cement, makes excellent concrete.

DRAINAGE.

Traps.—A trap is a sanitary appliance, designed to form a barrier between the interior of the drain, and the interior of the house. The water which is contained in the trap, blocks the lumen of the pipe, and so prevents drain air finding its way into the house.

For practical purposes, we may divide traps into two classes—Simple and Complex.

Simple traps are virtually bends in the drain pipe, which enable water to lodge therein, so forming the water seal. The shapes of these bends are various, and are usually named from their likeness to some letter of the alphabet, e.g., U, P, S. (See Exhibits Nos. 9.111 to 9.117.)

In construction, traps must fulfil certain requirements, and this will be best understood by indicating points, or conditions, which ought to be found in a good trap.

(1) Even bore throughout; (2) no corners, or places to furnish lodgment for solid materials; (3) to be made in one piece, that is, no joints providing opportunities for leakage; (4) accessibility for cleaning purposes, both inside and out; (5) efficient water seal.

The water seal in the trap is an extremely important factor, it should not be too deep, nor yet too shallow; if too deep, too much obstruction is offered to the flow of the contents of the fixture to which the trap is attached, and results in the trap being not self-cleansing. Solid materials in the liquid refuse settle down in the trap, and clinging to the sides, eventually block it up altogether.

If, on the other hand, the water seal be too shallow, it does not act as sufficient barrier against the passage of drain air from the house drain into the room. It is found that the air inside the house drains is constantly undergoing changes of pressure, sometimes negative, and sometimes positive. There is thus a tendency for the water in the trap to be either sucked out, or blown out, and when once either of these things has occurred, the drain air has free access to the house: a very dangerous state of affairs, for, as we have already seen, it may contain both poisonous gases and dangerous germs.

In practice a depth of water from two to three inches is the most suitable to form a water seal, for such a depth of water is capable of withstanding the ordinary variations of air pressure within the drain, and it is not too great to form any appreciable obstruction to the flow of liquids through the trap.

The depth of the water seal means the height of the column of water in the trap, which has to be moved before the free passage of air can be obtained. This is indicated by the painted portion of Exhibit No. 9.111.

As a further safeguard against the breakage of the water seal in these simple traps, vent pipes (puff pipes) ought to be installed: these are connected with the drain [illegible] immediately on the drain side of the trap, and communicate freely with the outside air. With such a provision, marked alterations in the air pressure within the drain can occur without interfering with the stability of the water seal; in the case of positive pressure, the air is driven up the vent pipe, where there is no obstruction, and so the pressure is relieved; likewise in the case of negative pressure, instead of the water seal being sucked out, air from the outside is simply drawn down the vent pipe to restore the balance of pressure.

These vent pipes then furnish an efficient safe-guard to the water seals, and at the same time they serve another useful purpose, for they assist in the ventilation of the drains. (q.v.)

Complex traps comprise all those varieties which are more complicated in construction than simple traps. They are usually made in several parts, thus necessitating one or more joints. The lumen is always irregular, varying in size, so offering facilities for the collection of solids in the liquid waste; various specimens of these are on the market. The two types most patronized are shown in Exhibits Nos. 9.151 and 9.152, wherein the characteristics above mentioned, relating to complex traps, are well shown. These complex traps were invented chiefly with a view to prevent Syphonage of the water seal, and to do away with the necessity of a vent pipe. To attain this end, extra obstruction is introduced to render more difficult the sucking out of the water seal, and so withstanding larger ranges of negative pressure within the drain pipes.

An examination of these complex traps will reveal immediately the sacrifice of several of the essentials of a good trap. From their very construction, leaks and blockages are the two common faults most commonly met with in this class of appliances. (See Exhibits Nos. 9.151 and 9.152).

Another faulty sanitary arrangement frequently seen is the Mercury Seal Vent. This is designed to allow of air being drawn from a room into the drain pipe, when the air inside the latter indicates a negative pressure—thus preventing Syphonage of the water seal in the trap. It is intended as a substitute for a vent pipe (Exhibit No. 9.153). It obviates the trouble and expense of installing long lengths of vent pipe ; theoretically it allows air to be drawn into the drain, but not the passage of drain air outwards into the room,—any positive pressure tends to force the aluminum cap tight down on the mercur·

As a matter of fact, in practice, we find that both the mercury and the aluminum are terribly corroded by the drain gases, and the mercury seal soon becomes defective, allowing the drain air to escape into the house. For this reason they are not to be recommended.

There are other special forms of traps designed to meet special requirements.

Gulley traps (Exhibits Nos. 9.121 to 9.123), are really simple traps with an enlarged head, being used in such places as basement floors, stables and backyards, and are liable to receive gravel and sand. The enlarged head allows these substances to be caught before entering the drain, and also affords facilities for cleaning these materials out.

Grease traps (Exhibit No. 9.141), are again modifications of a simple trap. The first part (or head), is very much enlarged, allowing a large quantity of water to remain in the trap ; the idea is to cause any liquid grease entering the trap to be congealed when it enters that large volume of cold water lying in the first part of the trap. A subsequent flush comes along, the congealed fat is broken up and washed through the trap into the drain pipe, where it is carried along as solid pieces. The idea of this arrangement is founded on the fact that solid pieces of fat are much less liable to stick to the sides of the trap, or drain pipe, than if the fat existed in the liquid state, for liquid fat, when it strikes the cold sides of the pipe at once congeals and sticks there, thus tending to block the drain.

Intercepting traps are large forms of simple running traps, usually of a diameter four inches and upwards. (See Exhibits Nos. 9.131 to 9.134).

They are intended to be used as a "cut off" between the house and the public sewers, to prevent the sewer gas entering the house drains. They are always equipped, as the Exhibits show, with an opening for ventilation on the house-drain side, allowing the entry of fresh air into the house drain.

A raking arm is provided, to give access, in case of blockage, to the length of pipe between the trap and the sewer. Those forms of intercepting traps used in conjunction with manhole chambers are not furnished with an opening for ventilation, but only a cleaning eye on the far side of the trap; the ventilation opening is unnecessary, for in the manhole itself free ventilation is always provided.

DRAIN PIPES AND DRAINAGE SCHEMES.—As in the case of all sanitary fittings, so in dealing with pipes and drains, we still have our ideal in front of us, viz., to remove quickly and efficiently all sewage matters; not to permit the retention of any part; not to allow the escape of either sewage, or sewer gas; and also to provide full command over the drains, insuring complete accessibility to the interior of them.

Commencing with the materials for pipes and drains, lead and galvanised iron are used for the small ones, up to two inches in diameter; both metals are about equally good, each possessing little advantage, or disadvantage, as compared with the other. In larger drains inside the house, iron pipes (3 to 6 inches in diameter) are used; these should be of a strong, heavy type (Exhibit No. 9.212), and not too light in weight (Exhibit No. 9.231). In times gone by, it used to be the practice to utilise stone-ware, and tile-ware pipes, for the main house drain, lying beneath the basement floor, and continuing out to the public sewer. As these tile drains cannot withstand any pressure, and are very liable to be leaky at the joints, strong iron pipes are nowadays necessarily used in their stead, up to a point outside the foundation wall of the house. From that point, to the public sewers, tile drains are used.

Remarking upon the comparative value of these various materials used as pipes,—in the case of leaden pipes, they should be of a solid drawn variety (Exhibit No. 9.234), and not of a seamed type (Exhib. . No. 9.272), because the seamed lead pipes always corrode, and give way along the line of seam. The great advantage of lead lies in its pliability, being easily accommodated to bends and angles. It has the great disadvantage of being very easily perforated, and this is a drawback.

There is little to say regarding galvanised iron pipe, beyond the fact that it is hard and durable, and not easily perforated; but the durability is not so pronounced as in the case of very heavy iron. The latter is the only kind of pipe that can be used for vertical stacks, and lengths of pipe which have to bear their own weight; they are rigid. Lead pipes would sag in their own weight, and so destroy the eveness of bore. Tile-ware, and stone-ware pipes (Exhibit Nos. 9.221 and 9.222) have been used largely on account of cheapness, and are practically limited to that portion of the drain lying well outside the house, leading underground to the public sewer; in this position they are not subject to heavy weights, like passing under the foundation of a house, or a basement floor, both of which have a tendency to settle, and would smash any tile pipe lying beneath them. As a wearing material, tile and stone ware are moderately good, but it is surprising how quickly they wear out under the scouring action of grit and sand, which may be contained in the sewage.

It is important to note a few things regarding the joints of these various kinds of pipes; lead pipes should always be joined to one another with "wiped" joints (Exhibit No. 9.234), never with a "bitted" joint (Exhibit No. 9.272), because these "bitted" joints are so liable to become corroded, and eventually leaky. Where lead is to be joined to iron pipes, or stone ware, this must be done through the medium of a brass collar, because lead cannot soldered to iron, or stone work; neither can it be screwed or tamped; but lead can be soldered to brass (Exhibit No. 9.232), and a screw thread can be put on brass; also the brass is strong enough to withstand the pressure of packing, or tamping; in this fashion can the joint be made between iron or stone ware pipes. The joints in all iron pipes are one of two kinds, either screw joints, which are used in smaller pipes up to three inches in diameter, or caulked lead joints, in pipes of diameter larger than three inches (Exhibit No. 9.231). It requires a good strong iron pipe to withstand this caulking process, the collar on a light pipe is very apt to split.

The joints between stone-ware, or tile pipes, ought always to be made with good cement. Various tricks are sometimes resorted to, to save cement, by unscrupulous workmen (fortunately not common), clay often being substituted; sometimes clay with a thin facing of cement; and on occasion, the jointing material being left out altogether, the sewage being allowed to escape freely through the open joints into the ground surrounding the pipe.

All drain pipes should be laid so that the inside bore, or lumen, should be perfectly even and straight, of course with the necessary grading to enable the sewage to flow; any sagging of the pipe allows a portion of the sewage to be retained, there to undergo decomposition. Bends and angles should be avoided as far as possible, and where the direction of a line of pipe is to be changed, either laterally, or from horizontal to vertical, pipes having nicely curved bends, and not sharp angles, should be employed. In all drains for houses, the smaller pipes for sanitary fixtures on the various floors are made to converge on each floor to one, or more, vertical stacks of main drain pipe; these stack pipes are never less than four inches diameter, because they have to receive not only the small drain pipes, but must take in all the pipes from water closets, which we have already seen have a minimum diameter of four inches. Continuing upwards, this soil stack, as it is sometimes called, rises in a straight line above the top floor and through the roof, projecting to a height of not less than four feet above the highest opening in the house, not counting the chimney. This is for the ventilation of the drain, (q.v.) Following the soil stack downwards through the lower storey, we come to the basement floor, where the pipe takes a bend, and runs beneath the floor in a line towards the public sewer. In its course beneath the basement floor, however, it has to pick up pipes from certain fixtures, like wash tubs, sinks, and gulleys, which may be situated in the basement; having done this, the main drain leaves the house beneath the foundation wall, and away to the public sewers.

The principles of drain laying and branching vary in different places somewhat, but there can be no question about deprecating the practice of joining pipes together promiscuously, more especially beneath the basement floor, which in most houses nowadays is concrete. In the upper floors, the best plan to adopt is to have the drain pipes visible, if possible, throughout their entire length, thus insuring complete accessibility in case of need. The pipes from the various fixtures generally run in straight lines to the soil stack, and where they join either one another, or the soil stack, at such junctions "Inspection Eyes" should be provided—giving access to the interior of the drain in case of blockage.

In that portion of the drainage system lying beneath the basement floor, the best practice is to make all the drain pipes, whether it be a main drain, or the pipes leading from the basement fixtures, to run in perfectly straight lines to a " Manhole Chamber," situated as near as possible to the point where the main drain leaves the house.

The general construction of the "Manhole Chamber" is well shown in Exhibit No. 9.253, and by reference to the Diagram Exhibit. By adopting this principle of the "Manhole Chamber," we obviate entirely a system of branching pipes lying beneath the concrete floor of the basement; each pipe from the basement fixtures opens separately into the chamber, and, running in a straight line between the

"Manhole Chamber" and the fixture, is thus completely at the command of anyone standing inside the "Manhole Chamber"; so being fully accessible in case of blockage.

Compare this with the system of indiscriminate branching of the drain pipe beneath the cement floor; in this case, a blockage taking place on any of the branch drains, access to the pipe is impossible, unless by tearing up the concrete floor, and breaking into the drain.

In those systems where no "Manhole Chambers" are provided, the only means of access to that portion of the pipes lying beneath the basement floor, is an "Inspection Eye," placed on the main drain just before it leaves the house. These "Inspection Eyes" can be obviously an apology only, in the way of accessibility to the drain. People who have to work with drains, cleaning, or testing, find it quite impossible to command the system of pipes through such an inadequate opening. The use of raking rods is precluded.

As regards testing drains, there is no comparison between the system of straight drains and "Manhole Chambers," on the one hand, and the system of indiscriminate branching on the other. In the first, each pipe, as it enters a "Manhole Chamber," can be tested separately; a leak can be located with the greatest amount of ease, and the least amount of trouble.

In the second case, where the only means of entrance to the main drain is an "Inspection Eye," the whole drain, and its several branches lying beneath the floor, must be tested all together. Under these conditions it is quite impossible to locate a leak, not knowing whether it exists in the main drain, or in one of its branches; and any attempt to fix a definite point, involves a tearing up of the concrete floor.

Ventilation of drains is necessary, to rid them of the drain air, or sewer gas, which, as we have seen, is a dangerous concomitant of sewage in the drain. We endeavour, by a rapid and efficient removal of the sewage from the drains, to prevent the formation of noxious gases therein.

Under the best conditions, however, seeing that sewage decomposes so rapidly, we cannot avoid the formation of a certain amount of gaseous products; but by the introduction of a stream of fresh air into the drain, we endeavour to dilute, and sweep out, any of these gaseous products which may have formed. With this end in view, an inlet pipe is placed near the ground, which, in those cases where "Manhole Chambers" are installed, leads directly into the Chamber, thus permitting the entry of fresh air to the main drain, and all its branches. We have already seen that the main drain continues up the vertical soil stack, and out above the roof. As the air in the drain is usually warm, it has a tendency to rise, the length of the vertical soil stack acts as a kind of chimney, up which the warm air ascends, sucking the fresh air after it through the inlet opening situated at the other end of the main drain.

With reference to a perfect ventilation of drains, it would be well to recall the system of installing vent pipes, or puff pipes, which was recommended to prevent Syphonage of water seals in traps. As will be remembered, these vent pipes either separately, or joined together, run up through the roof and communicate with the outside air; here we have an exit for the drain air lying in all the drainage pipes connecting the various sanitary fixtures with the main drain; fresh air is thus drawn along all these branches, and on this system, free circulation of fresh air is assured throughout the main drain, and all its branches. Compare this with the case of those traps which do away with vent pipes. Although the main drain and the soil stack may have a current of air passing along, none of the branch pipes leading from the various fixtures will have any circulation of air through them, for obviously we cannot have circulation along a length of pipe which terminates blindly. In this respect, all those complex traps which are designed to do away with the vent pipe, although they may be a little more economical to install, certainly do not give such a perfect system of ventilation as the simple types.

At this point, we must consider "Intercepting Traps." These are large traps placed on the main drain just as it leaves the private premises on its way to the public sewer; and were designed to prevent the entry of sewer gas from the public sewer into the private house drain.

Knowing, as we do, the dangers contained in this sewer gas, except in the case where the public sewers are so beautifully kept, and the ventilation so perfect, that the air therein is as good as the fresh air outside; knowing, as we do, that the state of the public sewer is generally very far from this ideal, there can be no question as to the soundness of the contention that it is better not to allow the bad sewer gas in the public sewers to pass into the house drain, if it can be prevented by the "intercepting trap." In spite of this, many city engineers inveigh against the use of these traps, and do so on two grounds; first, that they afford an obstruction to the free flow of the house sewage, and are liable to become blocked; secondly, they prevent ventilation of the public sewers through the house drains; and they claim that, if all the numerous soil pipes in the houses, connected with the public sewers, could be utilised as outlet shafts, fresh air will have to be drawn in to the sewers to replace this foul air, and so good ventilation of the public sewers would result. No one would contend that this would not be so, but most householders, naturally, would object to any part of their private property being utilised as a foul air shaft for public concerns, and are partly justified in maintaining that, if the city authorities want their sewers ventilated, they should devise some system of their own whereby it could be accomplished, and not intrench upon the private rights of the householders. Again, there is another thing in the householder's favour, when he has his house drain full of foul gas from the public sewer, and any leak occurs in his private drainage scheme, he then gets the full benefit of this foul air in his house, whereas if he had his own drain well ventilated and cut off from the public sewer, he is not so badly off in the case of a leak.

Drain Testing.—There are two classes of work in which drain testing is necessary:—(1) new drainage schemes, which should be thoroughly tested before being passed, and (2) old drains, wherein leaks are suspected.

The latter kinds of work are usually not subjected to such severe tests as the former, because old drains, tile ones especially, are apt to be worn, and consequently weak, even though they be whole, and any undue pressure put upon them by the test, might easily cause serious damage.

The following are the tests commonly practised:—Water test, Smoke test, Air test, and Chemical test.

The Water test is one of the most severe, and all new drains should certainly be put through it. The test is made by first plugging the lower end of the drain pipe, then filling it up with water until a head, or pressure, is produced,—this pressure varying with the different kinds of pipe under test. Strong Iron Pipes ought to be able to stand a pressure of 10—20 feet of water, or even more. Tile drains are generally capable of withstanding a pressure of 2 or 3 feet of water.

If the level of the water remains constant, after the pipe has been filled, it shows sound work; if the level slowly sinks [illegible] is indicated, and the pipes must be examined to loca[illegible] he joints are usually the defective spots.

The Smoke test is applied most commonly by means of a smoke machine (see Exhibits Nos. 9.261 and 9.265); but occasionally smoke rockets are used. This test is perhaps the favourite one used when old drains have to be examined. The machines deliver dense smoke through a flexible pipe, which is connected up with the drain at some convenient point. The smoke is pumped in under slight pressure, about two inches of water. Leaks are evidenced by the escape of smoke.

Rockets are used in cases where machines are not available. When the fuse is lighted, the rocket is thrown into the drain, and the ends of the drain pipe closed. Dense volumes of smoke are generated, and permeate the length of drain pipe.

Rockets are decidedly inferior to machines, because the output of smoke cannot be regulated, or controlled; and, moreover, the machines give a continuous supply, whereas the smoke from a rocket is disengaged within the space of a few moments.

The smoke test is very useful when applied to drain pipes exposed above the ground, for any escape of smoke from leaks is detected at once; in underground drains, however, escaping smoke may take a long time to reach the surface, and become evident; this applies more especially to drains lying beneath a basement floor made of concrete.

The Air test consists of driving air, under pressure, into the drains, and noting, by means of a gauge attached to the pump, whether the pressure is maintained constant. Of course the ends of the drain are securely plugged, previous to the air being forced in. The pipe, conducting the compressed air from the pump, connects with a special plug, which has a tube in the centre, communicating with the interior of the drain (see Exhibit No. 9.264). This test is rather a severe one, because the slightest pin-hole leak permits the compressed air to escape, with a corresponding drop of the pressure gauge. For this reason it is only rarely adopted.

The Chemical test is made by introducing some chemical substance, possessing a powerful odour, into the drain; and then noting whether the characteristic smell can be detected inside the house,—if so, a leak in the drain pipe exists.

The commonest substances used for this purpose are, Oil of Peppermint, Assafœtida, and Phosphorus.

As an efficient test, it cannot be strongly recommended, because we possess in the preceding tests much better means of detecting leaks.

A drawback to the use of these chemicals is, that their pungent odour practically excludes their introduction inside the house, or building; they should, for this reason, be inserted into the drain pipe at some point outside the building, e.g., the vent-pipe of the main drain.

It is practically impossible to put these substances into the drains inside the building, without having the odour permeate the atmosphere therein; and when this takes place, the whole test is rendered useless, for the basis of the test lies in the detection of the characteristic smell.

Arising out of the foregoing remarks concerning the different tests usually employed, is the question how to apply them.

Drainage schemes may be very simply constituted, or they may consist of a vast number of drain pipes converging on one or more common outlets, or main drains. In any case, drain testing cannot be efficiently carried out unless the pipes are accessible for such purposes.

Herein lies one of the most important points connected with the proper designing of drainage schemes,—accessibility should be secured throughout. Moreover, it is obvious that only certain sections can be properly handled at any one time; it is impossible to conduct a satisfactory test upon the whole of a large system at once. These considerations lead to the advisability of so designing drainage schemes that they can be sectionised, so as to enable anyone conducting a test to handle small sections one after another. The plan of drain pipes should be so devised as to make them converge in straight lines upon one point, this point is the Manhole Chamber; (see reference to these installations under Drainage Schemes, Sect. 9).

The testing of drains exemplifies, more than anything else, the advantages of the Manhole Chamber. The complete command over the whole drainage system given by such an arrangement is patent enough.

A common error in the design of drainage schemes, more especially on this continent, is the installation of Inspection Eyes to the various drain pipes, of such a nature as to effectively prohibit the introduction of suitable plugs, for drain testing purposes. For instance, one frequently comes across an inspection eye, 3 or 4 inches in diameter, giving access to a 6-inch drain pipe; how impossible is it to introduce a 5—6 inch plug through a 3—4 inch opening.

We now come to the most important sanitary fixtures to be found in houses.

WATER CLOSETS.

They are most important, because they have to deal with the most dangerous component of sewage, namely, human excremental matters. We have seen already that these matters contain large numbers of dangerous germs capable of causing diseases. It is eminently necessary, therefore, that these appliances should remove the dangerous materials quickly and efficiently. In passing judgment on any water closets, these requirements should always be kept in mind, and any structural arrangement in the water closet, which will permit of the retention of the contents of the bowl, is quite sufficient to condemn it as an efficient sanitary apparatus.

The dangers attendant upon retention of excremental matter in any part of the bowl of the closet cannot be overestimated, because the germs lurking therein are given the opportunity to be carried away, and find lodgment in a healthy person, thus setting up disease. The two methods of dissemination, under these conditions, are personal contact with the dangerous matter, and also transportation by flies.

In the study of water closets, it will probably be better to consider them in the order in which they appeared before the public.

The first variety was the old-fashioned Pan Closet (see Exhibit No. 9.411). Next came the Long-Hopper, and Short variety of the same. (See Exhibits Nos. 9.421 to 9.423). These two classes are now entirely out-of-date, and no longer sanctioned by Municipal authorities.

An examination of the exhibits will soon demonstrate that both these types of closets are a long way from being self-cleansing. By their shape and general construction, and inefficient flushing, they offer every facility for the retention of excremental matters.

Next in order of invention, are the simple Wash-down varieties; they have stood the test of time, are much patronised at the present day, and it is very doubtful if more modern types of closets are an improvement on them. An examination of this class (Exhibit No. 9.441), demonstrates both the simplicity and efficiency of their general construction.

The bowl and trap are built in one piece, thus offering no joints which are liable to become leaky. Half the water seal in the trap lies within the bowl, providing a large water surface for the reception of the excremental matter, and accessibility to the trap is thus fully assured. The shape of the sides, and the straight back, are designed towards the same end—cleanliness.

A good flushing rim is an essential feature, and in any efficient form will so distribute the flush water as to insure thorough washing of all parts of the bowl, and the various streams from the rim converge to the outlet in the trap, the contents of the bowl thus being effectively forced through the trap into the drain pipe immediately beyond. Simplicity of construction, self-cleansing, efficiency of flush, and complete accessibility to all parts of the bowl and trap, are the characteristics of this type of closet.

Closely following the Wash-down, came the Wash-out variety of closet (Exhibit No. 9.431). This was thought to be an improvement over preceding types, more especially because it provided a larger bowl, and a bigger water surface presented. The idea being, of course, to insure the appliance being more perfect as regards self-cleansing properties.

The trap is placed beneath the bowl, and is built all in one piece without joints. On the whole, it is a moderately good type of closet, but has drawbacks relative to its self-cleansing powers. When the flush is in action, the contents of the bowl are washed out (hence the name), and are forcibly dashed against the side of the first part of the trap.

Compare these with the Wash-down.

Again, as the contents of the bowl are swept into the first part of the trap, it passes over the lip, or edge, forming the front part of the bowl, and solid matters are very apt to stick on the under surface of that lip. The flush water generally passes over that particular spot after the manner of a cascade ; the only power therefore to force the contents of the bowl through the trap is the actual weight of water, no force from the flushing rim being available, and for this reason the state of the trap is not as clean as in Wash-down types.

Within the last ten years or so, a new type of closet has come into use, the Syphon Jet, and the Syphon-like closets. The earliest specimens of this class were truly Syphonic in their action. They constitute a good type of bowl, with trap all in one piece, very much after the style of the Wash-down closet, but different from the latter in having a second trap set below and a little beyond the first trap ; a vertical length of pipe, about 18 inches, connecting the two. (See Exhibit No. 9.451).

At the top of this vertical portion of pipe, a jet of water is thrown down the centre, falling into the second trap. This generates negative pressure in the pipe lying between the two traps, by exhausting some of the air contained therein. An ingenious arrangement connected with the flushing apparatus, allows of this jet to come into action a short time before the main flush appears in the flushing rim of the bowl, so that the contents of the bowl are carried away under the action of two forces—the driving power of the flush in the bowl, forcing it through the first trap, and the suction action on the far side, tending to drag it through the same trap.

The liquid flows down the vertical part of the pipe, and then passes through the second trap, and so on into the drain. There is no question about the self-cleansing power of this type of closet, the contents of the bowl are swept away with great force. It has never been very popular, however, because the flushing operation is such a terribly noisy performance, and resounds through the house where one of these closets is installed.

A modification of this Syphon Jet very soon followed : it is known as the Syphon-like closet. The second trap in the Syphon Jet type was quickly realised to be a drawback, both on account of offering a certain amount of obstruction, and its inaccessibility. In the Syphon-like type, the second trap is done away with: the jet had likewise to be discarded, because without the second trap you can get no appreciable exhaust action.

The bowl and trap, all in one piece, present the usual appearance of the Wash-down closet ; the opening for the jet [illegible] placed at the bottom of the trap just within the bowl, this jet comes into play just before the main flush in the flushing rim, so giving a little extra thrust to the contents of the bowl, as they are forced through the trap by the power of the main flush ; the contents then pass down the pipe leading from the trap to the house drain, this pipe being bent upon itself at right angles, and, as the liquid falls through the first or vertical portion of this bent pipe, it is supposed, by its weight, to cause a slight suction. (See Exhibits Nos. 9.452 to 9.453).

In actual practice it is found that this suction action is of no moment whatever, and it is exceedingly doubtful whether this form of closet possesses any advantage over the simple Wash-down. In fact, it is a question whether the convoluted section of pipe immediately following the trap is not a disadvantage, as compared with a straight length of drain pipe which exists in the Wash-down variety ; for undoubtedly this bent section, being smaller in diameter than the ordinary drain pipe, and by virtue of several bends therein, must interpose resistance to the free flow of liquids. Again, in case of blockage, it is very inaccessible, for if we wished to clear the inside of that part of the pipe, it would be necessary to take up the whole water-closet from its seatings on the floor.

Flush Tanks.—As these tanks form part of the general construction of a water closet, it will be best to consider them at this point. They are designed to fulfil two requirements—first, to provide storage and delivery of the requisite amount of water to flush the bowl, and, secondly, to prevent unnecessary waste of the water ; on the latter account they are called "water waste preventers."

When dealing with the average person, it must be realised that they require some apparatus involving the minimum amount of care and attention, and that people will not take the trouble to hold the valve open while the necessary amount of water passes, so leading to want of cleanliness. On this account, therefore, all flush tanks, now-a-days, work on the automatic principle, that is to say, the moment the chain is pulled, the flush starts off and is continued automatically, although the chain is released.

The various exhibits of water closets show their attached flush tanks placed about six feet above the bowl; they are placed there in order to give the water a certain amount of pressure, or "head." The amount of water required to flush an ordinary closet bowl, is usually about 3 gallons; less than two is found to be inefficient, and, of course, a maximum limit must be fixed, otherwise there would be an undue consumption of water, and this is of vital importance in towns and cities, where the water supply is not over abundant. The average capacity of these tanks runs about 2 to 3½ gallons.

Another type of flush tank, which is in general use, is situated low down, just above the back of the closet seat; in this kind, there is obviously very little pressure, or "head," available, to impart force to the water for flushing purposes; to overcome this difficulty, what advantage is lost in regard to force, is made up by additional volume of water delivered through the wide pipe; the attraction of this arrangement is an absence of noise, but we must take note of the fact that this type of tank requires a much larger volume of water; the average tank giving from 6 to 10 gallons per flush (Exhibit No. 9.452).

In places where water has to be carefully conserved, such apparatus, consuming as they do large quantities of water, are not looked upon with very great favour.

Lastly, the Flushometer. This ingenious device was intended by the inventor to replace to a certain extent the flush tank, the original idea being to install these appliances in places where batteries of closets had to be arranged for, and instead of having a flush tank to each closet, to install one large general flush tank, the water supply from which would be controlled at each closet by a flushometer. An examination of Exhibit No. 9.453 will show the working parts.

The appliance can be regulated to deliver any quantity of water, and is set in motion by simply pulling the handle. The ease and the economy with which these apparatus can be installed has made them very popular, but it is becoming quite common, now-a-days, to find them connected up directly with the system of water pipes, instead of to a special tank.

This question of connection between flush tanks and a system of water pipes, is a very important one from the hygienic point of view, as it opens the door to certain risks of contaminating the public water supply. We may safely premise our argument on this question, by assuming the water in the flush tank connected with a water closet, to be unsafe for drinking purposes. No one would deny the possibility of undesirable germs gaining access to flush tanks at certain times, and under certain conditions, and therefore the water contained in these tanks cannot be allowed under any circumstances to gain entrance to the general system of water pipes conveying drinking water.

One finds so very often, in flush tank installations, that the water pipe feeding the tank is submerged, when the tank is full; this condition means that the water in the tank and the water in the feed pipe are in direct connection, the valve of the ball-cock being the only thing intervening.

Now we know from experience that these valves are commonly not water tight, and that if any suction action takes place in the water pipes, the water in the flush tank can be sucked back into the water pipes, thus joining it to the public drinking supply in the water mains. Cases of this kind are by no means infrequent, and in order to guard against the danger, the water supply pipe, with the valve at the end, should always terminate a few inches above high water mark in the tank, so that there will exist an air space between the water in the flush tank and the end of the feed pipe; thus any suction taking place in the water pipe, only air, not the tank water, can be drawn into the pipe. It is for this reason that one views, with a little doubt and suspicion, the increasing practice of connecting flushometers directly with the water pipes conveying drinking water.

Lastly, a word must be said about over-flow pipes, in connection with flush tanks. In fact, the remarks to be made apply to all over-flows, and, more especially on this continent where water and drain pipes are usually installed inside the house for climatic reasons, over-flow pipes from any tank are nearly always connected up directly with a drain pipe. Under such circumstances, the existence of a trap on this over-flow pipe is regarded as an adequate safeguard against the entry of drain air, or drain gas, into the house along the over-flow pipe. The security thus afforded is seen to be very doubtful, unfortunately, if it be realised that such a trap can only be a safeguard when it contains its proper amount of water, that is, water seal; and if it is also realised that over-flow pipes are only called into service very occasionally, because they are not over-flowing all the time.

It can be readily understood, that in the long intervals occurring between the times of water actually flowing down the pipe, the water seal in the trap will naturally dry up, and the moment this occurs, the drain gases have just as much opportunity of entering freely into the house, as if no trap existed on the pipe at all.

In regard to the installation of over-flow pipes, the soundest and safest practice, therefore, is to make them open directly through the wall of the house, and let them terminate there in the open air, so that, whenever the tank does over-flow, the water can escape freely into the outside air, and there is no possibility of any drain air, or drain gas, returning along such a pipe; an arrangement which has the further advantage of indicating, at the earliest moment, to the inmates of the house that there is something wrong with the ball-cock, and requires attention.

Under the common prevailing system, the valve may be leaking for weeks, or months, and none of the inmates be any the wiser, because the over-flow of water finds its way directly into the drain, where they cannot possibly see it.

In order to complete the subject of flush tanks, their construction may be briefly noted. Exhibit No. 9.423 shows a very cheap, inferior, kind of tank; this style is to be avoided, because they are very inefficient, and quickly become defective through their flimsy construction. Exhibit No. 9.431 shows, what we might term, a moderately good tank, but in comparison with such samples as Exhibit No. 9.441, the superiority of the latter will be readily observed.

The substitution of porcelain ware, for wood and copper work, is a great advance in this section of sanitary fittings; the extra cost is very trifling, and their durability and general cleanliness more than amply repay this expenditure.

These remarks concerning durability and soundness of construction, relating to water closets and flush-tanks, apply equally well to all other kinds of sanitary fixtures. There seems to be a growing tendency, in the present age, to make all fixtures and pipes extremely light, with the result that they are not capable of withstanding prolonged wear and tear, to which such appliances are necessarily subjected; and there is no question that the average householder, when installing sanitary fixtures, appreciates something that will last a good few years, far more than fixtures that wear out rapidly and require repairs very soon.

BATHS, LAVATORY BASINS, SINKS, ETC.—All these fixtures are judged by the same standards as the preceding appliances, viz.: do they offer any facilities for the retention of waste materials (*e.g.*, fat or soap), which would either be dangerous to health, or be a nuisance.

In all three classes, the appliances now-a-days found on the market, are usually so simply constructed and well made, that little opportunity is afforded for retaining waste matters. The interiors of these fixtures present no corners or crevices where decomposible matters might lodge. The only place, where such a lodgment might come about, is in the overflow. All these sanitary fittings have to be provided with an overflow, and it is chiefly in the design of this adjunct that any shortcoming arises.

Briefly put, the whole matter resolves itself into the question whether or no the overflow is so complicated in construction as to be inaccessible, and therefore incapable of being easily cleaned.

Kitchen sinks, by virtue of the culinary refuse which they dispose of, are very liable to have their attached traps blocked with grease. It is under these fixtures that grease traps are frequently installed, with the intention of preventing greasy substances entering the drains, and blocking them up.

Baths have a little hygienic interest attached to them all their own. Under certain peculiar conditions, *e.g.*, where they are used by Scarlet Fever or Typhoid patients,—the waste waters from them may be distinctly infectious, and special precautions should be taken to deal with the wastes. Some Sanitary Authorities have recommended that these fixtures, when used for such purposes, should have special drain pipes leading directly to the main outlet, and in no way communicating with the rest of the pipes of the ordinary drainage scheme; with the idea of preventing any possible return flow, *viâ* the other fixtures on the system, to other parts of the building. In any case, it is worth while remembering the possibility of infection being spread by this channel, and it should serve to accentuate the advisability of rendering such infectious waste waters sterile by the addition of some suitable disinfectant, before they are released into the ordinary drains.

DISPOSAL OF SEWAGE.

As the sewage leaves the house drains and passes along the public sewers to their outfall, there is nothing very particular for us to note, beyond the fact that it is taken for granted that the public sewers are kept in good order, and well ventilated. At the outfall the sewage is finally disposed of in one of several ways :—

(1) Pouring into the sea, rivers, or lakes.
(2) Disposal on land.
(3) Chemical Precipitation, Septic Tanks, dimentation.
(4) Biological Treatment on Artificial Beds.

Sea Water.—Disposal of the sewage into the sea in its crude state is quite legitimate and sound, wherever the nature of the coast line and tidal current will insure that there shall be no fouling of the fore-shore. If the latter occurs, then some form of treatment is called for. The presence of shell fish industry should also be noted, for the shell fish have been shown to be capable of picking up disease germs from sewage, and so transmitting them to consumers of these shell fish. Several epidemics of Typhoid have been traced to this source.

Fresh Water.—The disposal of sewage in its crude, or untreated state, into bodies of fresh water like rivers and lakes, especially if these are the sources of drinking supplies, is strongly to be deprecated. It may be that the bodies of water are vast enough to dispose of the chemical organic constituents of the sewage, but the sewage germs can, and do, retain their vitality in such waters for a long time, and are carried great distances by the various currents existing in such bodies of water. Disinfection of the sewage effluent in this case in an ideal to be aimed at.

If the quantity of sewage be so large, compared with the volume of fresh water into which it empties, as to make its presence patent to the ordinary senses of sight, taste, or smell, obviously such a body of water, so defiled, cannot be utilised for drinking purposes, quite apart from the presence of sewage germs ; for even though we could kill every germ contained therein, we should still be left with a noxious fluid quite unfit for potable purposes ; such conditions would demand treatment of the crude sewage, so as to produce a clear effluent, free from all odour and taste.

SEWAGE TREATMENT.

In order to fully appreciate the different modes of sewage treatment, it is essential to obtain a clear idea of the component parts of ordinary sewage, and to see what can be done in the way of treating these constituents. The following scheme will show clearly and briefly the composition of sewage, as we have to deal with it in sewage treatment.

Sewage
- Organic matter in solution
- Organic matter in suspension
- Salts
- Water

} Food for Germs } Inanimate Part

- Living Germs . . . . Animate Part

The inanimate part is really an aggregation of chemical compounds, organic and inorganic. The [illegible]ganic materials serve as a food for germs, and this is [illegible] demonstrated when raw sewage undergoes decompo[illegible]. Considering the organic materials only, we ma[illegible] the first place, eliminate the solid suspended matter [illegible] some process of filtration, or precipitation. The organic matter in solution in either of those processes, remains practically unaltered. Now, as all popular forms of sewage treatment virtually depend upon the powers possessed by germs to digest, or dispose of, organic matter, it follows that we may feed to these germs either the crude sewage containing organic matter in suspension, and in solution; or the sewage from which the solids in suspension have been removed, and so containing only the organic matter in solution.

Germs may be conveniently divided for our purpose into two groups—The Ærobic and Anærobic. Briefly expressed, the Ærobic digest organic matters, both solid and in solution, and convert them into final, simple, stable, end products.

The Anærobic, on the other hand, only partially digest solids in suspension, converting them into slightly less complex organic compounds, of the nature of Peptones and Albumoses.

An important point to note is that these Peptones and Albumoses are soluble bodies, and capable of undergoing violent decomposition, under the action of germ life; so we may say that the chief function of Anærobes is to liquefy the solid organic matter in suspension, and when crude sewage is fed to them, they virtually turn out a liquid containing the organic matter in solution, together with the new soluble organic compounds formed by their action on the solid materials.

In sewage processes they are made use of, therefore, in the way of preliminary treatment of the crude sewage, in order to obtain a fluid containing a maximum proportion of organic matter in solution, and a minimum in suspension. As we have seen, such a fluid is far more easily disposed of by the Ærobes than the original crude sewage. The Anærobes are the agents which accomplish this work in septic tanks.

The Septic Tank (Exhibit No. 9.57) is an arrangement whereby the air is excluded from the sewage as it passes through the tank, thus encouraging the growth of Anærobic germs, and inhibiting (but not destroying) the Ærobic germs.

A septic tank effluent is, therefore, particularly rich in soluble organic matter, and in a state easily disposed of by the Ærobes, who get in their work after septic tank treatment.

Looking at the above scheme of the composition of sewage, and bearing in mind the fact that we can remove the solid organic matter either completely by chemical précipitation, or incompletely by Septic tank action, we have a choice of feeding sewage to the Ærobes either in its crude state, or in a form free from organic matter in suspension.

From what has been said concerning the power exerted by Ærobes on organic matters, both in solution and in suspension, it is perfectly obvious that they would be able to deal with much larger volumes of the liquid in which there is only organic matter in solution, than they could if the liquid contained organic matter in suspension.

Another point of importance is the fact that the Ærobes, being able to dispose of the major part of the solids in suspension, leave a sludge; this sludge would tend to block up the interstices of any soil, or bed, in which these germs lay.

Seeing that, however we may employ germs in the treatment of sewage, we always obtain a certain amount of solids remaining (virtually irreducible), it is a question of choice as to whether we have our sludge formed in the beginning of the treatment, or at the end.

In the chemical precipitation process, we get our sludge at the beginning; in all forms of treatment where artificial Ærobic beds are employed to deal with either crude sewage, or Septic tank effluent, we get the sludge formed at the end of the process.

We are now in a position to consider more in detail the performance of the different systems of sewage treatment.

LAND TREATMENT depends upon the Bacteria contained in the superficial portion of the soil; these Bacteria are Ærobic in character, and require free access of air (Oxygen) to them. They virtually digest the organic matter contained in the sewage, and give an effluent very clear, and non-decomposable; the soil by itself acts as a mechanical filter, which accounts for the remarkable clearness of this effluent, and, at the same time, it certainly filters off a good percentage of the germs contained in the original sewage; but it does not, however, filter off all of them, by any means: the proportion eliminated depends largely upon the fineness of the soil material, and the rapidity with which the fluid passes through it.

There are two main types of Land Treatment—Broad Irrigation, and Intermittent Downward Filteration.

Broad Irrigation virtually consists of a simple application of crude sewage to the land, without any preliminary treatment beyond rough screening; it resembles, in many respects, the simple manuring of land adopted by farmers. The germs on the soil can only negotiate a certain amount of the original solid organic matter in the sewage, and, if over-dosed, the solid materials accumulate on the surface of the soil, creating a frightful nuisance. When such a condition has been arrived at, the Ærobic germs are practically smothered for want of oxygen and stop work;—the land is then said to be "sewage sick."

Owing to the limited amount of sewage, which can be applied to a given area of land under this system, it does not lend itself to the treatment of vast quantities of sewage, such as are derived from a large city, because the total area of land required would be enormous, and therefore quite impracticable. This process is sometimes termed "sewage farming"; and, speaking generally, an acre of ground is able to dispose of about four or five thousand gallons of sewage in twenty-four hours. Clay forms an absolutely unsuitable soil for this purpose, because it is practically impervious to water. A good sandy loam is the best of all soils, and where the process is practicable, the final effluent is a particularly good one.

Intermittent Downward Filteration consists of suitable land prepared and under-drained (Exhibit No. 9.51), so as to dispose of a much larger volume of sewage. It really partakes of the nature of an artificial sewage bed (q.v.), and works precisely on the same biological principles. Owing to a larger amount of sewage being applied in this system, as compared with Broad Irrigation, the solid materials naturally accumulate on the surface, necessitating either raking over, or digging over, the superficial portion of the soil, so as to introduce the solid matters to a greater number of Ærobic germs.

A modified form of "Land Treatment" is shown in Exhibit No. 9.57, and partakes of the nature of "sub-soil irrigation"; it deals with a clarified effluent, viz., that from a septic tank. This liquid is distributed in the first twelve inches of the soil, by means of distributing pipes, composed of agricultural tile drains. The cinders and coke surrounding these pipes are put there simply for the purpose of spreading the liquid over a larger area of soil, and insuring free access of air to the germs which are carrying out the purifying process.

Such installations are suitable only to private houses, and small institutions. If volumes of sewage more than two or three thousand gallons have to be handled, the scheme is unsuitable, because it would entail such a long length of pipe, and imperfect distribution results. Where practicable, the effluent from this system is an excellent one.

ARTIFICIAL SEWAGE BEDS.—The various styles of artificial sewage beds are really nothing more than an improvement upon Nature's bed, viz., the soil; in this respect, that, whereas soil contains only a given number of Ærobic germs in its upper layers, and that owing to the fine texture of the earth, it only allows the liquids to percolate through it at a moderate speed, artificial beds are constructed of materials affording large interstices (like coke and clinker); therefore, not only the surfaces of the coke, or clinker, are covered with a thick layer of germs, but air is freely admitted. Briefly put, an artificial sewage bed is an arrangement whereby the maximum number of germs is crowded into a minimum of space. These germs, of course, owing to the free access of air, are necessarily Ærobic. These artificial beds accomplish the same results as land, that is, the germs therein break up all the organic matter into stable end products. Seeing that these beds are Ærobic, we can serve to them either the crude sewage, or a clarified effluent, exactly as in the case of land treatment. If crude sewage be applied to these beds, the solids tend to collect, and finally block up the bed ; but if a clarified effluent be used, they can go on working almost indefinitely. As was pointed out before, their great advantage is that an enormous volume of liquid can be dealt with, in some cases as much as five million gallons of liquid can be treated per acre per day. Compare this with land treatment.

In actual practice, these artificial sewage beds take one of two forms, either the Contact Bed (Exhibit No. 9.52), or the Trickling Filter (Exhibit No. 9.59).

In Contact Beds, the liquid is allowed to lie in contact with the germs, clinging to the material composing the bed, for two hours; whereas, in a Trickling Filter, the liquid is sprayed on the surface of the bed, and allowed to trickle through it, coming into close contact with the germs in its passage. In the latter case, the time taken for the liquid to pass through a bed about eight feet deep is, on an average, three minutes, and it is a most astonishing fact, that during so short a time, the germs are able to accomplish their work. Various forms of apparatus for spreading the liquid on the surface of these trickling filters are in use—nozzles, sprays, rotatory sprinklers, and revolving drums on the water-wheel pattern (Exhibits Nos. 9.55 to 9.59a).

EARTH CLOSETS AND LATRINES.—Before leaving Sewage Treatment, it will be most convenient at this point to say a word about earth closets and latrines, because these two methods of disposing of excremental matters virtually depend upon the very same agencies for their working as are employed in "land treatment" and sewage beds, viz., Ærobic germs. Both earth closets and latrines are made use of in cases where water closets, etc., are impracticable:—earth closets being used in houses where there is no sewerage system, and latrines in connection with camps. In both cases, earth containing Ærobic germs is applied to the organic matter; these germs accomplish their work precisely in the same manner as described before under sewage treatment.

One or two points, regarding the practical working of these two installations, may not be out of place. In the case of earth closets, slop water should never be allowed to be emptied into the bucket, because the water would fill up all the intersticies of the soil, and so prevent the access of air to the Ærobic germs, which are in the earth contained in the bucket. Once being deprived of air, the Ærobes stop working, and the Anærobes presently begin to thrive and cause a frightful nuisance, owing to the foul gases which they produce. If anything should go wrong with the working of an earth closet, giving rise to a nuisance, the proper thing is to have the whole bucket thoroughly cleaned out, and start afresh; never, under any consideration, should strong disinfectants be used to mitigate the nuisance, because, by the addition of these disinfectants, all the germs are destroyed, and seeing that these are our workmen, we get no purification whatever carried on when they are destroyed.

Regarding latrines, these are simply trenches dug in the earth, and seeing that the Ærobic germs exist in largest number in the first twelve inches of the soil (rapidly diminishing below that depth), it is obvious these trenches should never be deeper than twelve inches, otherwise we are introducing the organic matter to that portion of the soil where the Ærobic germs practically do not exist.

These last remarks apply with equal force to the well known Privy, commonly seen attached to country dwellings, and it is merely nothing but a deep hole in the ground.

DISPOSAL OF DRY REFUSE.

9.0 Apparatus for Disposal of Dry Refuse.

9.01 FULL SIZED GALVANIZED IRON DUST-BIN

for house refuse: capacity of two cubic feet.

Experience has taught that this is the most useful size. With an ordinary household, this bin will hold nearly a week's refuse, and under the ordinary municipal management, dust-bins are usually cleared twice a week.

The other important points about the bin to be noted are:

1 Quite air-tight, preventing access of rain, and the dust from blowing about the yard.
2 It is moveable.
3 It is impervious, so that no liquid matter can soak into it.
4 It can be thoroughly sterilized.
5 Its convenient size enables it to be easily handled.

9.02 DOMESTIC GARBAGE DESTRUCTOR.

The apparatus is fixed in the flue just above the kitchen range. This is a useful little arrangement and obviates the necessity of putting decomposible matter into the dust-bin.

9.03 MODEL OF HORSFALL'S HIGH TEMPERATURE INCINERATOR.

The refuse is tipped at the back of the furnace and finds its way into the furnace chamber, generally by means of a "shoot." It then comes into contact first of all with the drying hearth; from there it is pushed along the fire bars until it comes into contact with the actual fire, which is situated near to the front door of the furnace. Previous to actual incineration, the refuse undergoes a marked process of distillation; the gases produced thereby are very abnoxious, and have to be thoroughly dealt with. The fire itself is worked by a "hot blast" which is supplied by the steam jets of the blower; this generates a tremendous heat, usually about 2,000°F. The outlet to the furnace chamber is situated immediately above the front door, leading into a zig-zag flue; this flue for a considerable distance is maintained at a white heat.

The fire itself is fed by the refuse only, and this is found to be quite sufficient for this arrangement.

It will be seen that the gases, produced by distillation, have to pass through the outlet, along the white hot flue before reaching the chimney; during their passage through the flue they are completely burnt.

As regards the refuse, nothing remains but fine ash and a little clinker. The ash collects in the space below the fire bars, and is very useful, when mixed with cement or lime, for making concrete or mortar. Lastly, there is a further economy; a series of boiler tubes can be placed in the flue, near the chimney, where the heat is quite sufficient to generate a large amount of steam, which can be utilized for mechanical purposes.

9.04 HEENAN AND FROUDE DESTRUCTOR.

9.09 MOULE'S PATENT EARTH CLOSET.

This appliance is particularly useful for country houses; it is exceedingly simple, and the different parts explain themselves. The thing to be noted about it is that the contents of the bucket must always be kept dry. Slops and the like must be carefully excluded, otherwise when a large amount of moisture is present, decomposition sets in and a nuisance results.

SEWAGE DISPOSAL.

9.1 Traps.

9.11 SIMPLE TRAPS.

- **9.111** Simple S-trap, showing depth of water seal, cleaning eye, etc.
- **9.112** Modified S-trap.
- **9.113** Simple U-trap.
- **9.114** Simple P-trap.
- **9.115** Model of 4-inch iron P-trap.
- **9.116** Simple syphon trap.
- **9.117** Model of dipstone trap (old fashioned, not used now-a-days).

9.12 GULLEY TRAPS.

- **9.121** Simple gulley trap.
- **9.122** Sediment gulley trap.
- **9.123** Head for gulley trap.

9.13 INTERCEPTING TRAPS.

- **9.131** Buchan's intercepting trap (mod[illegible]
- **9.132** Full sized sectional model of [illegible]an's intercepting trap.
- **9.133** Running trap with central inspection eye, 6-inch tile drain.
- **9.134** Weaver's intercepting trap (model).

9.14 GREASE TRAPS.

- **9.141** Section of a grease trap, full sized.

9.15 COMPLEX TRAPS.

- **9.151** Sanitas Trap.
- **9.152** Ideal Trap.
- **9.153** Simple P-trap with mercury air-seal.

9.2 Drain Pipes, etc.

9.21 IRON PIPES.

9.211 Specimen of 2-inch iron pipe, galvanized.

9.212 Specimen of 4-inch plain iron pipe.

9.213 Specimen of a 4-inch iron drain pipe with cleansing flange on end.

9.214 Iron manhole cover with double water seal.

9.22 TILE AND STONEWARE PIPES.

9.221 Models of ordinary tile drain pipe, simple joint with cement. In laying ordinary tiles, and iron drains, the difficulty is to keep the invert perfectly true.

9.222 Models of stoneware drain pipe, with bituminous collar, to insure a perfect invert. The joint is completed with Portland Cement.

9.223 Full size 6-inch tile drain pipe.

9.224 Two specimens of tile inverts for sewers.

9.23 JOINTS, PLUMBING, ETC.

9.231 Specimen of 4-inch iron piping, showing method of lead caulking for joint.

9.232 Specimen of wiped solder joint. This shows the junction of lead pipe to brass collar.

9.233 Specimen of wiped solder joint : junction between two pieces of iron pipe. The bright iron is coated with a thin layer of copper, by rubbing the surface with the copper soldering iron.

9.234 Specimens of wiped solder joint : junction between two pieces of lead pipe. This is the best method of joining lead to lead, the resulting joint is very strong ; occasionally one sees a seamed joint between two pieces of lead. It is not to be recommended, because the joint is weak and liable to crack.

9.235 Patent solder joint.

9.236 Model of eccentric joint for iron piping. The mechanism insures a perfectly true invert. The joint is caulked with molten lead, precisely the same as any other simple joint.

9.237 Specimen of Yarrow joint.

9.238 Specimen of Bainstead joint.

9.24 Junction Pipes, Reducing Sections, etc

9.241 Full size 6-inch tile drain, with 4-inch Y junction.

9.242 Full size 6-inch tile drain pipe, with 6-inch T junction.

9.243 A 4-inch iron pipe, with 4-inch Y junction.

9.244 A 4-inch heavy iron drain pipe, with triple junction. On the upper surface is a bolted casing to form inspection chamber.

9.245 Reducing section of tile drain pipe, from 6 inches to 4 inches.

9.246 Expanding section of tile drain pipe, from 4 inches to 6 inches.

9.247 A 6-inch tile drain pipe, curve bend.

9.25 Drainage Systems, etc.

9.251 Model showing simple house drain; tile pipes laid on cement bed; manhole with intercepting trap at the far end of the drain. The upper end of the drain is where the soil-pipe enters.

9.252 Working model of a system of house drainage, showing the different methods by which the water seals in the traps may be broken.

It also illustrates the disconnection of the drain from the sewer, and the ventilation of the whole system.

The four methods in which a water seal may be broken are as follows:

1 Evaporation,
2 Suction,
3 Back pressure,
4 Momentum.

9.253 Manhole Chamber.

9.26 Drain Testers, etc.

9.261 Burns' Eclipse Drain Tester

with connecting pipes. This is a simple smoke testing machine. Smouldering cotton waste is placed in the interior of the copper chamber, the cover is placed over it, and a little water poured down the side of the cover to form a water seal. On working the bellows, the smoke will be seen to issue from the connecting pipe, and if this be connected to the drain, the smoke, of course, will enter the drain pipe, and any crack or hole in the drain will be at once evidenced by the escape of smoke therefrom.

9.262 Burns' Circular Drain Plugs,

6 inch, 5 inch and 4 inch.

9.263 Burns' Square Gulley Plug with Clamp.

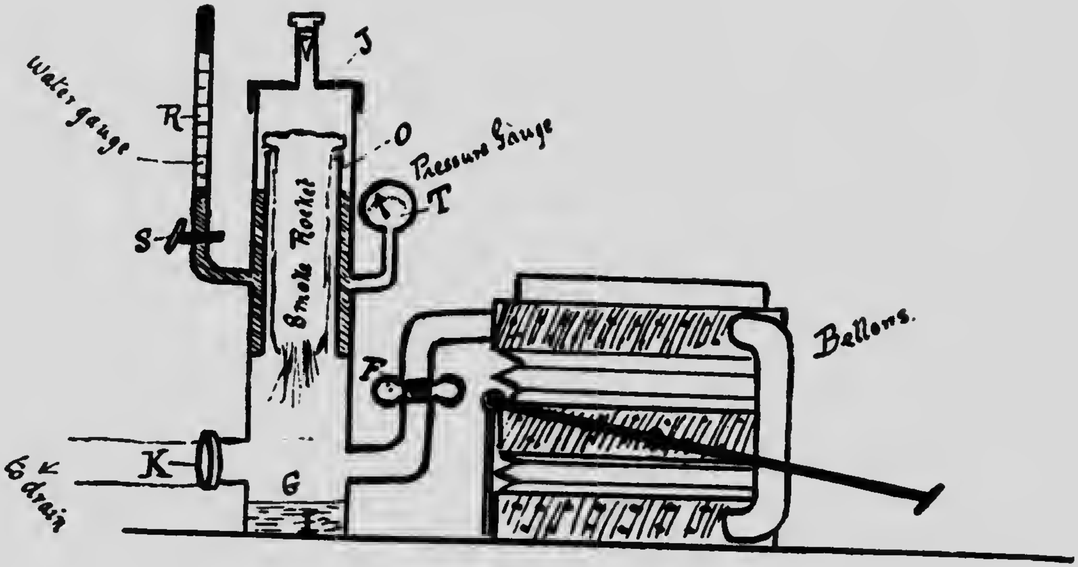
9.264 Burns' Expandable Gulley Plug,

canvas covered, with air pump to expand the same, also pressure gauge for testing pressure inside the drain.

This is a very useful plug, and one to be strongly recommended ; it will fit any drain from 4 to 9 inches wide.

9.265 Ravenor's Patent Drain Tester

The machine is for testing drains, by means of smoke, or air pressure, and has for its object the arrangement and construction of an apparatus with which Smoke Rockets can be used very effectively, in drains of considerable length, without danger of explosion of unconsumed gases emitted from the previous Rocket ; and, further, ready adaptability is secured for testing with air and smoke, separately or combined, at high or low pressure, as desired, viz., from ½ oz. to 10 lbs., or more. Rockets can be fired successively without disturbing the



9.265. Ravenor's Drain Tester.

connection with the drain, and without fear of explosion. At the bottom of the Smoke Chamber, Fig. G, will be found a small receptacle, Fig. I, for containing water, which will catch and extinguish any sparks, or incandescent material, that may be emitted by the Rocket during combustion; also fresh Rockets may be inserted, by simply removing the brass cap, Fig. J, at the top of the cylinder.

TO TEST UNDER LOW PRESSURE.

Before using the machine, remove the cap J from top of cylinder, and pour in water, until it can just be seen in the lower part of gauge R.

After stopping all ventilating pipes, connect the outlet K with the drain, by means of a length of hose, and, leaving both stop cocks (Figs. S & F) open, proceed to work the bellows. This will create a pressure on the water in the annular channel O, and cause the water to rise in the gauge glass R. The stop cock F must then be closed, and if the column of water in the gauge glass be maintained, it proves the drain is sound, but if the column of water falls, the drain is unsound. In such case, and to locate the leakage, remove the cap J, insert a lighted smoke rocket, replace the cap J, and work bellows.

TO TEST UNDER HIGH PRESSURE.

Simply shut off the small stop cock S and proceed as before. When the bellows are worked, the pressure will be indicated on the pressure gauge T, and on obtaining the desired pressure, quickly close the stop cock F, and if the pointer in the pressure gauge maintains its position the drain is sound, but if it falls towards zero the drain is unsound. The bellows will give a pressure of 4 lbs., equal to a column of water 8 feet high. If a higher pressure is required, an ordinary cyclist's inflator may be attached to the valve fitted in the cap J, but 8 lbs., equal to a column of water 16 feet high, should be the maximum.

9.27 DEFECTIVE DRAINAGE, PLUMBING, ETC.

9.271 Portion of trap from beneath a bath. The trap is made of seamed lead pipe and shows erosion along the line of seam. It also illustrates a hole, where the pipe has been eaten away by rats.

9.272 Specimen of P-trap made of seamed lead piping. Cracks and erosions can be seen all along the line of seam. It also shows too great depth of water seal; this is liable to prevent self cleansing of the trap.

9.273 Specimen of old lead P-trap with two overflows entering—one near the side of the trap, and the other at the lower part of it. The overflows most probably came from water tanks and safe-trays, and it can readily be seen how gases from the trap could find their way into the rooms, where these overflows took their origin.

9.274 Specimen of old fashioned D-trap with overflow pipe entering into the lower part. These D-traps are now-a-days condemned, and no longer allowed to be used. From their construction it is quite impossible for them to be self-cleansing, and hence they were always very foul, as this exhibit shows. In nearly every instance, the overflow from a water tank (such tank being very commonly used for drinking purposes), was always connected up with the D-trap, and it is obvious to everyone, seeing how filthy these traps were, that it was quite an easy matter to have large volumes of gases of decomposition entering the living rooms.

9.3 Baths and Sinks.

9.31 FULL SIZE BATH.

Enamelled iron, fittings complete, vertical plunger, with overflow in same. Enamelled iron has of late years come much to the front, as a rival of porcelain for baths and sinks. In comparison, one may note that iron is slightly cheaper than porcelain, and is not so liable to breakage. On the other hand, enamelled iron is liable to chip, and once the enamel is off the iron rusts. This drawback has been reduced to a minimum in modern enamelling.

9.32 Lavatory Sink.

Enamelled iron, fittings complete, vertical plunger, with overflow in same. This variety of sink is attached to the wall, and has no supports underneath. This arrangement favours access for cleaning purposes, and is, at the same time, very strong.

9.33 Lavatory Sink.

Porcelain, fittings complete, vertical plunger, with overflow in same.

9.34 Urinal.

Stalls and floor of high grade porcelain. The whole is designed to avoid corners, and crevices, and has the minimum of jointing between slabs. The automatic flush apparatus, attached to the fixture, provides an extremely good flush over all parts of the surface of the stall.

9.35 Kitchen Sink.

Porcelain, with fittings complete, overflow in body of porcelain side.

9.36 Slop Sink.

Enamelled iron, fittings complete. S-trap with anti-syphonage vent.

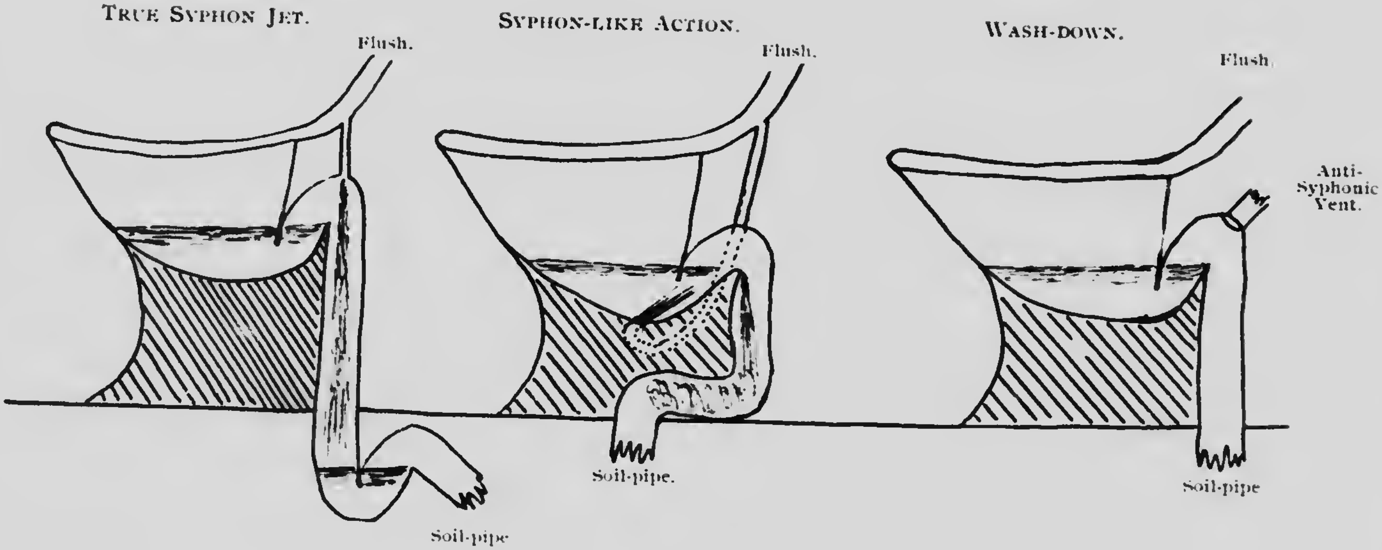
Slop sinks are, in every respect, to be treated precisely in the same way as water closets. They are very useful in hotels, hospitals, and very big houses.

9.41 Pan Closets.

9.411 Old Fashioned Pan Closet.

9.42 Hopper Closets.

9.421 Old Fashioned Long Hopper.



TRUE SYPHON JET.

SYPHON-LIKE ACTION.

WASH-DOWN.

9.422 SHORT VARIETY OF HOPPER CLOSET.

9.423 HYBRID VARIETY,

to illustrate a bad type of closet.

9.43 Wash-out Closets.

9.431 WASH-OUT CLOSET.

9.44 Wash-down Closets.

9.441 SIMPLE WASH-DOWN CLOSET.

9.442 A FULL SIZE SECTIONAL MODEL OF WASH-DOWN CLOSET,

showing construction of flushing rim, trap and anti-syphonage vent, depth and area of water seal.

9.443 SIMPLE WASH-DOWN CLOSET,

suitable for schools.

9.444 SIMPLE WASH-DOWN CLOSET,

with mural attachment, providing greater access for cleaning purposes.

9.45 Syphonic Closets.

9.451 SYPHON JET CLOSET,

English Type.

9.452 SYPHON-LIKE CLOSET,

American Type.

9.453 SYPHON-LIKE CLOSET,

American Type, with Flushometer in place of Flush Tank.

9.5 Sewage Disposal.

9.51 INTERMITTENT DOWNWARD FILTRATION.—Diagram.

This scheme differs from Broad Irrigation in the fact that it possesses collecting drain tiles placed about 3 feet below the surface of the ground. In this way a larger amount of sewage can be applied over a given area of land.

9.52 DIBDIN'S SYSTEM.—Diagram.

This scheme is said to be purely Ærobic, but in actual practice a fair amount of Anærobic action actually takes place.

Clogging of the first contact bed is the chief drawback to this system.

9.53 SCOTT-MONCRIEFF SYSTEM.—Diagram.

In this system one gets an Anærobic treatment first, and secondly, an Ærobic.

The first contact bed is very liable to become choked.

9.54 SEPTIC TANK SYSTEM.—Diagram.

The diagram explains the different components of the scheme.

After treatment in contact beds, in some cases, the effluent is applied to land on the Intermittent Downward Filtration Plan. Under such circumstances, a particularly fine effluent is the final result.

9.55 SEWAGE DISPOSAL MODEL

of large size sewage bed with automatic sewage spreader. The supply being regulated by an automatic valve—Mather and Platt's patent.

This process is to be recommended for weak sewage, and for effluents from settling tanks. The great feature is the continuous process. Unlike the simple contact bed which requires 8 to 12 hours rest out of 24, this continuous process is capable of going on steadily for months without stopping.

9.56 BOX CONTAINING MODEL

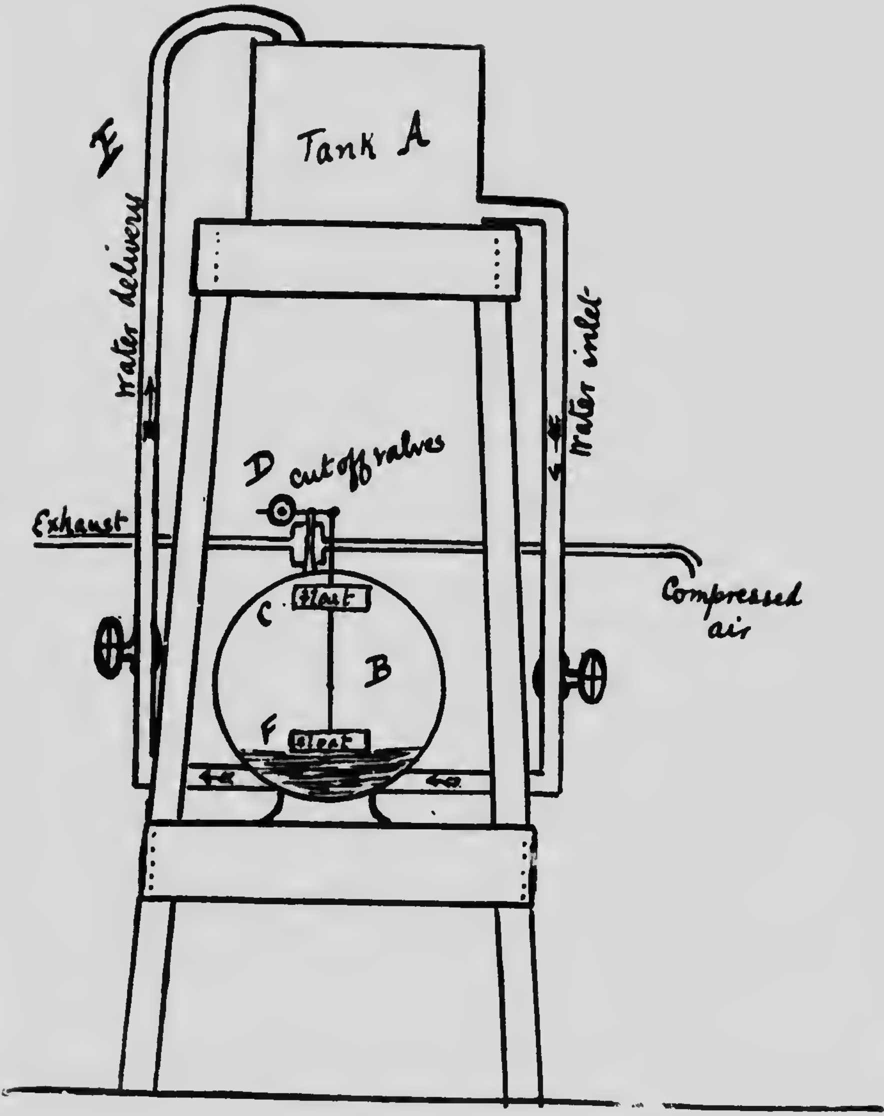
of automatic valves for supplying sewage sprinklers in series. This shows how the automatic gear can be applied to a series of beds at a sewage farm. The great beauty of the whole arrangement is that one man is quite capable of looking after a dozen beds.

9.57 SEPTIC TANK WITH MODIFIED LAND TREATMENT.

9.58 SHONE'S EJECTOR.—Large working model.

This apparatus has proved of great benefit in manipulating sewage and water as regards promoting the flow of the same in the pipes. It is particularly useful in a flat country, where, owing to the depth which sewers, for instance, must eventually reach in order that the necessary fall may be given to them, a fresh start has to be given to the pipe somewhere near the surface, and this the ejector accomplishes automatically, being placed at suitable points where the sewers reach such a depth as to become unmanageable; the sewage is then raised vertically to a point near the surface, and so begins on a new incline. Thus it goes on, and when the second incline has reached such a depth as is thought sufficient, it is raised again to the surface, and so on.

The model consists of a tank (A) at the top of the stand, representing a sewer; the sewage flows into a cylinder (B) in which it rises gradually, and when near the top lifts the upper float (C.) This actuates a series of cut off valves (D) which admit compressed air, supplied from a machine. This compressed air presses on the surface of the liquid in (B) and forces it through the water delivery tube (E) to any height required. In the model it is simply returned into the tank (A.) A valve, situated near the inlet, prevents back flow along the inlet tube. As the sewage descends in the cylinder (B), it eventually runs clear of the lower float (F), and the weight of water in the lower float pulls down the cut-off valves (D) which close the compressed air taps



9.58 SHONE'S EJECTOR.

and open the exhaust. The sewage then begins to flow again from the tank (A) and gradually fills the cylinder (B), when the whole process is repeated as before.

This simple arrangement works automatically, as will be seen from the description, and it is only necessary in practice to supply the compressed air, which is done by a series of pipes laid underground, much in the same fashion as gas pipes are laid. The compressed air is supplied from a central station.

9.59 PERCOLATING BED.

(Sometimes termed Streaming or Trickling Filters). Rectangular, with travelling distributor—on the water wheel principle. Jones & Attwood's Patent. The distribution of the liquid is very uniform.

9.59a PERCOLATING BED.

Circular variety, with distributor on the same principle—but the distribution is not as perfect as on a rectangular bed. Jones & Attwood's Patent.