PRACTICAL TROPICAL SANITATION

W. ALEX. MUIRHEAD

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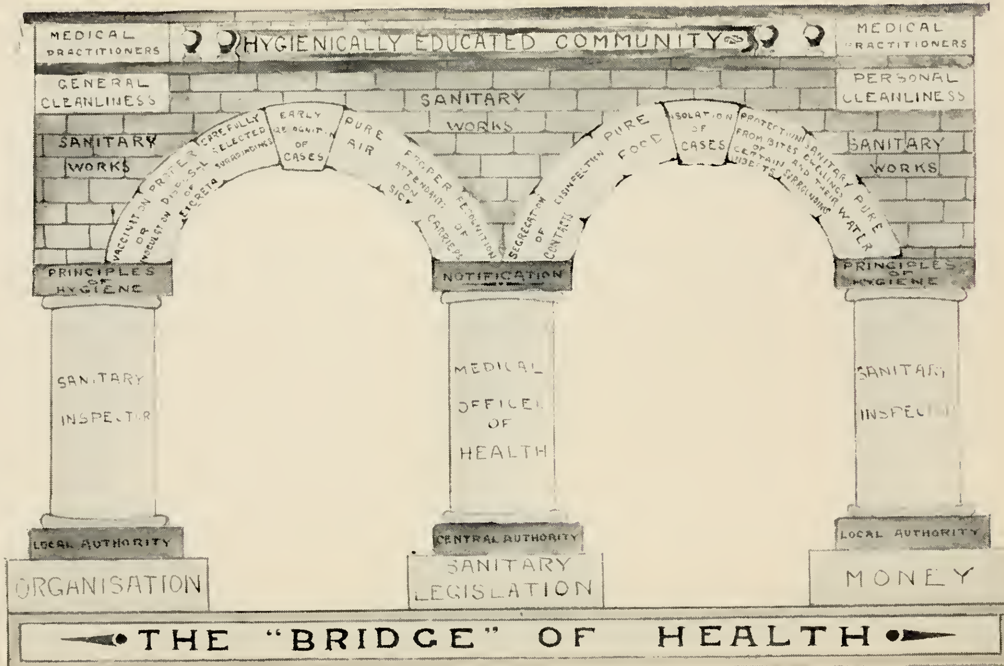

[*Frontispiece.*

PRACTICAL TROPICAL SANITATION

A MANUAL FOR SANITARY INSPECTORS AND OTHERS INTERESTED IN THE PREVENTION OF DISEASE IN TROPICAL AND SUB-TROPICAL COUNTRIES

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WITH ILLUSTRATIONS

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TO

SIR RONALD ROSS, K.C.B., F.R.C.S., M.D., F.R.S.

"THE APOSTLE OF TROPICAL SANITATION"

PREFACE

At the XVIIth International Congress of Medicine, held in London, in discussing "Sanitary Organisation in the Tropics," Dr Andrew Balfour (Khartoum) remarked that "The Sanitary Inspectors in Colonies should be trained in Tropical Hygiene. The Soudan Government had recognised the value of such a training by giving higher pay to those so qualified."

The Colonial Office now require a certificate of competency in this knowledge from candidates for appointments as Sanitary Inspectors on the West Coast of Africa, and doubtless in the near future the training mentioned by Dr Balfour will become compulsory for candidates for any such posts.

Therefore no apology is necessary for the issue of the following pages. Though originality is not claimed for the work, the writer has endeavoured to meet the needs of a fast-growing body of men who require a text-book above the standard of elementary Tropical Hygiene, yet below the standard manuals on Tropical Medicine for medical officers, which are couched in technical language, include many matters not germane to the training of a Sanitary Inspector, and omit consideration of several of the practical subjects connected with his duties.

The endeavour has been to make it readable, reliable, and practical; the principles of Hygiene in addition to their practical application being dealt with, where considered necessary, in as brief a manner as possible consistent with the importance of the subject.

An assumption has been made that the reader is a man of average general knowledge but without special sanitary training: it is seldom that experienced Inspectors from home take up tropical appointments: they are usually bound by family and other ties.

Practically the whole book is written from notes used by the writer for lecture purposes, partly founded on his experience in tropical, sub-tropical, and temperate climates and partly compiled from text-books (on Tropical Medicine, etc.) and lectures of well-known sanitarians, including Sir Ronald Ross, Professor Boyce, Colonels Firth, Aldridge, and others.

In arranging them the following text-books have been freely consulted to ensure accuracy, an acknowledgment of which is due to the respective authors.

Theory and Practice of Hygiene (Firth).
Bacteriology (Muir and Ritchie).
Tropical Hygiene (Manson).
Prevention of Malaria; Mosquito Brigades; and other works (Ross).
Manual of Tropical Medicine (Castellani and Chalmers).
Handy Guide to Public Health (Hime).

The Appendix and Index are prominent features of the book: the former is a collection of useful miscellaneous information, and the latter, necessarily in a work of this kind, has been made as serviceable as possible.

Throughout the text numerous illustrations have been used: many are original, and for these the writer wishes to acknowledge his indebtedness to Mr Neil Campbell's skill. To the various firms who have given permission to reproduce figures, and to Mr Wilson for the loan of photographs thanks are also due.

In addition thanks are tendered to Major C. E. P. Fowler, R.A.M.C., for suggestions during the preparation of the work; to Mr R. J. McKay for corrections and much kindly criticism; to Mr A. Gray Tod for assistance in reading proof sheets; to the Trustees, British Museum, for permission to make extracts from their pamphlets on the Collection of Diptera; to the Royal Meteorological Society for permission to make extracts from their publications; and last, but not least, to the publisher for his valuable suggestions and co-operation whilst the work has been going through the press.

W. ALEX. MUIRHEAD.

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PRACTICAL TROPICAL SANITATION

CHAPTER I

INTRODUCTION

The tropical Sanitary Inspector, so far as our own colonies are concerned, may be appointed by the municipality which is to employ him direct, or through the Colonial Office.

At present, except in the case of Sanitary Surveyors, India, no qualifying examination is held, but a sound knowledge of sanitation in general, and the more common tropical diseases and their prevention in particular, is essential.

No doubt, in the near future examining bodies will hold distinct qualifying examinations for these appointments, for much of the subject matter of the examination for the post of Sanitary Inspector at home is not applicable to tropical sanitary effort.

An ideal Inspector would be one who combined the functions of a builder, in order to detect insanitary conditions in house construction, and specify remedies; an entomologist, in order to recognise the different kinds of insects met with, especially those known to convey disease; a microscopist, in order to be useful in a laboratory; a hospital assistant, in order to recognise in the early stages the symptoms of infective diseases; a butcher, in order, if necessary, to point out the best methods of slaughtering and cutting up animals and to detect bad meat; a barrister, well versed in sanitary law, in order to enforce sanitary legislation; an architect, in order to read plans and sketches; a municipal engineer, in order to direct town-planning; and last, but not least, a public speaker and teacher, in order to educate the community in hygienic principles.

Apart from technical qualifications, a sound knowledge of "first aid" will be found very useful, especially in gaining that confidence of the community in primitive towns which is so essential to successful sanitary effort.

He must be healthy, strong, and thoroughly fond of his work; tactful, yet capable of enforcing orders; and skilled in the art of handling men, adopting the roll of guide rather than that of prosecutor.

The duties of an Inspector vary enormously, according to whether he is employed in a well-organised city, a native town, or a primitive district. Speaking generally, acting under the directions of the Medical Officer of Health or Sanitary Officer, he is responsible for the general sanitation of his area, and all measures for disease prevention are his immediate concern; in this connection he should always remember that nowhere more so than in the tropics does the old 'saw' apply, which runs, "If you want a thing done, you can get it done; but if you want it done and *right* done, do it yourself!"

Elementary Facts.

The science of disease prevention and the preservation of health is termed hygiene.

The practical application of the principles of hygiene is termed sanitation.

These terms, 'hygiene' and 'sanitation,' are not synonymous, but are respectively the science and art of disease prevention. There cannot be bad hygiene, but one has only to 'look around' to find bad sanitation.

The popular notion that sanitation is connected solely with the removal of filth and the detection of nuisances is fast dying out, and with its demise will come more respect for, and confidence in, those connected with sanitary administration.

Sanitation includes all practical work done in the prevention of disease and preservation of health. Its effect on a particular community is judged by results, as seen in statistics, comparing sickness and death-rates during the period under review.

Many examples can be given of successful sanitary effort; for instance, the complete extermination of malaria at Ismailia, on the Suez Canal; and of Mediterranean fever amongst the troops stationed in Malta. Another example is the enormous reduction in the number of enteric fever cases occurring amongst British troops in India. The yearly average for the period 1899 to 1906 was 1353 admissions, with 330 deaths; the latest available figures for the year 1912 show there were only 118 admissions, with 21 deaths. Smallpox, a disease rarely seen now in Britain, was very common years ago, and a face unmarked by its ravages was an unusual sight. It is still quite prevalent in many places where vaccination is not carried out.

Typhus, or gaol fever, once very common, is rarely heard of now, many medical men never having seen a case.

It is not claimed that all improvements in the sickness and death-rates are due to sanitation alone, for doubtless improved social conditions and other factors have a bearing on them.

If a place is 'behind the times,' as indicated by a high death-rate, it may be safely assumed that one or more of the four requisites are absent, namely :—

1. Training of the community in hygienic principles.
2. Suitable legislation.
3. Organisation.
4. Money.

The last is, in many cases, the dominant factor.

In the following pages will be found a description of the general principles of preventive work and methods of carrying them out, some applicable to one place, some to another. It should be clearly understood that no one method is capable of universal application. Although one should have ideals to aim at, local conditions are often in the way of their accomplishment. Such conditions can be only known to, and dealt with by, the Inspector on the spot.

CHAPTER II

THE CAUSES OF DISEASE

Disease may be defined as a condition of the body which is the reverse of being healthy. A study of its causes is necessary to the work of prevention.

Diseases may be classified roughly as follows :—

1. Those which arise within the body itself, such as diabetes, nervous diseases, gout, and the like.
2. Those which are caused by the introduction into the body of something from without.

With the exception of diseases due to faults in the make of the body, and those which are the result of accident or injury, it may be said that disease in general is largely preventable; and of these so-called 'preventable diseases' the majority are infective, that is, capable of being passed in various ways from an infected person to healthy persons. (It may here be noted that the terms 'infectious' and 'contagious' are not used in this manual, the term 'infective' being used to cover all the diseases which in the past have been grouped under those headings, as there is no distinct line of demarcation between the two.)

The causal agent of an infective disease is a microbe or germ. The original source of infection in all cases, so far as at present definitely established, is the body of some person or animal suffering or having suffered from such a disease, and nowhere else.

The popular notion that bad smells, open drains, damp, draughts, etc., cause disease is wrong; each may be a contributory cause, but never a primary one.

They simply indicate insanitary conditions requiring definite remedies.

Germs.

This is a term used to indicate a number of minute living cells invisible to the naked eye. The smallest of them are called bacteria. They are single cells of protoplasm which multiply by fission, or dividing into two. Some have movement, others have not, and they vary in size from $\frac{1}{50000}$ to $\frac{1}{10000}$ part of an inch.

Bacteria are classified in groups according to their shape, as under :—

1. Those which are globular or 'dot-like,' called cocci.
2. Rod-shaped, called bacilli.
3. Curved, called vibrios.
4. Certain higher forms, termed yeasts and moulds or fungi.

Although no lower forms of life than bacteria have been demonstrated, experimental evidence points to the existence of ultramicroscopic forms which play a prominent part in disease production.

Bacteria are said to belong to the Vegetable Kingdom, as distinct from other organisms which belong to the Animal Kingdom.

It has already been stated that they reproduce by fission—that is, of course, under suitable conditions. Many divide hourly ; thus from a single organism some millions are created in a period of twenty-four hours.

A few kinds of bacteria form spores—that is, bead-like bodies occur which grow at the expense of the parent organism, from which they eventually burst and are set free. These spores or young forms of certain types are the hardiest forms of life, and are capable of resisting temperatures which kill other organisms.

In the growth of bacteria, the following five factors operate :—1. Food supply; 2. Moisture; 3. Environment ; 4. Temperature ; 5. Light. All have a bearing in different ways on different bacteria, some requiring much of one and little of others, and all varying in some degree. All require food, moisture, and a certain temperature; some, termed aerobes, require oxygen; others, anaerobes, will not grow in the presence of oxygen. Light has generally an inhibiting effect; the majority grow best in darkness.

Bacteria[1] and certain organisms of the Animal Kingdom can be and are artificially cultivated in suitable media. They are termed 'cultures.' Broth or refined beef-tea is largely used. Other materials in use are gelatine, agar, serum, milk, ox bile, and potato. There are a large number of different media, for it is found that some organisms grow better in one medium than in another.

Certain germs give definite reactions with certain chemicals, develop characteristic growths in the 'suitable' medium, and have distinguishing features when stained, *i.e.*, coloured by certain dyes, and examined under a high-power microscope.

Bacterial Action.

The chief effect of bacterial action is to break up organic matter into simpler compounds. Many chemical substances are produced; these vary greatly with different bacteria. As will be seen later, some are toxic or poisonous, some diffuse into the surrounding medium, others are retained by the organism which formed them. Many processes are due to the action of bacteria; *e.g.*, nitrification of the soil, the souring of milk, the ripening of cheese and butter. In addition, they play a great part in aiding digestion.

[1] The singular and plural of certain nouns used in connection with this subject are here given, for the benefit of readers who may not be familiar with them :—

Singular.	Plural.	Singular.	Plural.
Bacterium	Bacteria	Vibrio	Vibrios
Coccus	Cocci	Fungus	Fungi
Bacillus	Bacilli	Protozoon	Protozoa
Spirillum	Spirilla		

Many bacteria are parasitic—that is, they take up their abode on or within some other living organisms (termed hosts), chiefly for the purpose of obtaining food. A small number of these parasitic bacteria are now known as the causal agents of disease in man; they are termed pathogenic—that is, they are capable, given suitable conditions, of producing morbid changes in the body cells. Bacteria which are harmless are termed saprophytes. As a rule bacteria breed true, though the type and virulence of an organism may vary; but no hard-and-fast line can be drawn between the harmless ones and the pathogenic or known disease-producing ones, as it is considered possible that environment may bring about changes from one class to the other.

Pathogenic germs, after entering the body, multiply and produce certain poisons or toxins which may act upon the tissues generally or locally. Some grow at the point of entry, others invade generally. The toxins made are diffused throughout the system, produce tissue changes, and interfering with the normal work of the body give rise to noticeable changes, termed symptoms. It is not yet demonstrated whether toxins are 'excreted' by the organisms or are the products of their action on the tissues or other media.

Certain higher forms of life than bacteria, namely, animal parasites, also cause disease in man in various ways. In these the structure and means of reproduction and locomotion vary enormously according to the class of organism. They may belong to either of the sub-kingdoms, protozoa or metazoa. The former are 'single-celled' animals with sexual and asexual reproduction, variously named and grouped according to characteristics and structure. The latter are a higher order than protozoa. They are composed of many cells (multicellular), and are "characterised by a division of labour among their cells." They include the many kinds of worms which produce disease in man by their mechanical action in the tissues or body fluids. The action of protozoa in the body is considered similar to that of the disease-producing bacteria.

The following are the dates of discovery of some of the most important pathogenic organisms :—

Anthrax	(Davaine)	1850
Relapsing fever	(Obermeyer)	1873
Leprosy	(Hansen)	1876
Typhoid	(Eberth)	1880
Malaria	(Laveran)	1880
Elephantiasis	(Manson)	1881
Tuberculosis	(Koch)	1881
Tetanus	(Nicolaier)	1884
Cholera	(Koch)	1884
Malta fever	(Bruce)	1887
Plague	(Kitasato)	1894
Dysentery	(Shiga)	1898
Kala-azar	(Leishman)	1900
Sleeping sickness	(Dutton)	1901
Syphilis	(Schaudinn)	1905

Table of some of the Causal Agents of Infective Diseases.

(See Figs. 1 to 6.)

Vegetable Kingdom.

Bacteria.

Cocci (dot-like).	Bacilli (rod-shaped).	Vibrios (curved).	Fungi (show branching).
Micrococci.	Some of this group form spores.		
Diplococci (in pairs).			
Streptococci (in 'strings').			
Staphylococci (in clusters).			

Chlamydozoa.
(Undiscovered organisms.)

Includes the many known 'filter-passing' agents, which are considered ultramicroscopic.

ANIMAL KINGDOM.

Protozoa.	*Metazoa.*
Amœbæ, Trypanosomes, Plasmodia, and many other forms. (The Spirochætæ are not yet definitely classified, but the majority of investigators are in favour of including them under this heading.)	Various parasitic worms. (*Helminths.*)

IMMUNITY.

Of a given number of people exposed to infection, all will not develop the disease, and of those who do so some will suffer more than others. Those who escape are spoken of as being immune or insusceptible to that disease. This phenomenon of resistance to disease is termed immunity, and is possessed by all in varying degrees. Apparently it is connected with: (1) the health of the individual at the time he is exposed to infection, and (2) the action of certain body cells and substances in the body fluids, the former affecting the latter more or less in direct ratio.

Immunity may be natural or acquired. Natural immunity is always present in a relative degree, depending on many factors; it varies in different individuals, with different diseases, and in the same individual with the same disease at different times.

Acquired immunity is obtained in different ways, and is spoken of as being either (*a*) active or (*b*) passive. Active immunity may be obtained in one of the three following ways:—

(1) Conferred by a previous attack of the disease, an excess of immunising substances having

Types of Organisms. Highly magnified.

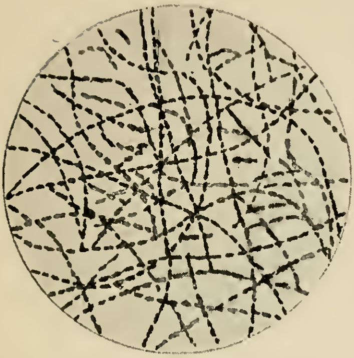


Fig. 1.—Bacilli.

Fig. 2.—Bacilli (spore-bearing).

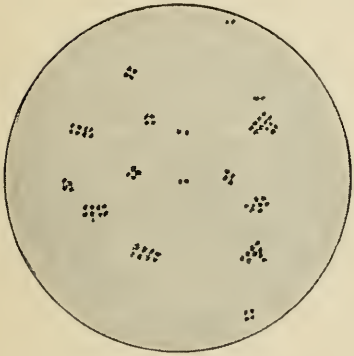


Fig. 3.—Micrococci.

Fig. 4.—Streptococci.

Fig. 5.—Vibrios.

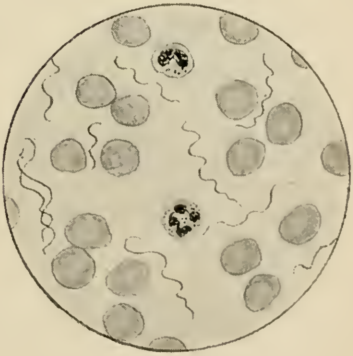


Fig. 6.—Spirilla (in blood).

been produced. (It is well known in connection with certain diseases that second attacks are uncommon, for instance, smallpox.)

(2) Conferred by an attack of a similar disease—for instance, vaccinia, a disease which confers immunity against smallpox.

(3) Produced by an injection of organisms (preparations which are termed vaccines) or toxins.

Passive immunity may be obtained by injection of the serum of an animal immunised against the causal agent of an infective disease.

If immunised against a particular toxin, the serum is called anti-toxic serum ; if against a particular organism, anti-bacterial serum.

The principles governing all the methods are the same; they aim at increasing one's natural immunity.

The subject of immunity is very complicated, and not yet fully worked out. The following factors are known :—

(1) Some of the tissue cells and certain of the white cells of the blood, termed phagocytes, ingest the germs, *i.e.* they are 'eaten up' and disappear.

(2) There are certain substances in the blood-fluid, capable of being increased on the invasion of germs, which make them a more easy prey for the phagocytes.

(3) In the blood-fluid are substances which poison the germs, or at least render the blood a less suitable habitat.

(4) Certain substances occur in the blood-fluid which either neutralise the toxin produced by the germs or render the body cells insusceptible to it.

Summarised, it may be said that when disease germs enter the body the toxins produced (*a*) excite the making of more protective substances, and (*b*) cause reinforcements of phagocytes to be despatched to the affected part. There a 'battle' goes on, and if the germs and their toxins win the initial fight, symptoms of disease will occur. During the course of the disease the battle still goes on, and according to the result, so the body either recovers, or there is a local death of the part affected, or a general death of the individual.

The germs make their exit from the infected individual by way of (1) the excreta, (2) air, or (3) directly through the skin (by the bites of certain insects).

From the foregoing it will be seen that for the development of an infective disease three things are necessary :—

(1) The germs of the disease from an infected person or animal;
(2) A channel of infection;
(3) A susceptible individual.

Whether a person exposed to infection will develop the disease or have it in a mild or severe form, depends on :—

(*a*) The dosage and virulence of the germs of the disease; and
(*b*) His powers of resistance.

There are three distinct periods in the course of any infective disease which ends in recovery of the individual :—

(1) Period of incubation : the time elapsing between the entry of germs into the body and the manifestation of symptoms. (These periods in the majority of cases of infective disease are known.)
(2) Period of active disease : the period during which symptoms occur, the time varying in different individuals suffering from the same disease.
(3) Period of convalescence : the period during which the body regains the normal after symptoms cease. (In many diseases this

period is a dangerous one, in that the convalescent person may still spread the disease to others by excretion of the germs.)

A knowledge of the various periods of incubation of infective diseases is essential to the work of all sanitary inspectors for two main reasons :—

Firstly, it is a great aid to tracing sources of infection.

Secondly, where necessary, it enables segregation of contacts and suspects in connection with certain diseases to be carried out for a definite time, thus avoiding the possibility of their forming other 'centres of infection.'

The following are the incubation periods for some of the infective diseases :[1]—

Disease.	Usual period (in days).	But may be (in days).
Cholera	3 to 6	1 to 12
Diphtheria	2 „ 10	12
Measles	10 „ 14	16
Plague	2 „ 8	20
Scarlet fever	3 „ 5	10
Smallpox	12 „ 14	16
Relapsing fever	2 „ 10	14
Yellow fever	1 „ 5	13
Enteric fever	10 „ 14	7 to 23
Malaria	8 „ 12	...

The following diseases are by legislation usually made notifiable to the Medical Officer of Health of the area concerned :—

Smallpox, cholera, diphtheria, erysipelas, typhus fever, relapsing fever, enteric fever, cerebro-spinal fever, yellow fever, plague, tuberculosis, and sleeping sickness. Other diseases may be added from time to time as is considered necessary.

[1] An endemic disease is one common to a place or district. An epidemic disease is one, not common to a district, which is widely diffused, many people being attacked in a given area at the same time.

Infective diseases are detected and diagnosed from the clinical symptoms and bacteriological tests where applicable. Those undetected are usually :—

(1) Persons during the last few days of the incubation period and the first few days before recognition.
(2) Slight, unrecognised cases.
(3) Convalescent, chronic, and healthy 'carriers.' These undetected cases have been aptly termed "The living storehouses or factories of disease."

By 'carriers' are meant those persons who, although not suffering ill-health, have disease germs in their bodies, which grow, *i.e.*, multiply and are passed out of the body in various ways, chiefly in the saliva, urine, and other excreta. They are usually persons who have had the disease or who have been in contact with those suffering from the disease. Enteric fever and diphtheria are examples of diseases which are often spread by 'carriers.'

Channels of Infection.

By this term is meant the various ways in which disease germs are transferred from infected persons or animals to healthy individuals. A knowledge of these 'channels' is essential to a proper understanding of the object of routine sanitary measures. They may be tabulated thus :—

Channels of Infection.

1. *Food*	(*a*) Certain diseases are common to man and animals whose flesh or milk is used as food of man; *e.g.*, tuberculosis, Mediterranean or Malta fever. (*b*) Handling of food by infected persons; *e.g.*, cooks. Such diseases as enteric fever and dysentery are spread in this way. (*c*) Food contaminated by flies carrying germs from filth. Bowel diseases are spread in this way.

Channels of Infection—continued.

2. *Water* . . .	(*a*) Direct; *e.g.*, drinking-water contaminated by sewage. (*b*) Indirect; *e.g.*, contaminated water used in dairies and kitchens; vegetables grown in polluted water; shellfish fattened in such waters. The chief diseases spread by an infected water supply are: enteric fever, dysentery, cholera, infective or epidemic diarrhœa, ankylostomiasis, bilharzia and other worm diseases.
3. *Air*	Spray infection. Germs attached to particles of dust. Skin diseases and diseases of lungs and air-passages may be spread in this way; *e.g.*, tuberculosis, diphtheria, pneumonia, smallpox.
4. *Personal contact* .	(*a*) Attendants on the sick. (*b*) Persons living with infected individuals. (*c*) Indirectly in other ways, such as using common bedding or clothing, or a common latrine.
5. *Direct into blood through the skin* . .	(*a*) Accidental cut, followed by the entry of disease organisms. Lockjaw and rabies are spread in this way. (*b*) By the 'bite' of certain biting insects which suck the blood of infected persons and inoculate others on biting them. Germs thus transmitted are usually those of the sub-kingdom protozoa; *e.g.*, mosquitoes of certain genera spread malaria and yellow fever.

From a perusal of the foregoing table, it will be understood that usually there are many channels of infection for one disease, and not necessarily one channel only, the exceptions being, chiefly, diseases caused by protozoa transmitted by biting insects.

The blocking up of the 'channels' through which disease is spread forms the major part of a Sanitary Inspector's work, and is the first line of defence in disease prevention. The second line aims at increasing man's powers of resistance to disease. Legislation is passed to carry out the former, with the assistance of organisation and money. Education of the individual units of a community is necessary before the latter can generally be applied.

General Sanitary Measures.

The general measures to be taken in disease prevention may be here stated :—

1. Early recognition of cases of infective disease, also of 'carriers' and 'contacts.' Isolation and segregation respectively. Precautions should be taken to prevent attendants on the sick conveying disease to others through personal contact.
2. Disinfection.
3. Pure air.
4. Pure water.
5. Pure food.
6. Proper removal and disposal of excreta and refuse.
7. Carefully selected surroundings to avoid the neighbourhood of infected persons.
8. Protection from the bites of certain biting insects.
9. Personal and general cleanliness.
10. Proper construction of dwellings and other buildings with sanitary surroundings.
11. Vaccination or inoculation, where applicable.

With the exception of the first and the last, the Sanitary Inspector is intimately concerned with all these measures, and even in the case of the exceptions noted his co-operation is desirable.

CHAPTER III

TROPICAL DISEASES

"The more rapid the eradication of the idea that the climate, *per se*, injuriously affects the nervous system, the more rapid will be the decrease of such mild forms of neurasthenia and irritability as are due largely to a preconceived dread of the effects of tropical residence. It seems to us that the figures are strong evidence in favour of the assumption that most of the morbidity which formerly occurred as a result of residence in the tropics was due, not to the climate, *per se*, but to infections which, in the light of present knowledge, can almost entirely be avoided by good sanitation."—*Report of the Tropical Diseases Board*, Philippine Islands, 1912.

The term 'tropical diseases' is a term used to include diseases which are specially prevalent in warm climates, not necessarily diseases which are peculiar to the tropics only, or, on the other hand, all diseases occurring in the tropics.

It may be asked, how is it that a certain class of infective diseases is absent from the tropics, and how certain diseases common in the tropics are absent from temperate climates? In the previous chapter it is stated that the causal agents of infective diseases require for their propagation certain conditions, *e.g.*, certain media, certain temperatures, and certain opportunities. If the conditions are not suitable for a particular germ, it dies, that is, ceases to infect. In two diseases the germ may be air-borne, yet one may succumb to tropical heat, and the other to temperate 'cold.'

Many tropical diseases require for transmission from person to person the services of an intermediate agent, usually an insect of a tropical species. Such diseases are necessarily tropical, because they are only present where such 'intermediate host' exists. Certain of the known disease-transmitting insects in tropical regions are found in temperate climates, but as a rule they are not blood-suckers in such climates; they are 'vegetarians,' thus they do not play a part in the causation of their associated diseases.

Enteric Fever.

This disease is common to many countries. It attacks chiefly young adults; immunity appears to be much less between the ages of twenty and thirty years than at other periods. The causal agent is a bacillus.

The bacilli enter through the mouth, and get into the stomach and intestines; there they multiply and get through the intestinal walls into the blood-vessels and spleen. Symptoms may develop in from one to four weeks after entry of the germs, the usual period being ten to fourteen days. The onset is gradual, followed by high fever, diarrhœa, and possibly collapse, the patient often becoming delirious. The usual course of the disease lasts three or four weeks, during which time ulceration of the small intestines occurs, resulting possibly in perforation and death, or at the end of the period the temperature drops and the patient may recover.

Some cases are very mild, and not noticed; the usual clinical signs are absent.

Second attacks are uncommon, as the immunity conferred is considerable.

The germs are discharged in the excreta, urine, and possibly in the saliva. Once outside the body they survive but a little time, as the surroundings are not suitable for them: if this was not the case, enteric fever would be much more common. If exposed to the action of the sun, they die in a few hours. In water they disappear in from one to two weeks, in earth in from three to four weeks.

It should be remembered that the body of a person suffering or having suffered from the disease is the 'centre of infection,' and that the disease is spread from such centre in a variety of ways.

The channels of infection may be summarised thus:—

1. *Water* . . .	(*a*) Direct. From drinking-water infected with sewage matters. Usual in epidemics, as indicated by the outbreak being sudden and by the occurrence of a large number of cases. (*b*) Indirect. Water as in (*a*), used in dairies and kitchens. Vegetables eaten raw and watercress grown or washed in such water. By shellfish fattened in polluted waters.
2. *Latrine infection* .	(*a*) Hands, clothes, or boots soiled in latrines. (*b*) Infection carried to food by flies.
3. *Food*	Infected by being handled by infected persons; *e.g.*, undetected cases and 'carriers.'
4. *Personal contact* .	Infection from 'carriers' and undetected cases may also be spread in this way.

From the above it will be seen that enteric fever is not solely water-borne, a view put forward by some hygienists, but that 'carriers' and flies play a great part in the spread of this disease.

It is important to note that where dry methods of sewage removal are in use, enteric fever cases are more numerous than in places where a water-carriage system is in vogue. The life-history of the house-fly and the part played by it in the causation of disease has a direct bearing on this increased incidence.

Flies are found in food-stores, latrines, rubbish-heaps, and elsewhere; they feed on any kind of organic matter. They breed very rapidly; the female fly lays her eggs on all kinds of filth, chiefly in accumulations of horse manure and decaying organic matter. Moisture, warmth, and food, the three things necessary for the sustenance of the larvæ, are present in such filth. On an average 120 eggs are laid every 4 weeks. These hatch out in about 8 to 24 hours into larvæ (maggots). This stage lasts from 4 to 5 days; they then change into pupæ, which, after a period of from 2 to 5 days, develop into the full-grown fly (the imago). Figs. 7 to 10. The cycle, from egg to fly, is usually from 8 to 15 days, but may be as long as 4 weeks, temperature being the chief factor.

Flies alight on filth and food indiscriminately. They cannot swallow solid food, so to dissolve food required, they vomit the contents of their crop or false stomach on to it. By this means the food is contaminated with the contents of the crop, which may contain the germs of disease sucked up from excreta or other form of filth. In addition, the infective material may also be transferred to food on the fly's feet.

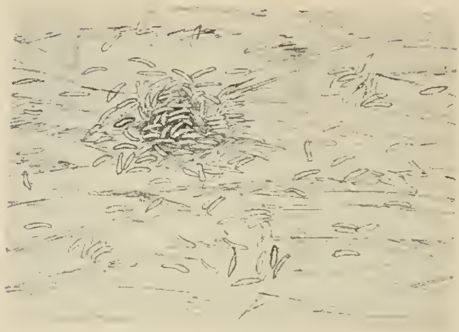
In India many examinations have been made with soil from filth trenches. From so small an amount as one-sixth of a cubic foot put in a cage, over 4000 flies have been hatched out.

The following extract from an article by Colonel R. H. Quill, R.A.M.C., on the subject of 'The Spread of Enteric Fever by Latrine Infection,' which appeared in the *Journal of the Royal Army Medical Corps*, October 1912, is of interest:—

"In connection with this subject I well remember an experience in Poona which will bear relating. Enteric fever, at the time I am speaking of, was very prevalent at that station, and a close investigation was being made in relation to the cause of the outbreak. Among other matters, it was considered advisable to make an inspection of the place where the sewage of the native city of Poona was deposited. This place

Periods of development.

Eggs.
Fig. 7.



8 to 24 hours.

Larva.
Fig. 8.

4 to 5 days.

Pupa.
Fig. 9.

2 to 5 days.

Imago.
Fig. 10.

Figs. 7 to 10.—Life-History of the Common House-Fly. (Partly after Austen.)

was some two miles from the city and about an equal distance from the barracks. When about half a mile from the odoriferous spot we were in search of, a 'booming sound' was heard, the cause of which was a mystery. We continued our journey; the 'booming sound' steadily increased in intensity, and explained itself on the sewage ground being reached. There we found three large tanks, one full, the others partly full, of putrescent filth, giving out an overpowering stench; on the surface of these filth tanks was an incredible swarm of flies, all busily engaged in sucking the foul, green corruption. The buzzing of these flies was the cause of the 'booming sound' which had so puzzled us when first heard over half a mile distant. The putrid contents of the tanks was eagerly bought by natives for agricultural purposes—a suggestive subject. But further, what of the poison-laden flies? Did they migrate? If so, where to, and with what result?"

Prevention of Enteric Fever.

1. There should be early recognition of cases, isolation, and disinfection. Attendants on the sick should be inoculated. (Laboratory tests for diagnosis are Widal's reaction, and the cultivation of the germs from the patient's blood in ox bile.)

2. Convalescents should be watched and their excreta examined, in order to establish whether they are 'carriers' or not.

3. To avoid the danger of latrine infection there should be a properly organised method of sewage disposal. The water-carriage system is undoubtedly the best, and should always be introduced where practicable.

Where so-called "dry" methods of disposal are in use, strict supervision is necessary to lessen the danger. The important point is that the excreta should be covered up as soon as it leaves the body. For such covering, either dry earth or cresol is used. The latter is by far the better method. More will be mentioned on this subject in Chapter X.

4. Destruction of breeding places for flies, *i.e.*, stable litter, refuse heaps, and the like. If removed and destroyed every week, each generation of flies is destroyed with it.

5. Proper protection of food in kitchens and stores, also proper cleansing of utensils used therein. Cooks on appointment should for a time be kept under observation and examined to see whether they are 'carriers' or not.

6. Water supplies should be safeguarded at the source, and during storage and distribution, to avoid pollution by sewage matters.

7. Last, but not least, inoculation.

The present system of inoculation against enteric fever was first introduced by Sir A. Wright in 1897, and since then has been employed on a very large scale, especially in His Majesty's Forces, to protect those proceeding to tropical places where enteric fever is endemic.

The vaccine used is a standardised and sterilised culture of typhoid bacilli to which a small amount of antiseptic has been added "to guard against any possible contamination after the capsules have been opened."

From experience it has been found that the best results are obtained by giving the dose in two parts: one-third as a first inoculation, and two-thirds as a second inoculation, ten days after the first. The quantity to be injected depends on the strength of the vaccine—this is stated on the capsules.

The immediate effects of the inoculation usually commence about the sixth hour. There is a certain tenderness at the site of inoculation, which is either the arm or the region of the chest above the pectoral muscle.

In some cases there is a certain amount of fever which lasts about twenty-four hours; in others, faintness occurs.

Patients are instructed to remain quiet, avoid exertion, and eschew alcohol for about forty-eight hours.

The protection afforded, *i.e.* increase of "protective substances" in the blood, lasts for about two years; and if inoculation is done prior to embarkation for tropical regions, it protects the individual concerned during his first two years in the tropics, the period during which he is most likely to be run down and made more susceptible to enteric fever by the change in climatic conditions.

Inoculation does not afford absolute protection, but from statistical evidence it can be affirmed that the chance of contracting the disease after inoculation is reduced to one-fourth that of the non-inoculated man. And the inoculated who do develop the disease have it in a milder form; also the incidence of death from the effects of it is reduced to one-sixth of that of the non-inoculated enteric fever patient.

If these preventive measures were carried out in their entirety, enteric fever rates would be enormously reduced.

Paratyphoid Fevers 'A' and 'B.'

These are distinct diseases resembling enteric fever, but not so severe. They are distinguishable from enteric fever by the 'serum' reaction. They are spread in the same way, and, with the exception of inoculation, the preventive measures are the same as those outlined under enteric fever.

Dysentery.

There are two kinds of dysentery: (1) bacillary, and (2) amœbic. It is affirmed that there are three or four different kinds of organisms isolated in this disease. The large intestines are attacked, ulceration occurs, and blood and slime are discharged with the dejecta. There is usually no high fever. Amœbic dysentery is often followed by liver abscess, some authorities considering that they are one and the same disease. It is endemic, as distinct from the bacillary form, which is usually epidemic.

The channels of infection and the preventive measures, excepting inoculation, are similar to those dealt with under enteric fever.

Cholera.

Originally cholera was an Asiatic disease, but it is now common to many countries, having spread along the trade routes.

The causal agent, a vibrio, is taken into the body *via* the mouth, and multiplies in the intestines, in which tract it is usually localised. The organisms leave the body in the bowel discharges. The incubation period is usually from three to six days, but may be from one to twelve days.

The symptoms of the disease are purging, vomiting, retention of urine and watery stools. The patient becomes intensely collapsed, and from 50 to 80 per cent. of the cases die.

The original source of infection is nearly always a polluted water or milk supply, the latter often being the cause where the number of cases is comparatively small and not widespread.

Outside the body the organism quickly dies; in water it disappears in from three to four days, so that recent contaminations only cause epidemics.

Water may become infected through sewage contaminations in many ways, such as subsoil drainage, surface washings, use of promiscuous vessels in obtaining water from wells, and the washing of persons and clothes in or near supplies.

Preventive Measures.—These should be similar to those discussed under enteric fever, especially as regards water supplies and quarantine. Suspected persons should be kept under observation and examined daily for at least six days.

Food supplies should be inspected. It may be necessary to stop the sale of raw fruits and vegetables, and also to stop inter-communication with other infected districts.

A strict lookout should be kept for cases of diarrhœa, and such cases kept under observation, as they may be cases of cholera. If missed, they spread the disease.

The water supply should be examined to find where the contamination is getting in, and once located, the supply should be properly protected, and a system of water purification introduced, boiling preferred.

If purification cannot be carried out or relied upon, it may be necessary that the community, if small, should move to a new place where a good supply of water is available, taking care that everything connected with the distribution of water, *i.e.*, water vessels, tanks, etc., is left behind. Such vessels, tanks, etc., require to be disinfected thoroughly before being again taken into use.

In outbreaks of the disease not very widespread, the milk supply should be enquired into, as a possible channel of infection.

Smallpox.

This disease is widely distributed, and is usually endemic in the tropics among the native population. The incubation period is usually twelve to fourteen days, but may be from six to sixteen days. The causal agent is at present unknown. The initial symptoms appear on about the thirteenth day and the rash on the fifteenth. The case mortality varies enormously. The chief channels of infection are air, personal contact, bedding, clothing, rags, etc.

The general preventive measures include early recognition of cases and isolation, disinfection, segregation of contacts and suspects. Individual protection is obtained by vaccination, an operation which is now compulsory in many European countries and elsewhere. The immunity conferred, which is considerable, is said to last for about ten years.

Cerebro-Spinal Fever.

This disease is widespread and common in tropical Africa. The causal agent is a diplococcus.

It chiefly occurs among children and appears to have a seasonable prevalence, occurring usually during the dry season. The symptoms are sudden fever, headache, vomiting, stiffness of the neck, and spasms of the muscles, followed by convulsions, delirium, and coma. The mortality is very high, and varies from 30 to 70 per cent. Diagnosis is confirmed by the microscopical examination of the cerebro-spinal fluid for the organism, which is often also found in the nasal mucus.

The incubation period is at present unknown. Carriers and convalescent patients are often the cause of epidemics; though immune themselves, they carry the infection to others. Some authorities assert that horses and goats suffer from this disease.

Air is the usual channel of infection, though no doubt personal contact in many ways plays a part. The germs do not live long outside the body.

Prevention.—Early recognition, isolation, and notification of cases occurring are most important. Disinfection of bedding, clothing, and discharges of patients is essential. There should be a search made for slight or mild cases and carriers, especially among members of a patient's family. During epidemics, large gatherings of people should be avoided, and native labour should not be hired from infected areas.

Tuberculosis.

Although not a 'tropical disease,' as previously defined, tuberculosis is included here on account of its general importance. It is common to all civilised countries, tropical and otherwise; from 200,000 to 300,000 persons in England alone are constantly suffering from it.

Primitive races are very susceptible to this disease, and when brought into contact with civilisation it spreads rapidly amongst them. This is accountable for by the three following factors :—

(1) The tubercle bacillus. (A 'product' of civilisation.)
(2) A 'virgin soil.' (The susceptible native.)
(3) Overcrowding and lack of ventilation in their dwellings.

The disease may attack any part of the body ; it is not confined to the lungs, as is popularly imagined.

The incubation period is unknown, the onset is gradual, and the disease is chronic, though not so fatal as it was thought to be in the past.

It is caused by a bacillus which is very resistant, and can remain alive after leaving the body for a longer period than many other disease germs. In rooms that have been occupied by tubercular patients the organisms have been recovered at the end of a period of six weeks after being vacated.

The germs enter the body through the nose and mouth.

Infected persons when speaking give out a fine spray of saliva containing germs ; they also cough the germs up in their sputum, this dries and is then blown about and gets attached to dust particles ; thus the germs may be inhaled in two ways.

Personal contact plays a great part in the spread of the disease ; feeding utensils, clothing, bedding, and even food may be infected.

It is easy to understand why a case of tuberculosis in a family is a great danger, and the less the air space for each person the greater the danger ; therefore floor space and ventilation are very important factors. It should be remembered that no extra amount of cubic space will make up for lack of floor space. The ratio should not exceed 12 to 1. (See Chapter VII.)

Supposing 50 men occupied a room the floor space and cubic space of which were 500 sq. ft. and 6000 cub. ft. respectively, each would have 10 sq. ft. floor space and 120 cub. ft. air space. If only 10 men were in the same room, each would have 50 sq. ft. floor space and 600 cub. ft. air space, and presuming an infected inmate, the chances of infection by spray or personal contact of the 10 men would be one-fifth that of the larger number of men.

The reduction in the number of cases of tuberculosis amongst soldiers is chiefly due to the increased allowance of floor space and cubic space in barracks.

It is a recognised fact that cattle suffer from tuberculosis. The cattle disease is thought to differ slightly from the human one, the organism being of the same species but a different variety; yet man may be infected with bovine tuberculosis.

The disease is passed from cattle to man either in milk from tuberculous cows or in flesh of tubercular cattle used as food; chiefly in the milk. The danger from infected meat is not so great, as the carcass is examined before sale and the flesh is cooked before being consumed.

In some countries it is estimated that 10 per cent. of stall-fed cows are tuberculous, and the cows suffering from the disease have tubercular nodules in the udder and germs are passed out in the milk. The milk from a farm is not solely from one cow, but is the result of mixing milk from many cows, and though only one of the herd is tubercular the whole of the milk is infected.

In England, from bacteriological analysis of numerous samples of milk purchased haphazard in the street, 10 to 15 per cent. have been found to contain tubercle bacilli.

Milk may also be infected by the dust in the cow-shed, which may be full of the germs, or by the dairyman not paying attention, before milking, to details of personal cleanliness.

Some authorities state that milk is of minor importance, bovine infection being of infrequent occurrence, and that evidence shows air infection, direct from man to man, plays the major part.

Prevention.—Early diagnosis and isolation of the case are very difficult to carry out. The former because onset is usually very gradual, and the latter because it is a question of money to provide segregation for all infected persons. Those unable to obtain sanatorium treatment should be instructed how to live to secure the best results for themselves, and to lessen the risk of infecting others.

There should be universal prohibition of spitting.

Dry dusting of rooms, especially in public buildings, should be abolished. This method of cleaning simply circulates the dust and contained organisms in the air, which is inhaled by the occupants. A damp cloth should always be used.

There should be ample floor and cubic space per person in rooms occupied, and efficient ventilation. The object aimed at is really the dilution of disease germs.

Milk should be boiled before use to kill the germs.

Pasteurised milk is milk which has been heated to a temperature of 70° C., and kept at that temperature for ten minutes (the time required to kill the bacilli): it is then rapidly cooled.

Sterilised milk is usually that heated to a temperature above 212° F., so that all the germs are killed off.

Routine inspections of imported cattle should be carried out, and special attention paid to cows with nodules in the udder.

Malaria.

This term is derived from Italian words meaning 'bad air.' It signifies a group of fevers which in the past were always associated with bad air, *i.e.*, marshy emanations, etc.

There are many synonyms for malaria; the most common one in use is 'ague.'

The disease has been known for hundreds of years. It is common to tropical and sub-tropical regions and is the cause of more inefficiency amongst Europeans than any other disease. It has a seasonable prevalence similar to that of the mosquito.

It is very persistent, recurring again and again, but is seldom fatal; the highest mortality is amongst infected native children.

The symptoms are high fever in definite attacks, and fits of shivering.

The body temperature rises to 104° F. or higher, and the patient perspires. This is followed by a reduction in the temperature often to normal. After an interval of one, two, or three days the fever occurs again. The blood is impoverished, and the spleen may become enlarged.

The causal agents in malarial fever are parasites of the protozoa group, termed plasmodidæ.

There are three known types, each of which causes a distinct fever :—

(1) Benign tertian. Fever recurs every third day.
(2) Quartan. Fever recurs every fourth day.
(3) Malignant tertian. Fever does not occur at regular intervals, but usually about every thirty-six hours.

The parasites are injected into the body by certain species of mosquitoes, which act as carriers of the disease from sick to healthy. In other words, mosquitoes are the infecting agents, but before being infective they must sometime previously have sucked the blood of an infected person.

The causal germs were discovered by a French doctor, Laveran, in 1880, but it was not until 1898, after many years of patient research work on birds and mosquitoes, that Major (now Sir Ronald) Ross fully demonstrated the part played by certain species of mosquitoes in the spread of the disease.

The parasites enter the blood at the time the infected mosquito 'bites'; they are in the saliva and ejected from the salivary glands into the wound made by the stylets of the proboscis.

The saliva contains an irritant poison, which causes the pain and swelling. Fig. 11 shows the three glands on one of the branches of the salivary duct.

Several theories are put forward regarding the

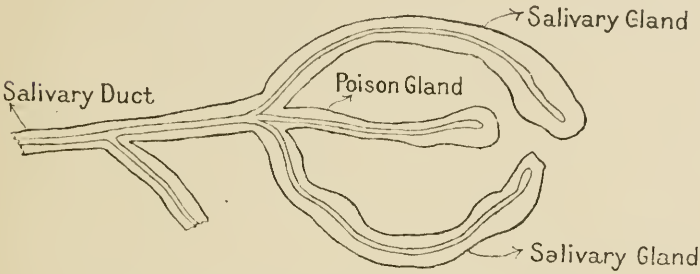


FIG. 11.—Sketch of the Salivary Glands of the Mosquito.

action of the ejected saliva, the more prominent being:

(1) That it creates a flow of blood to the puncture made.
(2) That it is to dilute the blood before being sucked into the mosquito's stomach.
(3) That it prevents coagulation.

The parasites once in the blood stream either:

(1) Are destroyed by the phagocytes; or
(2) Reach the spleen and remain dormant there; or
(3) Develop and cause fever.

The period of incubation is from eight to twelve days; during that time the organisms are multiplying and toxin is being made.

It is said that the length of the period depends on the initial number of organisms injected. The dormant ones in the spleen may cause fever on the vitality being lowered.

The attacks of high fever occur at the time young forms of the parasite are liberated from impregnated red cells and penetrate others.

Three types of the same parasite are present in a patient's blood: one, the asexual type, grows at the expense of the red blood cell on which it fixes; the others are sexual, male and female, and require another host for their further development. Such hosts are mosquitoes of certain genera of the sub-family Anophelinæ. Fertilisation of the female germ by a flagellum from the male occurs in the mosquito's stomach. There the impregnated female lies up; it increases in size, burrows its way through the stomach wall and eventually bursts, liberating young forms, some of which enter the salivary glands. Fig. 12 is an unorthodox method of diagrammatically illustrating the connection between man and mosquito and the cycles of development of the causal agent in each.

The mosquitoes usually lie up during the day and bite at night; that is, between sunset and sunrise.

Only the female Anopheline is a blood-sucker; the male is harmless, and feeds on various vegetable foods. (This also applies to other blood-sucking diptera, with the exception possibly of the genus Glossina, in which the blood-sucking habit is said to be common to both sexes.)

From what has been said it will be apparent: (1) that the malaria parasite undergoes certain changes passing from one host to another; (2) that a man bitten by an infected mosquito does not develop symptoms of the disease until a week or ten days afterwards; (3) that the man is not infective to another mosquito until the sexual types of the parasite are in the peripheral blood; and (4) that the second mosquito is not infective until the young forms of the parasite have matured and been conveyed to the salivary glands.

Prevention.—(1) As far as is possible there should be protection from persons who have the disease, but early recognition and isolation of cases are very difficult to carry out amongst natives, as it is chiefly a matter of money and organisation. Malarial patients under treatment are protected from the bites of mosquitoes by the use of mosquito nets effectively to screen each bed, or by being segregated in mosquito-proof wards, *i.e.*, all windows, doors, ventilators, etc., are screened with wire netting. The mesh should be 16 to 18 to the inch.

DIAGRAMMATIC ILLUSTRATION OF THE CONNECTION BETWEEN

MAN AND MOSQUITO

IN THE SPREAD OF MALARIAL FEVERS

A man suffering from malarial fever is 'bitten' on the arm (or other exposed part) by a mosquito (sub-family Anophelinæ). Blood sucked by the mosquito for food is taken into its stomach. The mosquito flies away.

The person whom it bites ten to fourteen days afterwards will probably develop the disease, the organisms having been transmitted by the mosquito.

One can follow the development and reproduction of the parasites in the man's blood on lifting the upper flap ;

And,

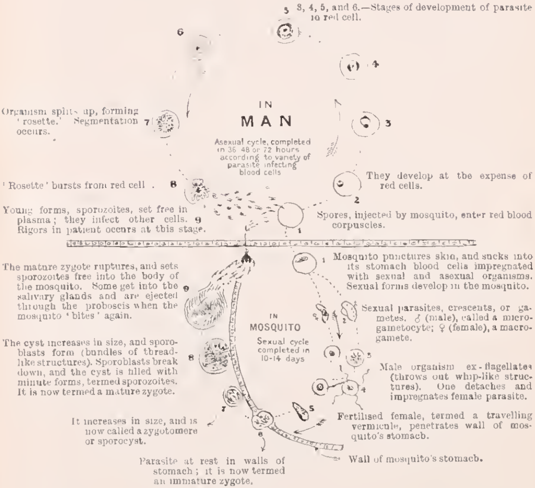
On opening the lower one, the development and reproduction of the parasites in the mosquito.

FIG. 12. [*Face page* 34.

For the transmission of the disease from man to man, two things are necessary :—

(*a*) The malarial parasite ;

(*b*) The mosquito (Anophelinæ).



REMEMBER

(1) Mosquitoes breed on water.

(2) No water means no mosquitoes.

(3) No mosquitoes—no malaria.

Native children suffer largely from malaria, and they become more or less immune to the disease although the parasites are contained in the blood. For this reason it is necessary to avoid living in the vicinity of native towns, a European colony being usually formed some little distance away. Visits to native quarters should always be carried out in the daytime, when there is little risk of being bitten by an infected mosquito. In visiting such places in the evening or during the night one is simply asking for trouble.

The Inspector may be called upon to assist in estimating the amount of malaria amongst native children. Two indices are used: (1) Splenic index, the proportion of children with large spleens; and (2) Endemic index, the proportion having parasites in the blood, obtained from microscopic examination of blood films (for method of making blood films see Appendix). The results of these examinations are tabulated monthly, as shown on page 36.

(2) Destruction of mosquitoes of *every variety*.

Although only the female Anophelinæ are concerned in the spread of malaria, other genera are associated with the causation of other diseases; therefore it would be useless attacking simply the breeding places and haunts of one genus only.

Anti-mosquito measures, and the work to be performed by mosquito brigades, are dealt with in the chapter on mosquitoes.

Professor Sir Ronald Ross considers that it is impossible absolutely to exterminate mosquitoes, but their numbers can be kept down very largely. He states that, roughly, mosquito-borne diseases may be decreased as the square of the decrease in numbers of mosquitoes. For instance, if mosquitoes are reduced to one-half, mosquito-borne diseases will be reduced to one-quarter; if reduced to one-third, mosquito-borne diseases will be reduced to one-ninth.[1]

(3) Suitable legislation to enable Inspectors to deal

[1] In the second edition of Sir R. Ross's book, *Prevention of Malaria*, a much more complex table is given for these calculations.

Native children suffer largely from malaria, and they become more or less immune to the disease although the parasites are contained in the blood. For this reason it is necessary to avoid living in the vicinity of native towns, a European colony being usually formed some little distance away. Visits to native quarters should always be carried out in the daytime, when there is little risk of being bitten by an infected mosquito. In visiting such places in the evening or during the night one is simply asking for trouble.

The Inspector may be called upon to assist in estimating the amount of malaria amongst native children. Two indices are used: (1) Splenic index, the proportion of children with large spleens; and (2) Endemic index, the proportion having parasites in the blood, obtained from microscopic examination of blood films (for method of making blood films see Appendix). The results of these examinations are tabulated monthly, as shown on page 36.

(2) Destruction of mosquitoes of *every variety*.

Although only the female Anophelinæ are concerned in the spread of malaria, other genera are associated with the causation of other diseases; therefore it would be useless attacking simply the breeding places and haunts of one genus only.

Anti-mosquito measures, and the work to be performed by mosquito brigades, are dealt with in the chapter on mosquitoes.

Professor Sir Ronald Ross considers that it is impossible absolutely to exterminate mosquitoes, but their numbers can be kept down very largely. He states that, roughly, mosquito-borne diseases may be decreased as the square of the decrease in numbers of mosquitoes. For instance, if mosquitoes are reduced to one-half, mosquito-borne diseases will be reduced to one-quarter; if reduced to one-third, mosquito-borne diseases will be reduced to one-ninth.[1]

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MALARIA INVESTIGATION.

(TO BE RENDERED MONTHLY.) [a] SPLEEN RATE. MONTH OF 19

Date.	Place	Age 0 to 3.	Number with enlarged Spleens.	Age 3 to 8	Number with enlarged Spleens.	Age 8 to 15	Number with enlarged Spleens.

Total number examined
" " with enlarged Spleens.
Percentage with enlarged Spleens.

[b] BLOOD EXAMINATION.

Number Examined.	Ages.	Percentage with Parasites.	Percentage without Parasites	Type of Parasites.	Remarks.

Medical Officer.

To the Senior Sanitary Officer,

Station

Date

with the finding of mosquito larvæ in compounds as a nuisance, admitting of a remedy, *i.e.*, destruction of breeding place, screening of tanks, etc.

(4) Protection of the individual against the mosquito, by (*a*) selecting sites free from breeding places where possible; (*b*) living in mosquito-proof houses; or (*c*) using mosquito nets.

(5) Use of quinine. This, although of great value, should be a supplementary measure to the others already dealt with, and should not take their place. Quinine acts as a poison to the parasites in the early stages. It is generally distributed free to natives from local dispensaries, and is provided by the local authorities.

It is best administered in 5-grain doses daily, though some authorities recommend a dose of 10 to 15 grains bi-weekly.

The chief objection by the individual to the use of quinine is its nasty taste, especially in the liquid and powdered forms. Europeans usually provide themselves with bottles of 5-grain tabloids.

An easy way of measuring and taking quinine sulphate in the powdered state is to heap a sixpenny piece with it, tilt it off the sixpence into a cigarette paper, roll it up into a ball, and swallow it whole.

(6) Education of the community. Pamphlets and leaflets should be printed and distributed explaining reasons for preventive measures, and asking for co-operation of householders. The following is a copy of a leaflet issued in West Africa by local authorities.

How to Avoid being Prosecuted by the Sanitary Inspectors.

1. Mosquitoes cause fever and other diseases, which cause the deaths of half your children; therefore, if you and all who live in the house wish to enjoy good health, do what you can to keep your house free from mosquitoes.

2. Mosquitoes lay their eggs on the water contained in chatties, tanks, barrels, gutters, and in the water contained

in old tins, pots, and bottles lying about the compound. From the eggs the little wrigglers are hatched out, and these after a few days turn into mosquitoes.

If you do not believe this, put some wrigglers in a bottle, tie mosquito gauze over the top of it and look at the bottle every day. In a few days you will find the wrigglers have disappeared from the water and mosquitoes will be seen flying about in the bottle above the water. The wrigglers have changed into mosquitoes. Do not believe that wrigglers exist in all water; they cannot get into water except from the eggs laid by mosquitoes on the water. Every fowl's egg must be laid by a hen, and so must every mosquito's egg be laid by a mosquito.

3. If you wish to keep your house free from mosquitoes take the following simple measures to prevent mosquitoes laying their eggs in, and so introducing wrigglers into the water-vessels in your house or compound.

(*a*) Make the tank mosquito-proof.

(*b*) Make the barrel mosquito-proof.

(*c*) Grade your gutters or punch holes in them so that water will not lie in them after the rain has ceased to fall.

(*d*) Collect all the old pots, tins, and bottles in the compound and take them to the nearest dust-bin.

(*e*) *Last, and not least*, always wash out each chatty every day before pouring into it fresh water brought in from outside.

If you do this the Sanitary Inspector will never find wrigglers in your chatties and will not trouble you.

4. The Sanitary Inspector will always help and show you how to do all this.

5. The Sanitary Inspector does not want to trouble you by taking you to Court, but he knows that if there are wrigglers in every compound soon the town will be full of mosquitoes, then there will be much sickness, perhaps even an Epidemic and Quarantine.

Try to help the Sanitary Inspector by taking a little trouble to do the simple things you have been asked to do, and so prevent Court Proceedings, Sickness, Epidemics, and Quarantine.

The following has been issued by the Liverpool School of Tropical Medicine. It is illustrated by suitable drawings and photographs :—

WARNING

Danger of Mosquitoes

Notice to all who live in the Tropics.

It has been conclusively proved that "Climatic Fever," Malaria, Yellow Fever, Dengue Fever, African Fever, Endemial Remittent Fever, Bilious Remittent Fever, are invariably present in one form or other in Tropical Countries.

(*a*) Hitherto it has been supposed that every new arrival in the Tropics must sooner or later get fever. A precisely similar opinion formerly obtained in the now very healthy towns of Rio, Havana, Panama, and other places.

(*b*) These fevers can all be avoided, as smallpox at home is avoided. They are propagated from man to man by three groups of mosquitoes: the Stegomyia, Culex, and the Anophelines. Of all these kinds the first is most house-infesting, and therefore the most dangerous.

(*c*) The bite of a mosquito should be dreaded as much as that of a mad dog.

(*d*) The best and most certain cure is Prevention, therefore avoid exposure to needless risk.

1. Sleep under a mosquito net.
2. Keep your yards and compounds scrupulously free from stagnant water of any kind.
3. Cut down useless bush and weeds.

4. Remove all water-holding tins, bottles, and similar odds and ends, no matter how small or trivial.

5. Sprinkle paraffin oil once a week on every puddle or collection of water in or near your compound which cannot be immediately drained.

(*e*) Every resident should help the Health Authority by guaranteeing the mosquito security of his own premises.

(*f*) Remember, above all, that it is the domestic mosquitoes, those living in and around the towns where you trade, that are most to be dreaded, and that if each resident will do his duty the day is not far off when these fevers will be as rare as they are to-day in Rio, Panama, Havana, and many of the West Indian Islands.

(*g*) Finally, remember that the future prosperity of the Tropics depends upon their health security.

(*Signed*) RONALD ROSS.
RUBERT BOYCE.

Conspicuous examples of the success of anti-malaria measures are the cases of Ismailia and Havana. Others could be quoted, but these are chosen as being representative of two different communities, where efficient organisation and money were available, but where, in the one case, Ismailia, the inhabitants were practically all employees of the Suez Canal Company, and where regulations made could be readily enforced; in the other case, Havana, the inhabitants were ordinary citizens not under similar discipline.

Anti-malaria measures were carried out at Ismailia (on the Suez Canal) under the advice and guidance of Major Ross, at the request of the Suez Canal Company.

The following table of statistics, quoted by Major Ross in a lecture on Researches on Malaria, speaks for itself:—

Statistics of Malaria at Ismailia.

(From the statistics of the Suez Canal Company.)

Month.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
January	83	94	201	156	128	162	13	...
February	103	83	165	139	83	105	20	...
March	129	126	129	266	99	101	16	...
April	135	127	109	175	100	64	14	...
May	173	77	126	169	82	133	9	...
June	180	43	126	114	68	154	15	...
July	188	81	104	145	74	120	23	...
August	242	86	107	166	123	130	19	...
September	336	128	128	258	244	176	25	...
October	254	178	172	228	372	139	39	...
November	178	271	209	244	352	174*	12	...
December	88	251	208	182	265	73	4	...
Total	2089	1545	1784	2242	1990	1531	209	...

* November 1902, operations commenced.

With regard to the campaign against yellow fever and malaria at Havana in 1901, Colonel (now Surgeon-General) Gorgas of the United States Army, who was in charge of the work, reported as follows :—

"The results of these combined measures adopted were very marked: mosquitoes entirely disappeared from many parts of the city and were decreased everywhere. On the first inspection made in January 1901, 26,000 collections of fresh water were found in the city containing mosquito larvæ, this exclusive of the cesspools. In January 1902 the consolidated inspection reports covering the same area showed less than 300. The most striking evidence was its result on yellow fever. (Figures are given under notes on yellow fever.)

"The work with regard to malaria is not quite so striking, and this necessarily follows from the nature of the disease. But I think the results, as shown by the sanitary reports, are very hopeful with regard to malaria, and indicate that in the course of time malaria can also be eradicated.

"In 1904, the year before mosquito work, the deaths from malaria were 344 in 1901; the first year of mosquito work, they had fallen to 151 in 1902; the second year of mosquito work, they had dropped to 90; and for the first four months of 1903, 16."

Blackwater Fever.

This has been described as "An acute disease, characterised by an initial chill, fever, bilious vomiting, jaundice and hæmoglobinuria." The urine becomes dark (sometimes black), hence its name, and returns gradually to its normal colour.

Very little is known about the causal agent of this disease. It is common to various parts of tropical Africa, and has a high death-rate.

It has always been associated with: (*a*) malaria, of which it has been asserted to be a severe form; and (*b*) the taking of large doses of quinine. Recent work done in connection with this disease points to the fact that it is probably a separate and distinct disease, and not in any way connected with either of the above theories.

The fact that it occurs in malarious districts points to a possibility of the mosquito acting the part of transmitter and of some blood protozoon as the causal agent, but this has not yet been determined. Debility from previous illness is undoubtedly a predisposing influence.

Until more is known of the cause, little can be said of preventive measures except the general one of avoiding the lowering of one's vitality.

Yellow Fever.

This disease has a restricted distribution. It occurs chiefly in the West Indies, South America, Mexico, Southern States of U.S.A., and tropical Africa.

In the tropics many isolated cases occur which may be mistaken for malaria or blackwater fever.

The usual symptoms are: high fever for a week, jaundice, black vomit, acute pains in the back, albumen in the urine (usually a dark colour).

The case mortality is about 30 per cent. One attack of the disease appears to confer immunity.

There is no bacteriological test to settle diagnosis, as the causal agent is at present unknown, but it has been demonstrated that it is a 'filter-passing' one. The virus exists in the blood, and is transmitted by a mosquito, the *Stegomyia fasciata*.

This was first demonstrated in 1900, by a committee of surgeons of the United States Army, who were sent to Cuba to study the disease.

Their line of research was largely based on and greatly influenced by Major Sir Ronald Ross's work on malaria.

It was conclusively proved by them and confirmed by many other investigators, that the sole transmitter of the disease is the brindled mosquito.

The incubation period is from one to five days, but may be thirteen days.

It is thought that there are two cycles of development, as in the case of the malarial parasite, the cycle in the mosquito being completed in twelve days; that is, a mosquito having fed on a yellow fever case cannot infect another person until the twelfth day; not only that, it is also necessary for the original case to have been in the first three days of the disease. After the third day mosquitoes cannot transmit the disease.

Prevention.—Prevention should be on the same lines as for malaria, remembering that the Stegomyia bite by day and night. Some authorities state that Stegomyia which bite during the day cannot transmit the disease, explaining it in this way:—The female Stegomyia lays eggs only after a feed of blood, usually three days after such feeding. Before the first egg-laying it bites day and night, afterwards it bites only at night. Therefore a Stegomyia that bites during the day does not convey yellow fever, as it is too young, and such parasites as it might harbour would be immature.

In this way it can be understood why yellow fever centres may be visited with impunity during the daytime: the visitors may be bitten by the Stegomyia, yet not contract the disease.

Early recognition, isolation, and notification are most essential.

Any questionable case of fever should at once be brought to the notice of the Medical Officer of Health, to see if it is a case of yellow fever. Early notification is of the greatest importance, otherwise the disease may spread rapidly.

If the patient is removed to hospital, all the rooms in the house should be sealed and fumigated. If the patient is not so removed, he should be screened by suitable netting (18 meshes to the inch) and all rooms excepting his should be fumigated, the excepted room being fumigated when vacated. Adjacent houses should also be fumigated.

In some tropical places demolition follows fumigation in native quarters or dilapidated buildings in which yellow fever has occurred.

These measures, which aim at the destruction of infected mosquitoes, must be (1) thorough; (2) carried out personally by the Inspector, and not left to the supervision of subordinates.

An example of the dangers associated with an outbreak of yellow fever where the necessary preventive measures are not taken is shown in the figures connected with an epidemic of this disease in New Orleans in 1898, while the figures connected with the epidemic in the same place in 1905 demonstrate, in the words of Professor Boyce, "one of the most brilliant examples of the practical applicability of the teachings of medical science to the prevention of disease."

The epidemic in 1898 lasted from July to November; there were 13,817 cases, with 3984 deaths. The estimated population was 300,000. In 1905, from

July to October, there were 3389 cases and 443 deaths, the estimated population being 325,000.

The following figures serve to illustrate the magnitude of the operations against the mosquito during the 1905 epidemic. There were employed in the campaign :—

50	doctors.
910	inspectors, screeners, oilers, etc.
156	men in the fumigation department.
105	men in the investigation department.
32	men in the purveyor's department.
1253	total employed.

70,000 cisterns were screened in a few days.
£50,000 was the sum subscribed for the work.

The result of the anti-mosquito measures commenced at Havana in 1901 is strikingly shown in the following figures, taken from the report by Colonel Gorgas, already referred to under 'Malaria.' Yellow fever had been constantly present in Havana since 1760, and since 1889 the deaths from the disease had been as follows:—1890, 303; 1891, 364; 1892, 352; 1893, 482; 1894, 388; 1895, 549; 1896, 1355; 1897, 743; 1898, 127; 1899, 118; 1900, 301; 1901, the first year of anti-mosquito work, the number of deaths was reduced to 5, and since September 1901 there has not been a single case.

Dengue.

This is a specific and infective fever common to the tropics. Epidemiologically it resembles influenza, and diagnostically it has been mistaken for smallpox. There is a distinctive eruption accompanied by severe pains in the limbs and joints. The causal agent is not yet known, though generally surmised to be an ultra-microscopic organism conveyed by the mosquito *Culex fatigans*. This theory is supported by its seasonable prevalence.

The incubation period is said to be from one to five days. *Preventive measures.*—Until the actual cause is known, little can be said regarding these, except those of a general nature, including use of mosquito nets and destruction of mosquitoes.

Filariasis.

This is a term used to denote the infection of man by Filaria of any species.

The disease is met with in nearly all tropical countries, in a variety of forms, the more commonly known being elephantiasis, so called from the elephantine proportions of the leg, arm, or other affected part.

The causal agents are minute, worm-like organisms which inhabit the blood and lymph streams; the young forms in the lymphatic glands block them up, producing lymphangitis in any inflamed and congested area.

These organisms are transmitted by mosquitoes, the *Culex fatigans*, and possibly other species.

The cycle of development of the organism is said to be completed in the thoracic muscles of the mosquito, from which the embryo passes into the labium (the tube in the proboscis).

When the mosquito bites, the embryo works its way on to the skin, through which it penetrates into the body, and makes for the lymphatics, where fecundation occurs; young forms escape from the lymphatic glands through the thoracic duct into the blood. A second mosquito completes the cycle.

Prevention consists entirely of measures against the mosquito, and protection from mosquito bites.

CHAPTER IV

MOSQUITOES

To the tropical Sanitary Inspector a sound knowledge of the life-history and general classification of mosquitoes and measures for their destruction is essential. Without it the superintendence of anti-mosquito work cannot be efficiently performed. It is now definitely established that the mosquito is the exclusive factor in the transmission of malaria, yellow fever, and filariasis, the chief factor in the spread of dengue, and a possible factor in the dissemination of blackwater fever and other tropical infections.

Mosquitoes (from Spanish words meaning little fly), or, as they are often termed, 'gnats,' form one of the most important families of insects, known as the Culicidæ, in the order of Diptera.

Insects (the study of which is known as entomology) form a class or subdivision of the phylum or group of the Arthropoda, a grouping in the Animal Kingdom which includes those creatures having a segmented body, a thick external cuticle, and jointed limbs on the segments; the limbs on the head being used as mouth parts and feelers.

The class Insecta includes those six-legged creatures which have a larval phase prior to the development of the adult form, or, to use the technical term, a complete metamorphosis. (The only other subdivision or class of the Arthropoda of sanitary interest is the Arachnidæ, in which is the tick family.)

In entomology the grades of classification are as follows:—Classes are divided into orders, orders into families, families into genera, and genera into species. There may be intermediate grades between the class and the order, the family and the genus, and so on; this is done by use of the prefix "sub-." Thus the unit of classification is the species, which includes those indistinguishable from one another by any constant mark, apart from the differences due to sex.

The order Diptera includes those insects having only one pair of wings, behind which are a pair of little knobbed organs, termed 'halteres,' or balancers.

The family Culicidæ is distinguished by having whorls of hairs on the antennæ, a costal vein which runs right round the margin of the wing, scales on the wings covering the lines of veins, and an elongated proboscis.

The differentiation of genera in this family is based on the arrangement and character of the scales, of which there are many varieties (Figs. 18 to 21).

The classification of species is based on the adult characters. (A detailed description of these would be of no practical value to the reader.) Those of sanitary interest belong to the sub-families, Anophelinæ and Culicinæ. Fig. 17 shows the entomological outlines of the disease-carrying mosquitoes.

The males may be distinguished from females by their antennæ or feelers, which are plumose (feathery) and pilose (wiry) respectively, as shown in Figs. 13 to 16.

There are four stages in the development of the mosquito: (1) The ovum, or egg; (2) the larva, or maggot; (3) the pupa, or nymph; and (4) the imago, or perfect insect.

In common with other insects, full growth is attained in the larval stage; in other words, the imago feeds, but does not grow.

The impregnated female lays her eggs in water, in which the larval and nymph stages are spent. The periods of development, depending largely on temperature, vary in different species at different seasons and

Details of "Head-Pieces" of Mosquitoes.

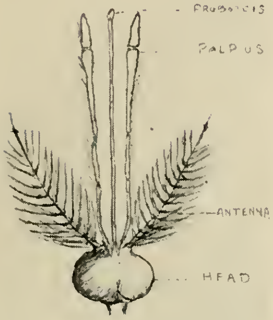


FIG. 13.—*Anophelinæ* (Male).

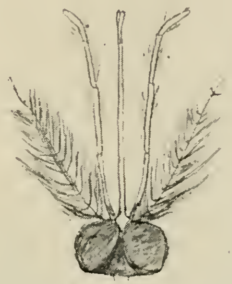


FIG. 14.—*Culicinæ* (Male).

FIG. 15.—*Anophelinæ* (Female).

FIG. 16.—*Culicinæ* (Female).

FIG. 17.

Entomological Outlines of Mosquitoes that are known Transmitters of Disease.

CLASS.	INSECTA.						
ORDER.	DIPTERA.						
FAMILY.	CULICIDÆ.						
SUB-FAMILY.	Anophelinæ.					Culicinæ.	
GENERA.	Anopheles.	Myzomia.	Pyretophorus.	Myzorhynchus.	Nyssorhynchus.	Culex.	Stegomyia.
SPECIES.	[4] *Maculipennis.* [3] *bifurcatus.* [7] *Jessenses.* [8] *Martini.* [8] *purcati.* [9] *Vincenti.*	[4] *Christophersi.* [2] *culicifacies.* [1] *funesta.* [1] *superpicta.* [2] *Listoni.*	[1] *costalis.* [2] *Jeyporensis.*	[1] *paludis.*	[2] *Stephensi.* [5] *Cubensis.* [6] *Lutzi.*	*fatigans and pipiens.*	*fasciata. or calopus.*

It is very probable that many others spread disease.

Key to figures, denoting where commonly found :—

[1] West Africa.
[2] India.
[3] Europe.
[4] Europe and North America.
[5] Panama.
[6] Brazil.
[7] Japan.
[8] Cambodia.
[9] Tonkin.

Arrangement and Character of Mosquito Scales.
(*Arranged after Theobald.*)

ANOPHELINÆ
(No Flat Abdominal Scales).

FIG. 18.—*ANOPHELES.*

Head—Upright forks . .

Thorax—Hair-like scales .

Scutellum—Hair-like . .

Abdomen—Hair-like . .

Wings—Long lanceolate .

Side view of upright fork scales on head . . .

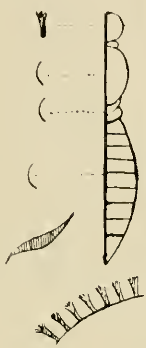


FIG. 19.—*PYRETOPHORUS*

Upright forks on *Head* (sometimes narrow curved).

Long narrow curved on *Thorax*.

Short narrow curved, *Scutellum*.

Hair-like and narrow curved on *Abdomen*.

Short lanceolate on *Wings*.

CULICINÆ
(Flat Abdominal Scales).

FIG. 20.—*CULEX.*

Head { Narrow curved, upright fork, flat .

Thorax—Narrow curved (sometimes hair-like).

Scutellum—Narrow curved .

Abdomen—Flat scales . .

Side view of scales on head . . .

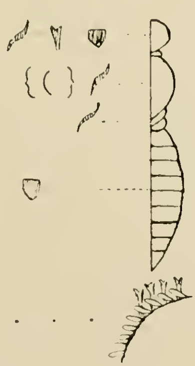
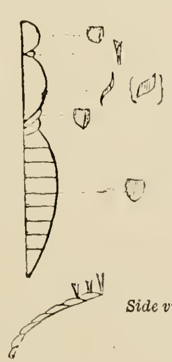


FIG. 21.—*STEGOMYIA.*



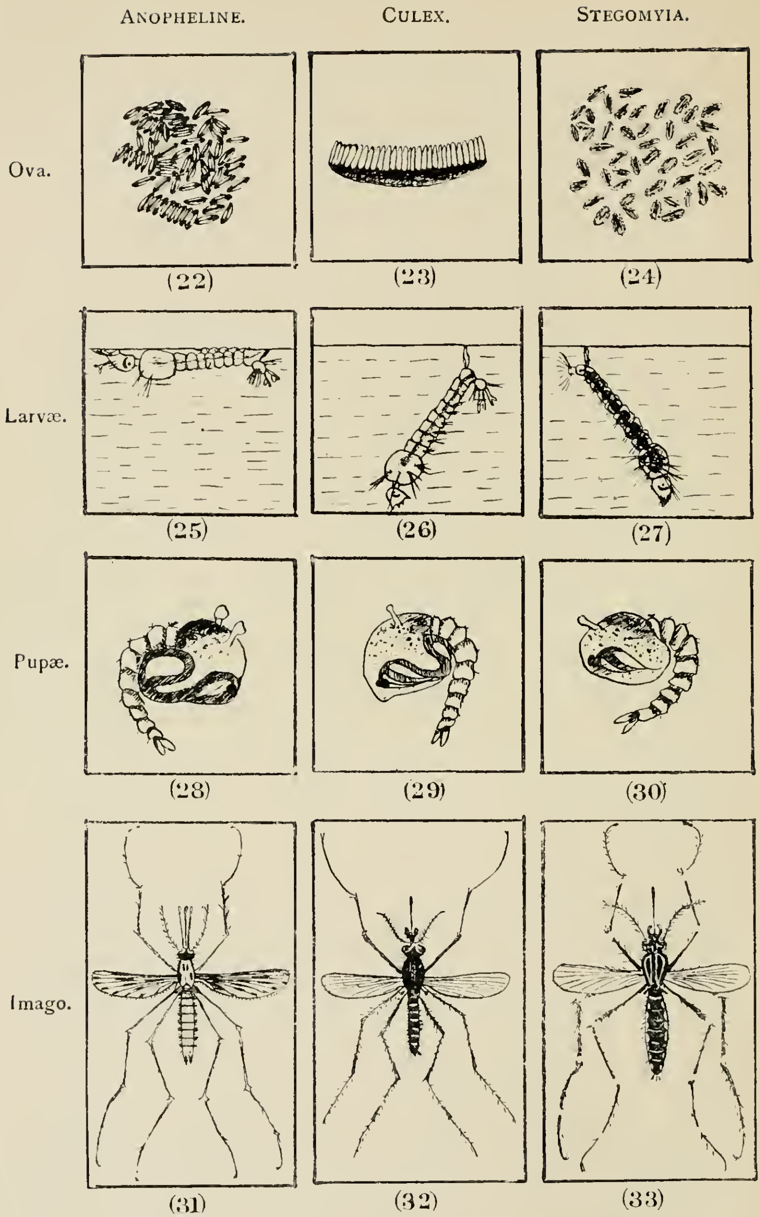
All flat on *Head*, but a few upright forks on nape of neck.

Narrow curved or spindle-shaped on *Thorax*.

Broad flat on *Scutellum*.

Flat scales on *Abdomen*.

Side view of scales on *Head*.



FIGS. 22 to 33.—Life-history of Disease-bearing Mosquitoes.

in different places, the whole process, "egg to mosquito," taking from one to three weeks. The usual period of the intermediate stages are: egg to larva, twelve hours to three days; larva to pupa, three to eight days; pupa to imago, two to four days. Generally speaking, Stegomyia develop more quickly than Anopheline or Culex.

The distinctive features of the Anophelinæ and of the genera Culex and Stegomyia of the Culicinæ in the four stages (depicted in Figs. 22 to 33) may be summarised thus.

Ova.—These are about 1 millimetre in length, and may be laid singly, often forming patterns, as in the Anophelinæ; or in groups, as in some species of the Stegomyia; or in boat-shaped masses, often termed egg-rafts, hundreds being cemented together, as in the Culex. All have air-cells as floats. Figs. 34 to 36

FIGS. 34 to 36.—Types of Ova (magnified).

are enlarged drawings of typical ova. Though of a whitish colour when first laid, they soon darken to brown, or, in the case of Stegomyia, to black.

Larvæ.—In this stage great activity is shown by them in feeding, hence their common name, wrigglers. They are about one-third of an inch in length, and consist of a head, thorax, and segmented abdomen covered with bristles. They are beautifully marked, and of a greenish brown tint. Being air-breathers, most of their time is spent at the surface of the water, with their respiratory openings or breathing tubes (which are placed near the tail) protruding into the air. The Anopheline larva, which has no distinct air-tube, lies horizontally beneath the surface of the water, whereas those of the Culicinæ hang head downward at an angle of about 45° to 60°.

The chief differences between the Culex and Stegomyia are: (1) the latter is much longer than the former; (2) it is more easily disturbed, rapidly disappearing from the surface of the water in which it is breeding; and (3) it has an air-tube which is much thicker and shorter.

The larvæ moult several times before entering into the pupal stage.

Pupa.—At this stage feeding ceases, and for the most part they quietly float on the surface of the water, somewhat like miniature tadpoles. Small breathing-tubes are provided above the thorax. The distinguishing features of the various genera are not so well marked as in the case of the larvæ. Eventually the pupa-case bursts, the mosquito hatches out, rests for a little while on the shed skin, and then flies away.

The Imago.—The Anophelinæ can be distinguished from the Culicinæ by: (1) their position when at rest, as shown in Figs 37 and 38; (2) their spotted wings

(37)

(38)

FIGS. 37 and 38.—Typical Position of Culicines (37) and Anophelines (38) at Rest.

(hence the name 'dappled' mosquitoes); (3) their characteristic palpi (Figs. 13 and 15). In the male the palpi have expanded ends, and in the female they are as long as the proboscis, whereas in other mosquitoes they are short and insignificant structures.

Some seventeen species of different genera of this sub-family are known to transmit malaria : *M. funesta*, *P. costalis*, and *A. maculipennis* are the most common.

The Culicinæ have long palpi in the males and short in the females. The two most important genera are the Culex and Stegomyia. The species *C. fatigans* and *pipiens* transmit filariasis and dengue, and the *S. fasciata*, or *calopus*, yellow fever. Both are distinguished by the ornamentation on the head, thorax, and legs, caused by the different scales and

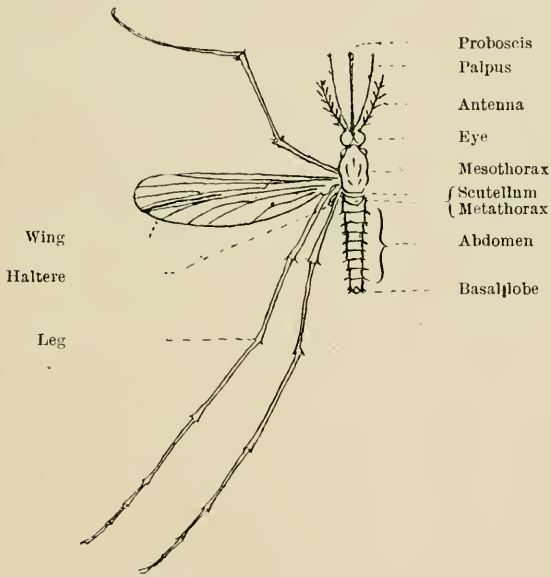


FIG. 39.—Illustrating Structure of a Mosquito.

bristles. The Culex is often described as the 'grey' mosquito; it has golden scales, and its dark abdominal segments have straw-coloured bands.

The *Stegomyia fasciata*, termed the 'brindled' or 'tiger' mosquito, from its markedly striped appearance, has a black thorax with distinctive markings in the form of a lyre or jews' harp, a black proboscis, a dark abdomen with snowy white bands, and legs similarly banded.

Fig. 39 is an outline drawing showing the structure of a mosquito and the nomenclature employed. Although not shown in the drawing, the proboscis consists of a sheath enclosing six stylets; these form a suctorial tube when in the act of biting. The sheath does not penetrate, but is bent backwards; the tips of the sheath splay outwards on the skin, and act as a support.

In addition to matured females hibernating, it is said that the species is carried over from one season to another in the larval stage.

Over 700 species of mosquitoes are now known.

Breeding Places.

It is an accepted fact that all mosquitoes breed in water.

Anopheline larvæ are usually found in water on the ground where there is shelter, *i.e.*, leaves, weeds, etc.; especially in slow and weedy streams, marshes, edges of rivers and ponds. They are also to be found in surface-drains and gutters badly laid, or choked with dirt or weeds; hollows in rocks and trees, and temporary pools of rain-water.

They are seldom seen on hilly ground or in pools exposed to scouring during heavy rain, or in lakes, ponds, etc., well stocked with fish.

Culex larvæ are found in pools, ditches, wells, cesspits, barrels, tubs, etc.; in fact anywhere where there is water.

Stegomyia larvæ are usually associated with dwellings. The stegomyia is a 'seaport' mosquito, but it is found in the interior, especially along trade routes. It is a domestic species, and breeds in any kind of receptacle, in close proximity to dwellings, *e.g.*, cisterns, butts, gutters, tins, pails, broken bottles, flower-pots, cesspools, washing-pits, and wells.

Their habits vary in different places; some thrive in fresh water, some in brackish water, and some in salt water. A usual breeding ground for all kinds of mosquitoes is the back yard of a merchant's 'factory' or store, and at sea-coast towns the tradesmen's wharves, where numerous collections of barrels, tins, cisterns, and other receptacles are to be found stacked. Such places are seldom systematically visited by the native sanitary 'constables.'

FIG. 40.—Native Streets, showing Nature of Surface Drains.

The collection of eggs, larvæ, and pupæ necessary for the making of a spot map to illustrate the mosquito density of a district, is simply a matter of diligent searching of pools, streams, cisterns, etc., using a large white enamelled spoon or tin mug tied to a stick, for dipping, and transferring 'finds' to 'wide-mouthed' bottles. (In the 'dry' season none may be found, as there may be no breeding places.) The date, nature of breeding place, type of larvæ or other form found, and situation should be recorded at once on the label of the bottle, and a note of same made in the pocket book. Young forms should be always hatched out to establish species.

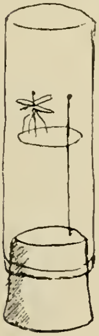


FIG. 41.—Method of Mounting and Preserving Insects.

Adult forms can be collected, when at rest, in a test-tube or pill-box, and killed by tobacco smoke or chloroform. It is usual to mount them on pins stuck through a disc of cardboard, on the underside of which is written the date, place, etc. They may be preserved in glass tubes, as shown in Fig. 41, or pinned in boxes made for the purpose.

Further information regarding the method of preserving and mounting insects will be found in the Appendix.

Anti-mosquito Work.

Reduction of the prevalence of mosquitoes amongst a community is carried out by, (*a*) creating conditions unfavourable to them, and (*b*) direct destruction.

(*a*) Aims at:—

1. Removal of mosquito-breeding waters.
2. Destruction of larvæ.
3. Creating other unfavourable conditions.

(1) Includes drainage of marshes and the like; filling up pits and holes; cutting out channels in rocks; or emptying out waters from puddles, pools, etc.

(2) Involves use of larvicides, and possibly the stocking of certain waters with fish.

(3) Includes the speeding of the current of streams, removal of grass and weeds, and trimming of the banks. Removal of undergrowth.

(*b*) Direct destruction is impossible to carry out with any measure of success, except in houses, etc., where adult forms are very numerous; but it is essentially a sound practice applied to houses where yellow fever cases have occurred, to limit the chances of infected mosquitoes spreading the disease.

From the above it will be readily grasped that anti-mosquito work in a malarial district should never cease, and that some works will be permanent and final, while others will be temporary, and therefore, of necessity, continuous. Again, some will be found to require engineering skill (major operations), while others a 'handful' of men equipped with shovel and broom can manage quite easily, once a definite plan has been arranged.

Both kinds of work are necessary for appreciable results, but in addition to proper organisation and adequate expenditure, the operations require carrying out over a sufficiently large area circumscribing the community concerned.

In this connection the warning of Dr M. Watson should be borne in mind: "To fill in a swamp at

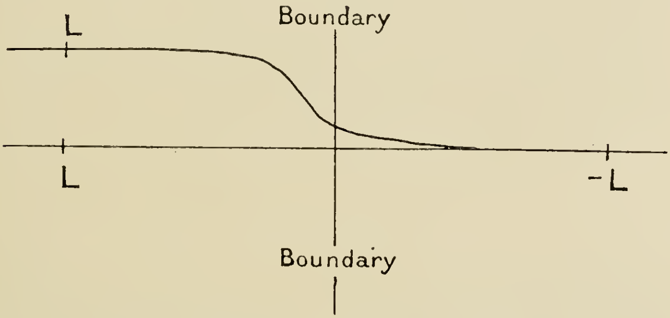


FIG. 42.—Diagram to illustrate Curve of Falling Mosquito Density due to Drainage on right of Boundary. L and – L are the Limit of Migration on either side of the Boundary.

a cost of ten times what would have been sufficient to drain it, means that nine other swamps remain undrained." The old blunderbuss methods are now out of date.

The argument, often used by laymen in the tropics, that these measures tend to be nullified by immigration of mosquitoes from without has been refuted by many observers, amongst whom Sir R. Ross has logically demonstrated that they do not radiate from a centre outwards, but remain in the vicinity of the breeding pool.

In other words, mosquitoes in houses indicate existing breeding places in the immediate neighbourhood. This was diagrammatically illustrated by him (Lecture at St Louis Exposition, 1904) as depicted in Fig. 42, which is self-explanatory.

Removal of Mosquito-breeding Waters.

(1) Major operations requiring engineering skill, include herring-bone drainage of swamps and marshes (Fig. 43), and cutting of undergrowth; sound road construction, especially in districts where there exists a rocky stratum of the subsoil, often accountable for the accumulation of pools; surface drainage by concrete channels (9 ins. diameter), suitably laid to give a sufficient fall, in place of the usual ditches on each side of the road. Figs. 40 and 44 respectively show examples of bad and good road construction and surface drainage.

In some districts it may be necessary to cut contour drains to intercept the inflow from the surrounding hills.

A piped water supply, and consequent abolition of cisterns and closing of private wells, is chiefly a question of finance. A benching of concrete with a 'cut' to the surface drain should be arranged around stand-pipes in the street where such exist. Fig. 45 gives a near view of the construction of such a benching, and Fig. 45A shows a typical example in actual use.

(2) Other measures include: filling in ponds, pools, borrow-pits, and hollows in rocks and trees; the larger with gravel and non-combustible rubbish, the smaller with concrete; trimming the edges of lakes, rivers, and streams, and removing vegetation.

Apart from the questions of a piped water supply and proper surface drainage, the need for action in regard to any of the above measures will depend on: (1) whether the areas under consideration are breeding places or not of disease-bearing mosquitoes, as indicated by mosquito survey; and (2) their distance from the community concerned; and whether such action is taken or not, depends on (3) money available; and (4) attitude of the Local Authority.

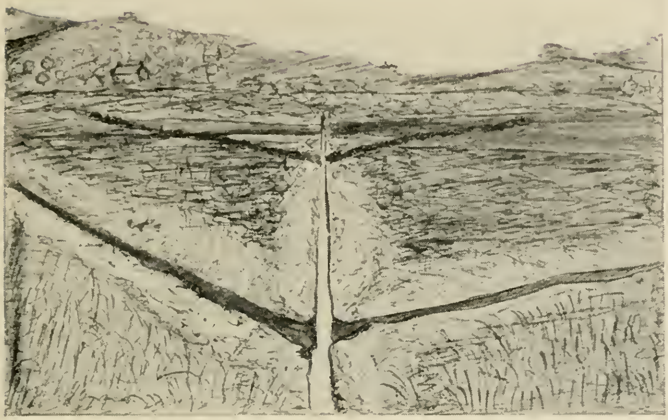


FIG. 43.—'Herring-Bone' Drainage of Swamps.

FIG. 44.—Sound Road Construction and Surface Drainage.

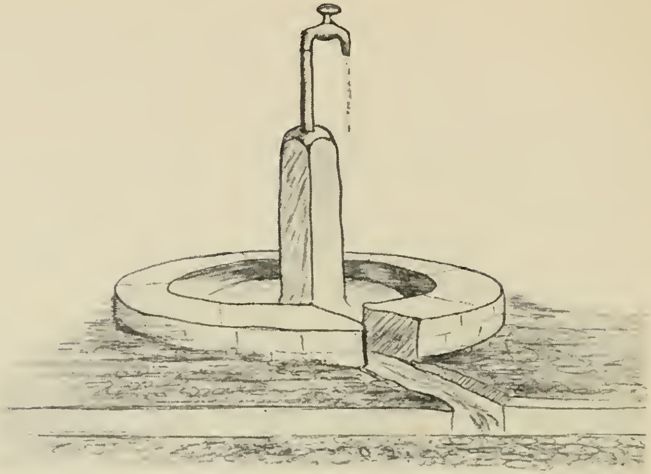


FIG. 45.—Street 'Stand-Pipe' showing Benching.

FIG. 45A.—Street Stand-Pipe in Actual Use.

The cost of drainage or other work about isolated houses in malarious districts is not commensurate with the probable effect, and moreover, such work is of doubtful value. A more appropriate measure would be that of making the house mosquito-proof by means of screens. Unless such houses are occupied of necessity, the occupants should be persuaded to vacate them.

The advantages to be obtained by the employment of a definite cadre on anti-mosquito work at mines, estates, plantations, etc., should, where local conditions render such desirable, be borne in mind by the manager or other official concerned.

Larvicides.—Many of these are on the market; the most serviceable is ordinary kerosene, or crude paraffin, sprayed on the surface of the water to form a film, which prevents the larvæ getting access to the air by choking up their respiratory openings. It is in common use for wells, cesspits, ponds, and the like. For large areas of water 1 gall. is required for every 600 sq. yds., the spraying being done from a punt or boat: for small collections of water, 'drip-cans' are often made use of. The work should be done weekly, as the oil evaporates in a day or two, this depending on temperature and the nature of the oil. (Labourers sometimes assure the Inspector that it evaporates in store: he will do well to keep the oil under lock and key, for it is almost as good as coin in the tropics.)

Legislation.—This aims at the removal of mosquito-breeding waters in the vicinity of houses, and where no piped water supply to dwellings exists, the screening of drinking-water cisterns, barrels, or tanks with brass-wire screens of a prescribed mesh—usually 18 to the inch. (Fig. 46.)

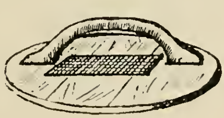


FIG. 46.—Screen for Water Barrel.

In the Soudan and other places wet cultivation of rice within 1 mile of a town is forbidden.

Tropical Public Health Ordinances differ somewhat on this subject, each being based on local conditions, but in the main they require that all water-vessels be emptied once a week, that collections of water in compounds, yards, etc., and in the street gutters be swept out daily, and that the finding of mosquito larvæ of any species be dealt with as a nuisance. The washing-pits, shallow wells, and cesspits in native compounds require particular attention.

Refuse Collection and Disposal.—This is an important work, in that it rids the districts of pots, bottles, tins, and the various other "odds and ends" that form breeding places during the rainy season.

Direct Destruction of Adult Forms.—This is done by fumigation of the houses concerned. There are three methods in vogue, all of which consist of vapourising chemical substances. The important points to remember are:—

I. The rooms or compartments to be fumigated should be measured, and the amount of material to be used based on the cubic space. No guess-work should be tolerated.

II. Care should be taken to avoid fire.

III. The fumigation should be maintained for at least three hours.

IV. After fumigation is completed and the apartment ventilated, the floors and walls should be swept and the sweepings burnt. This precaution is necessary to kill those mosquitoes which may be stunned only.

V. Place no reliance on a native's assurance that fumigation has been carried out. Usually the alleged fumigation consists of burning tobacco leaf in the various rooms.

VI. The whole of such work, especially in connection with yellow fever cases, should be under the personal supervision of the Inspector.

The three methods referred to are:—

1. Pyrethrum, 3 lbs. per 1000 cub. ft.
2. Sulphur, 3 lbs. per 1000 cub. ft.
3. A mixture of camphor and carbolic acid. Equal parts of each are mixed and gently heated:

4 ozs. of the resultant mixture are used per 1000 cub. ft. by vapourising it over a spirit lamp.

Notes on the general procedure in connection with fumigation will be found in Chapter V., on Disinfection.

Where a small pattern Clayton apparatus is available it will be found most useful for the work. (Fig. 47.)

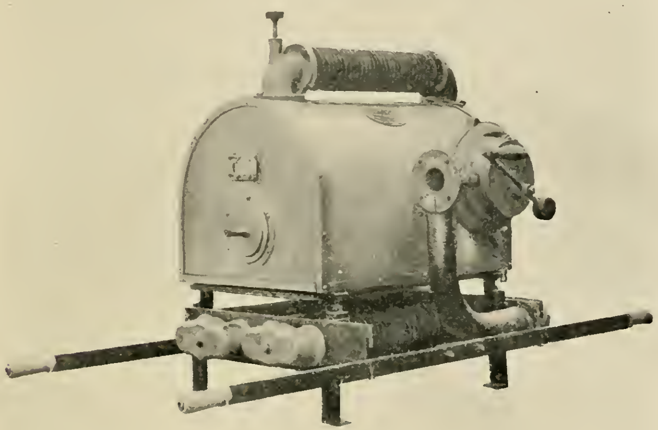


FIG. 47.—Small pattern Portable Clayton Apparatus.

A general description of this apparatus will be found in the chapter above mentioned.

Routine Work.—The reader may well ask at this juncture, "What are the routine duties of an Inspector in connection with anti-malarial work?" They vary in different districts, but in most they form an important part in the day's work. Organisation of squads, allotment of duties, supervision of assistants, checking reports, issuing of notices to abate nuisances, inspection of work done to remedy nuisances, identification of mosquito larvæ, and attendance at court, are some of the usual daily duties.

Routine inspections, by the assistant inspectors or sanitary constables, for the detection of larvæ are planned, so that the district is covered in a definite period, and all compounds, yards, and wharves are visited. A sanitary constable will visit daily on an average twelve to fourteen compounds in his sub-district. If larvæ are found they are collected, and the name and address of occupier of premises is taken. The following label is pasted on the bottle (see page 57) :—

This bottle contains a sample of

Mosquito Larvæ taken from a ....

....

at..

in the presence of....................

by......................................

Date .... Sub-district No. ....

Diagnosis made.........................

by...

M. O. H.

(*or Sanitary Inspector*).

....

It is signed by the Medical Officer of Health or Sanitary Inspector, and if police court proceedings are to be taken, it becomes an 'exhibit.'

Usually the first offence is followed by the service of a notice, the second by attendance at court, and, on conviction, a fine of 2s. 6d., increasing by 2s. 6d. for each subsequent offence.

The following is a specimen of the notice served :—

SANITARY DEPARTMENT.

No.. ....

Mr.............................

I HEREBY GIVE YOU NOTICE that Mosquito Larvæ have this day been found in a collection of water in............... .... within the Lot or Compound owned by you at........................

....

YOU are required to abate this nuisance within 24 hours, failing which legal proceedings will be taken against you.

Sanitary Inspector.

SANITARY OFFICE,

.. ..

.. ..191

The sanitary constables report daily, on the following form, the state of each compound, etc., visited.

DAILY REPORT.

Date *Section*

Street and Number.	Larvæ and what in.	Cesspits		Wells.	Water Containers.		Nature of Nuisances, if any. Instructions given or action taken.
		In Order.	Out of Order.		Barrel.	Tanks.	

Unless the Inspector is well versed in distinguishing the different larvæ and the resultant adults, all 'finds' should be taken to the Medical Officer of Health to 'diagnose.' This is necessary in order: (1) to maintain

MOSQUITO LARVÆ INDEX.

SUMMARY OF INSPECTION

Name of Town *Number of Lots or Compounds in Town*

Section, etc	Date of Inspection.	Number of Lots or Compounds Inspected	Totals of Articles holding Water used for Household purposes						Wells.	Totals of Articles holding Water NOT for Household use					Number of Lots or Compounds in which Larvæ found.	In what found in each case.
			Barrels	Native Pots.	Buckets					Tins.	Bottles	Calabashes.				

Summary of Articles in which Larvæ found with number against each: Bottles, Barrels, Tins, etc

Mosquito Larvæ Index of Town =

a continuous record of the mosquito types found in the districts, and (2) to complete the following monthly return (page 69) which is usually rendered to the chief sanitary officer of the colony.

Districts are subdivided, each sub-district being worked by a squad of labourers under a headman or foreman. Their work consists of filling up pools in roads and on footpaths, brushing out water from pools, surface drains, and gutters, and oiling when occasion requires. In some colonies the Public Works Department have 'road-gangs' constantly at work.

Inspectors appointed to 'new' districts where anti-mosquito work is necessary, should commence at once, doing whatever is possible with the labour, equipment, and money available, the operations being prefaced by a mosquito survey. In reporting on the measures considered desirable, recommendations should not be of a general nature; they should be particular, practical, and exact, accompanied by a spot map showing breeding grounds and types found and an estimate of the cost of

MONTHLY SANITARY RETURN.

Station.	Premises Inspected.	Larvae Found.	Protected Barrels	Unprotected Barrels	Protected Tanks.	Unprotected Tanks	Protected Wells	Unprotected Wells.			

(Signed)________________

MOSQUITO TYPE.

(To be rendered monthly.)

Month of____________19

District.	Type of Mosquito	Type of Larvæ	Larvæ bred out.

To the Senior Sanitary Officer,

Station________________

Date________________

the initial measures and annual upkeep, the latter being obtained from the Public Works Department.

Difficulties in the application of anti-mosquito measures are sure to be met with, and problems that no text-book teaching can solve in detail will arise. The advice of the Medical Officer of Health should always be asked for under such circumstances. Inaction spells disaster in a sanitary sense.

Summarised, the measures against mosquitoes are :—

1. Suitable legislation.
2. Detailed knowledge of breeding places. This is essential for economic and effective work.
3. Properly graded surface drains to suitable outfall.
4. Proper water supply on the 'constant' system, closing of private wells, and abolition of cisterns and tanks.
5. Borrow-pits and other places where water may collect, properly filled in or drained.
6. Speeding of current of streams and clearing of vegetation from their banks.
7. Major operations in marshy lands, *e.g.* contour and 'herring-bone' drainage, removal of undergrowth.
8. Oiling of ponds and lakes, etc., weekly.
9. Fumigation of dwellings when considered necessary.
10. Proper system of removal and disposal of disused bottles, tins,[1] etc.
11. Screening or in other ways covering water vessels necessary for domestic use.
12. Proper system of sewage disposal and closing of cesspits.
13. Distribution of educational pamphlets giving warning of the danger of mosquitoes.

The above, requiring an efficient staff to carry them out, compel a close watch to be kept on all areas in an Inspector's charge.

No note on this subject would be complete without

[1] Holes should be punched in tins, etc., so that they cannot hold water.

mentioning the Isthmus of Panama and the associated name of Colonel Gorgas. The Panama Canal Scheme, commenced by the French in 1881, was abandoned owing to the ravages of malaria and yellow fever among the workmen. Thousands lost their lives from these two diseases. In 1904 the Government of the United States of America took over the works, and under Colonel Gorgas a campaign against mosquitoes was at once commenced, and has since been kept up throughout the Canal zone, with the result that this huge engineering feat has been made possible, and the Canal is an accomplished fact. The average death-rate from disease among the employees for a considerable period has been 3 per thousand, a rate which compares very favourably with that of any other picked community. Reporting on the work of the Sanitary Department the Colonel has recently said, "I think the sanitarian can now show that any population coming into the tropics can protect itself against these two diseases, yellow fever and malaria, by measures that are both simple and inexpensive."

CHAPTER V

TROPICAL DISEASES (*continued*)

Relapsing Fever.

This disease is common to south-east Europe, Uganda, West Africa, and parts of India. It is both endemic and epidemic; the latter always follows great privation and famine, attacking the poor in the endemic areas.

The incubation period varies from two to ten days.

The symptoms are high fever, lasting five to seven days, then an intermission of seven days before another attack. The case mortality varies from 5 to 10 per cent. in Europe to 15 to 40 per cent. in Africa.

The causal organism, a spirillum, of which distinct types have been isolated in different countries, is usually found in the blood, and is transmitted by the bite of a tick (Fig. 48), in which the organism has a cycle of development analogous to that of the malarial parasite in the mosquito. In India the bug and the louse have been associated with the transmission of the disease.

Fig. 48.—A Common Tick.

It is interesting to note that it has been demonstrated that young forms of infected parent ticks are also capable of producing the disease in man.

Prevention.—This includes measures which aim at ridding persons and places of vermin. Rest-houses require special attention, and when an outbreak occurs, opportunity should be taken to demolish insanitary and dilapidated buildings.

'Sand-fly' Fever.

This disease is sometimes termed the "Three days' fever." It is common in parts of India, the Mediterranean, Egypt, and South America.

The causal agent is unknown, but a 'filter-passing' virus has been demonstrated as existing in the blood of patients suffering from the disease.

The onset is sudden, with severe headaches and pains in the back and joints. The patient is 'heavy eyed,' and his tongue is furred. There is a typical fever lasting three days, and with the fall of temperature symptoms disappear.

The transmitting agent in the spread of this disease is the sand-fly *Phlebotomus papatasii* (owl midge).

Prevention includes isolation of the infected, and protection against the bites of the fly by the use of mosquito nets of fine mesh.

Trypanosomiasis.

(Synonym, *Sleeping Sickness.*)

This disease is the cause of thousands of deaths annually in tropical Africa, and has been known for over one hundred years. Large areas are affected, usually on trade routes, the courses of rivers, and the margins of lakes.

Sleeping sickness, strictly speaking, is "a condition of an infected person in the terminal phase of the disease."

The incubation period is not definitely established; it is said to be anything from ten days to a like number of months. The symptoms of the disease are, swelling of the glands of the neck, a characteristic appearance of the skin, and fever, followed by stages of wasting, exhaustion, drowsing, and collapse.

The causal agent is a trypanosome, *T. gambiense*, transmitted by the tsetse fly *Glossina palpalis* (Fig. 52), and possibly others of that genus. Cattle and wild animals, apparently healthy, have been found infected with the human trypanosome, so that infection may occur (1) from man to man, or (2) from man to animals and then from animals to man.

Fig. 49 shows the causal organisms of this disease.

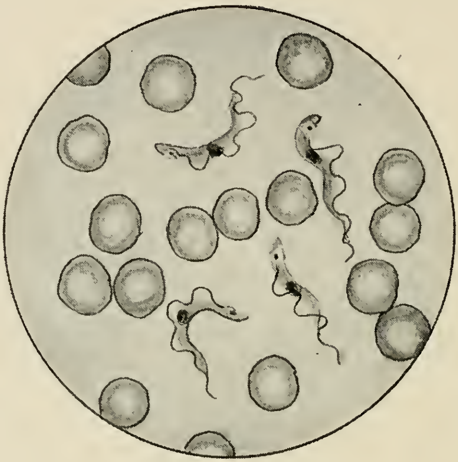


FIG. 49.—*Trypanosome gambiense.*

The blood-sucking habit of the Glossina is common to both sexes, and they bite day and night.

There are three ways in which the organism may be transmitted from an infected individual to a healthy one:—

(1) If after a bite trypanosomes are in the blood left on the proboscis, the fly may mechanically transfer the disease to another individual bitten within forty-eight hours.
(2) On biting a person, the fly having recently fed on an infected person or animal, regurgitation may occur.
(3) Apart from the above direct ways, the organism undergoes a cycle of development, and works out a means of exit from the fly, similar to that of the malarial parasite in the mosquito. The

cycle is said to take thirty days, after which period the fly is infective, and it may remain infective up to eighty days.

The fly belongs to the family of the common house-fly, which it resembles at a first glance. (Fig. 51.)

FIG. 50.—Pupa of Tsetse Fly.

FIG. 51.—Tsetse Fly (normal size).

FIG. 52.—*G. palpalis*, magnified.

The genus is distinguished by (1) the proboscis (ensheathed in the palpi) in line with the body, (2) the scissors-like position of the wings when at rest, and (3) the characteristic 'hatchet' marking on the wings formed by the veins about the centre. The wing-marking is shown in Fig. 53, the actual lines forming the 'hatchet' being somewhat thickened.

FIG. 53.—Wing of Tsetse Fly, magnified, showing 'hatchet' mark (inverted).

The chief species of sanitary interest in addition to the *G. palpalis* is the *G. morsitans*, concerned with the spread of a similar disease amongst cattle and wild animals. It is of a much lighter colour than the *G. palpalis*, which is dark brown; another distinguishing characteristic is the colouring of the tarsi. In the latter species they are quite black, while in the former the last two segments only are of a brownish colour.

These flies do not lay eggs. Larvæ develop in the body of the female one at a time. The fly hibernates near water, and drops the larva at the root of a tree or bush. The larva enters the loose earth and soon changes into a pupa (Fig. 50). From the pupal stage to the emerging of the imago a period of from four to six weeks occurs.

Prevention.—This includes measures which aim at the clearing of vegetation around habitations, especially those near water, for the fly is fond of shade (Fig. 54); removal of natives from the fly-belts, *i.e.* fly-infected areas, and the elimination of infected persons to isolation camps in fly-free areas. Also the detention of infected persons outside non-infected areas.

The infected are detected in the early stages by gland palpation (Fig. 55). Swollen glands, often hard and 'nutty,' are punctured, and the fluid removed is examined under a microscope for the causal organisms.

In the later stages of the disease a general infection

FIG. 54.—A Haunt of the Tsetse Fly (*Glossina palpalis.*)

[*Face p.* 76.

occurs, and the organisms are not always found in the peripheral blood, but are usually present in large numbers in the cerebro-spinal fluid, which is obtained by lumbar puncture.

Atoxyl, a preparation of arsenic, is usually administered to infected persons: this kills off the organisms in the peripheral blood. Though not a

FIG. 55.—Gland Palpation.

specific cure, it lessens the danger to others; for a fly biting such a treated person would suck blood free from living organisms.

In tropical Africa spot maps of fly belts and infected areas are usually available at headquarters of districts.

It has recently been stated that trypanosomiasis will not be eliminated from Africa so long as wild game exists there.

PLAGUE.

This is a disease common to man and rodents, though other mammals may be affected.

Primarily it is a disease of rats, epizootics being followed after definite intervals by epidemics in man.

The causal agent is a bacillus, *B. pestis*, which in various ways gains entry to the body, the most common being: (1) through the skin, by the bite of an infected flea from an infected rat; and (2) inhalation of bacilli from infected sputum, and discharges of pneumonic and septicæmic cases.

Four varieties of plague are known to occur.

1. *Pestis minor*, a mild form, usually seen at the beginning and end of epidemics. The symptoms include general malaise, slight fever, and enlarged glands.

2. *Bubonic Plague.*—The majority of cases (90 per cent.) are of this variety. The swollen glands—buboes—are usually those in the groin and axilla.

3. *Pneumonic Plague.*—This type accounts for a small percentage of cases. It is extremely infective and very fatal. The disease attacks the lungs, and bacilli are found in the sputum.

Personal contact and air are the two channels of infection, the rat being not necessarily connected with its transmission: this also applies to the septicæmic form.

4. *Septicæmic Plague.*—This type occurs when the organisms pass the glands and infect the body generally. It is a very rapid form, and 99 per cent. of cases are fatal.

The incubation period is usually two to eight days, but may be from one to twenty days.

Two species of rats are concerned in the spread of the disease: (1) the brown rat (*Mus decumanus*); and (2) the black rat (*Mus rattus*); the former is the more common type.

The fleas found on rats differ from the human flea; they breed in cracks, crevices, and in dry rubbish.

When an epizootic in rats occurs, they die in large numbers; the fleas leave the dead bodies and attach themselves to human beings, on whom they feed. When feeding, regurgitation may occur; also the fleas defecate in the vicinity of the puncture, and their dejecta, containing the organisms (*B. pestis*) are usually scratched into the wound by the human host, the rubbing being done involuntarily to allay irritation.

The epidemic in man follows some twelve to fourteen days after the outbreak among the rats. It usually has a seasonable prevalence, depending on temperature.

Infected rats may, by transportation in ships, cause outbreaks at ports of call.

The rat with acute septicæmic plague has been described as "The ultimate reservoir of the plague bacillus."

Prevention.—Preventive measures are based on the channels of infection, and include early recognition and isolation of patients, segregation of contacts, disinfection, and measures against the rat. The specific measures vary according to the type of the disease causing the outbreak.

At ports, ships from infected areas are quarantined, passengers and crews are inspected, and suspects detained. If any case has occurred, thorough disinfection of clothing and baggage is essential; carpets and hangings should be exposed to direct sunlight. The patient is isolated in hospital, and his discharges should be burnt or boiled before disposal.

Holds of ships are disinfected when considered necessary by the Medical Officer of Health, by sulphur dioxide. The apparatus commonly used is of the 'Clayton' type (as described in the chapter on Disinfection). This is usually provided by the Port Authorities.

Habitations in which cases of plague have occurred, or in which plague-infected rats have been found, are also disinfected; the former on disposal of the case, the latter as soon as vacated by occupants.

The usual procedure, where an infected house is one of a row or street, is to fumigate simultaneously the house on each side, then straight away disinfect the infected one. *E.g.*, supposing

1	2	3

represent three houses, of which No. 2 is infected, Nos. 1 and 3 are first dealt with, then No. 2. This method prevents infected rats escaping, which is likely to occur should No. 2 be the only house fumigated.

Inspectors should beware when dead rats are being found in their districts in excessive numbers; such rats should be taken to the Medical Officer of Health for examination, for, by post-mortem appearances he will be able to say whether they have died of plague

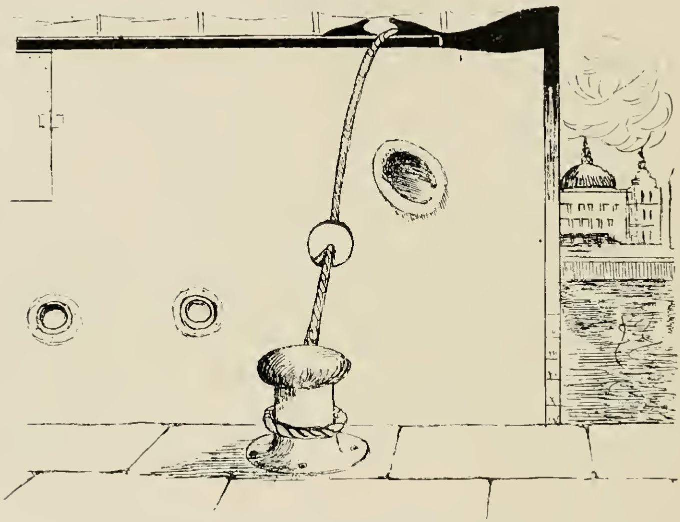


FIG. 56.—Showing Rat Guard on Hawser.

or not, and will take action accordingly. Assistant inspectors require constant reminders on this important point.

At ports, operations against rats include: (1) limiting the number leaving ships in dock by reducing the number of gangways to a minimum, and fixing metal guards to the hawsers in use (Fig. 56); (2) extermination of rats aboard ship by the use of sulphur dioxide.

In inhabited areas the extermination of rats is practically impossible, for, as some are killed more food is available for those remaining, which consequently thrive more readily. In small communities, when thorough measures are taken, it may be possible, but it is more probable that the rats leave the neighbourhood of danger for other areas. To avoid this it is necessary to commence operations on the circumference of a circle enclosing the area concerned and work towards the centre. Such a procedure requires an intelligent staff, sound organisation, and a generous exchequer.

The following are the usual measures against the rat :—

(1) The 'cutting off' of its food supplies by protecting grain and foodstuffs generally : also the removal and incineration of refuse. Stores should be made as far as possible 'rat-proof.' Burrows should be filled with broken glass and cement, or a mixture of tar and sulphuric acid, one pint to one ounce, poured into the runs.

(2) Chemical poisons used as baits. The most common in use are :—(*a*) Phosphorus, made into a paste, with flour or lard and smeared on bread cubes. (A little glucose is added to prevent spontaneous combustion.) (*b*) Barium carbonate : one part is made into a dough with eight parts of flour. This chemical is non-poisonous to human beings. The use of bacterial virus has in recent years caused much discussion.

Baits require to be laid in a systematic manner and in positions not accessible to children. Their situations should be carefully recorded, and notes made regarding their usefulness or otherwise. If not taken by the rats, they should be removed and others tried. It is important that they should be handled as little as possible : a common practice is to smear the hands of the bread-cutters and also the bread-board with oil of aniseed to remove the human scent.

(3) Traps. These should be all metal, and of the spring or cage pattern. They should be dipped in boiling water before being set, and gloves should be worn when handling them.

(4) 'Driving' of rats from their burrows is some-

times carried out by the use of smoke or sulphur dioxide.

(5) Cats.

(6) Fumigation of rat-infested buildings.

In endemic areas routine work in connection with plague prevention includes house-to-house cleansing in native districts by a plague inspection staff. Inoculation with plague vaccine is carried out in infected areas. The immunity conferred is relative and not absolute. The risk of infection is reduced to one-third of that of the non-inoculated man. Attendants on plague cases are inoculated every plague season. They are provided with a special working dress, and dressing-rooms are arranged for, away from the infected houses or wards.

At ports the masters of ships coming from or touching at a port infected with plague are served with a copy of a notice regarding measures to be adopted to prevent rats leaving the ship. The following is an example :—

Under [statute mentioned] the following precautions are considered necessary, by the Sanitary Authority, for stopping the access of rats from the ship to the shore :—

1. All ropes and mooring tackle for securing the vessel either to the shore or mooring buoys shall be fitted with effective guards, and the portion of such ropes and mooring tackle leading from the vessel to a distance from the vessel's side of at least 4 ft. shall be coated each night with fresh tar. Ropes may, if desired, be protected by a covering of canvas or yarns before tarring.

2. When not engaged in discharging cargo one gangway only shall be permitted to afford means of communication between the ship and the shore.

3. The end of the gangway near the ship shall be whitened for a length of 10 ft. and the watchman shall keep the gangway pulled inboard after sunset, or it shall be guarded in some approved manner.

4. When alongside the quay, the ports on the side of the vessel nearest the quay shall be kept closed after sunset.

5. All empty casks, etc., shall be examined before being landed, to ensure that no rats are contained therein.

6. It is recommended that all possible means be adopted for catching and destroying rats, both on the voyage and during the stay of the vessel in port. Any rats so caught shall be killed, then placed in a bucket of strong disinfectant solution, and afterwards burnt in the ship's furnace.

7. No rats, alive or dead, are to be removed from the ship without the permission of the Medical Officer of Health in writing.

Penalty on default . . .

The following extract from the Annual Report 1907, of the Principal Civil Medical Officer and the Medical Officer of Health for Hong Kong, describes the measures that are put into operation for the prevention of plague in that city and district :—

" There are at present four Plague Inspectors for the city of Victoria, and one for Kowloon. There are eleven coloured foremen interpreters, one for each district of the city of Victoria and one for Kowloon, who supervise the work of rat-catchers, assist in the house-to-house cleansing, and act as interpreters to the inspectors when necessary. There are four gangs in the city of Victoria, each consisting of a Chinese foreman, two artisans, and ten coolies.

During the non-epidemic periods the whole of this staff is engaged in house-to-house cleansing work. About ten houses, or thirty floors a day, are dealt with, and each tenant receives three days' notice, on a form in English and Chinese, requiring him to thoroughly cleanse his premises. On the fixed day the gang attends in the street in which the houses are situated, and supplies hot water and soap solution to the tenants, and cleans out all empty floors, basements, etc., the tenants themselves cleaning out their own premises. The refuse turned out during this cleansing is removed by the gang to the nearest dust-boat. The soap solution is also used by the tenants for washing their bed-boards, etc., in the street or on the verandah.

When the cleansing work is completed by the tenants, the inspector visits every floor, accompanied by the foreman interpreter and some of the coolies, with a bucket of pesterine (liquid fuel), which is applied to the sides and corners of the floors, and to the skirtings and round the partitions of cubicles, and the corners of the stairs, by means of the mops, under the personal supervision of the inspector.

Pesterine is a black treacle-like liquid which stains woodwork, and it was decided therefore at the latter end of the year to substitute for it an ordinary type mixture of equal parts of cyllin and petrol diluted with water 1 in 200.

This mixture acts both as a pulicide and a germicide, and has the advantage of not staining the flooring and the skirtings. The solution has to be freshly mixed each day, as it undergoes certain chemical changes, the nature of which has not yet been worked out. At this visit, when the floors are clear of furniture, etc., the inspector makes special note of the condition of the ground surfaces, the absence of gratings to drain inlets and ventilators, and the presence of rat-runs, and all these matters are dealt with by legal notice at once. The tenants are invited, by notice, to allow their bedding and spare clothing to be steamed, in order to destroy fleas and other vermin and their ova, and compensation is offered for all articles damaged. Should a case of plague occur in a house, the Kaifong (Street Committee) of the district are informed, and the floor on which the case has occurred is disinfected by the Plague Staff, the walls being sprayed with corrosive sublimate, and the floor and the bed-boards washed with the mixture of cyllin and petrol; crude carbolic acid is poured into the rat-runs, which are then filled up with cement; and the clothing and bedding is sent to the disinfecting station to be steamed. The remaining floors of the infected house are cleansed by the tenants in the same manner as in the house-to-house cleansing. Should there be any ceilings or stair linings in the infected house they are removed, and compensation is paid for them, if the case has been duly reported, while illegalities are dealt with by notices. The compensation is, in the case of Chinese, assessed separately by the Kaifong of the district and by the Plague Inspector, and their assessments are dealt with by a Committee of the Sanitary Board. The Kaifong are appointed by the government on the nomination of the inhabitants. . . .

Any spare time at the disposal of the Plague Inspectors is occupied in paying special visits to houses in which cases of plague have occurred in the previous season, with a view to seeing that they are free of rat-runs and provided with impervious ground surfaces. The Chinese have established public dispensaries, and also district plague hospitals, which in the city of Victoria are managed by a Committee, of which the Registrar-General and the two Chinese members of the Sanitary Board are members in Kowloon; a local Committee manages the dispensary and the hospital. These institutions are supported by voluntary contributions, and each is in charge of a licentiate of the Hongkong College of Medicine, who sees out-patients at the dispensary, performs vaccinations, visits patients in their own homes, and treats patients in the district hospital. Cases of infectious diseases are notified by these licentiates to the nearest district sanitary office, and if the case is one of plague, the patients may be treated in the district hospital."

Kala-azar.

This is a disease caused by a protozoon of the Leishmania group. It is very prevalent in certain parts of India, especially Assam; and has been found in China, the East Indies, the Mediterranean, and in the Soudan. Nothing definite is known regarding the mode of infection, but the most common theory places the bed-bug as the intermediate host. Dogs have been suggested as acting as reservoirs of a similar disease, common in North Africa; the dog-flea being suspected as the intermediate host.

'Tropical sores' are caused by another organism of the same group. The sores are local, and no general infection appears to take place. It is a common complaint amongst the inhabitants of camel-using countries.

Prevention. — Little can be said of preventive measures until the channel of infection is known. General measures aiming at ridding places of vermin would appear the most satisfactory.

Ankylostomiasis.

(*Hook-worm disease.*)

This disease is widespread in the tropics; in some places, *e.g.* West Africa, it is estimated that 70 per cent. of the natives suffer from it.

It is caused by certain Nematodes or round worms about half an inch in length, which, by means of little hooks around the mouth, fasten themselves on to the lining of the intestines; the upper part of the jejunum being the portion usually affected. They suck the blood for food, and as they are present in large numbers, produce an intense anæmia. The female worms lay large numbers of ova, which are constantly passing out of the body in the dejecta. Embryos, forming in four or five days, eventually find water and there live until they reach the next host.

The method of entry is by ingestion or through the skin by the hair follicles. If by the latter, a local irritation often occurs, termed by the natives 'Ground Itch.'

Prevention.—This includes isolation and treatment of cases where possible, education of all in personal cleanliness, proper methods of excreta disposal, and the safeguarding of water supplies.

Guinea Worm.

This is a disease very prevalent among natives in certain districts. It is caused by a parasite of the Filaria group, the *Filaria medinensis*, and has always been associated with water. It usually affects the lower extremities, where the female worm, seeking the surface, causes inflammation. A small blister forms and eventually ruptures; in the inflamed area an end of the worm may be seen. Douching with water brings part of the worm out, and traction on the worm by winding it round a match—small portions daily—is the usual method of treatment. Should the worm be ruptured in the treatment, the embryos escape into the tissues and lead to abscess formation; the suppuration often extending over a very large area.

The mode of entry into the body is in drinking-water. The embryos are discharged from the parent organism in water, and they pass a certain stage of their existence in the water-flea—the cyclops. These are ingested in drinking-water, and enter the tissues by way

FIG. 57.—Washing of Clothing in a Stream.

[*Face p.* 86.

of the stomach wall. After connection in the tissues the male is said to die off, and the impregnated female makes her way to the surface of the body. The period between the ingestion of the intermediate host and the manifestation of symptoms is about twelve months.

Prevention.—This includes protection of pools, streams, and other surface supplies of water, and education of the natives against contaminating these supplies, and in methods of treatment when affected.

Heat Stroke.

This condition, though not affecting the Sanitary Inspector as an official, has caused much theorising and argument amongst medical men. It is included in this short summary of diseases in the tropics on account of its common occurrence there. In some cases it is defined as sun stroke, in others as heat stroke or heat apoplexy, according to whether occurring in the sun or not.

Heat stroke is attributed to—(1) the sun's rays (actinic); (2) the heat rays; and (3) a micro-organism, as yet undefined. Some authorities hold one theory, some another, but the majority of medical men agree that it is due to the deficient cooling of the skin and evaporation from the skin, and in many cases is accelerated by the heat from the sun raising the surface temperature of the body.

Other Diseases.

Many other diseases are common in the tropics, which require for their prevention general sanitary measures. Among them may be mentioned such skin affections as scabies, ringworm, craw-craw, and yaws, diseases in which personal contact plays a great part. In many places the pernicious system of washing clothes in streams and other water supplies (Fig. 57), or in washing-pits adjacent thereto, and drying such clothing on the surrounding ground, is responsible for the spread of these tropical infections. Where practicable the practice should be forbidden and wash-houses erected for general use, with posts and lines for drying articles on.

The various Ordinances, Regulations, etc., governing infective disease control, in force in the tropics, differ enormously with regard to the powers conferred on the health officials. In some colonies and dependencies little or no law on the subject obtains, in others effective legislation exists, based largely on British law adapted to local conditions.

As already indicated, certain diseases are notifiable to the Medical Officer of Health, the responsibility for such notification being placed on the doctor attending the case, and in some instances the head of the household also. Usually occupants of buildings belonging to the Crown, *e.g.* soldiers and sailors, are exempted.

Under the International Sanitary Conference, 1912 regulations exist for dealing with epidemics of cholera, yellow fever, and plague. These cover general preventive measures and treatment of cases. At ports they include quarantine of passengers and crew if necessary, signals to be hoisted on vessels, duties of and questions to be answered by masters and others, and detention of vessels. Usually mails are neither interfered with nor delayed.

Mooring places for detained vessels are specially defined, and signals are required to be hoisted on entering the 'three miles' limit.'

The signals are: (1) between sunrise and sunset a large flag of yellow and black at the mast-head; and (2) at night, three lights arranged in a triangle—6 ft. apart—a white light at the apex and red lights at the base. The lights to be hoisted at least 20 ft. above the hull of the ship.

The Customs officers, and in some cases harbourmasters, have power to detain a ship, notifying the Sanitary Authority of the existence of one of the scheduled diseases.

Concerning tropical infections the following table, showing death-rates amongst European officials in our West African colonies, illustrates the result of routine sanitary measures, especially those against insects capable of transmitting disease.

Year.	Death-rate, per 1000.	Year.	Death-rate, per 1000.
1896	90.0	1912	12.4
1905	28.1	1913	11.8
1911	13.9		

CHAPTER VI

DISINFECTION

THEORETICALLY, following early recognition and isolation of cases, and segregation of contacts, disinfection is the next link in the chain of disease prevention, but for practical purposes, in the tropics, it is inapplicable to many affections, *e.g.* malaria and yellow fever; and priority has to be given to work directed against the 'insect porters' of such diseases. Nevertheless, disinfection is a sufficiently important link to warrant a close study of the subject, and especially so in view of the popular notions regarding disinfection and its allied terms deodorant, antiseptic, and disinfectant.

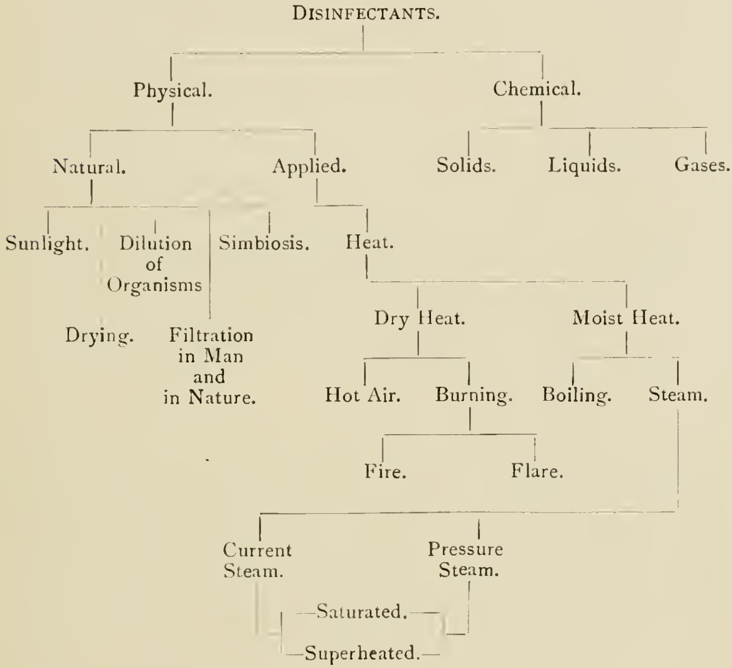
The magical powers accredited by even an educated public to any substance of a distinctive smell and colour labelled 'disinfectant' are a positive danger to the health of the community. More looseness exists in the theory of disinfection and its practical application than in any other branch of 'preventive medicine,' using the term in its widest sense. Even in up-to-date British municipalities at the present day, the sprinkling by a dustman of a few grains of some powder in the receptacles concerned constitutes the 'disinfection' of middens, ash-pits, and the like.

Disinfection aims at the destruction, outside the body, of infective matter emanating from infected men or animals; in other words, by disinfection is meant the destruction of the specific poisons which cause infective disease.

A substance which is capable of such destruction is termed a disinfectant. An antiseptic is a substance which will prevent putrefaction and destroy putrefactive and pus organisms. A deodorant is simply a substance which corrects or disguises foul and offensive smells.

Sterilisation, strictly speaking, differs from disinfection in that it implies the destruction of all forms of life.

Disinfectants may be tabulated as follows :—



Sunlight.—The action of sunlight is germicidal, and the majority of disease germs are killed by a few hours' exposure.

Drying.—Dry bacteria and their vitality is destroyed. Relative drying limits their powers of multiplying, hence putrefaction only occurs in the presence of moisture.

Dilution of Organisms.—This is brought about in air and water, lessening the risk of infection by reducing the dose of organisms. In addition, such dilutions favour the actions of sunlight and drying or desiccation.

Filtration.—This has been termed disinfection by exclusion. In nature it is seen in the case of water passing through the soil, and in man occurs in the passage of air through the respiratory tract. Artificially it is applied to disinfect water supplies of communities.

Simbiosis.—By this term is meant the action of 'crowding out' pathogenic germs by the more fertile saprophytic ones. It has a germicidal effect and undoubtedly is one of nature's strongest disinfectants. This is easily demonstrated by the contamination (by 'air organisms') of, say, a typhoid culture.

Although the 'natural' disinfectants enumerated are constantly at work lessening the chances of infection, they do not suffice to cope with specific infections where prompt action is necessary, because the two main factors operating, strength of disinfectant and time, are not under control, and cannot be concentrated on definite infected objects. Applied physical or chemical agencies are then required.

Heat.

Heat is by far the most powerful of all disinfectants, the most important, and the most generally used. It is an accepted fact that all organisms may be killed by heat. (Cold does not destroy bacteria, it simply retards their growth; this knowledge is made use of in connection with frozen and refrigerated meat, etc., to prevent putrefaction.)

The governing factors in the successful application of heat as a disinfectant are temperature and time applied. These vary somewhat for different organisms, but the variations are legislated for in all heat machines on the market. The instructions for use give: (1) the temperature to be reached; and (2) the time to be applied, based on the temperature and time required to kill the hardiest of organisms, *i.e.* spore-bearing ones.

Heat may be applied in two ways, *i.e.* dry or moist, the former being the more efficient in the form of fire and of lesser efficiency in the form of hot air.

Dry Heat.—(*a*) Fire. The burning of infected articles which cannot be suitably treated, *e.g.* native clothing during smallpox epidemics, is both effective and cheap, certainly costing less than would be the case if disinfection were neglected. Where no disinfectors are at hand it is particularly useful. It is also the best way of disposing of discharges from the sick.

(*b*) Flares. In expert hands the use of a paraffin flare may be directed to the disinfection of surfaces, 'fouled' sites, mud floors and walls of native houses, and contaminated water cisterns.

(*c*) Hot air. Machines for disinfecting by 'hot air' are "things of the past"—relics of the pre-steam age—in disinfection. The objections to hot air as a disinfecting agent are: (1) it has little penetrating power; (2) the temperature is not the same throughout the chamber in which disinfection is being attempted; (3) it requires a relatively high temperature; (4) it requires a prolonged exposure; and (5) certain articles are charred by the heat obtained.

Moist Heat.—(*a*). Boiling, or the raising of the temperature of a fluid to that required to kill pathogenic organisms. All non-spore-bearing organisms are killed on exposure in boiling water in a few minutes. Spore-bearing ones require ten to fifteen minutes' exposure or even more. It will therefore be readily seen that boiling is a practical way of carrying out disinfection, easily obtained, in any place. It is used for disinfecting drinking-water, milk, filter tubes, cotton and linen articles, and discharges from the sick. It causes certain coloured fabrics to "run," shrinks flannel and woollen articles, but does not harm blankets appreciably.

(*b*) Steam. This is the most efficient form of applying heat, and has many advantages over boiling water, the chief ones being that more can be done (1) in a given time, and (2) at a lower cost for large bulks.

It seems hardly necessary to state that the mere passing of steam over articles will not disinfect them. They require to be in a chamber and subjected to the penetrating action of steam, raised to a definite temperature and exposed for a definite time according to the make of steam disinfecting apparatus in use.

Under ordinary atmospheric pressure steam is evolved from water, on the application of heat, when it reaches a temperature of 100° C., *i.e.* when it begins to boil. A definite amount of heat, depending on the bulk of water, is expended in raising the temperature through each degree until boiling point is reached, when no further increase in temperature will take place irrespective of the amount of heat applied. This "unregistered" heat, expended in converting the water from a liquid to a gaseous state, is termed latent heat, and is a form of energy taken up by the steam. Over five times the heat necessary to raise a definite quantity of water from 0° to 100° C. is required to convert that bulk of water at 100° C. into steam; and in the conversion it expands 1728 times its own volume. Conversely, on condensing, it shrinks to $\frac{1}{1728}$th of its bulk and restores the latent heat to the substances of a lower temperature which have caused the condensation.

This knowledge is made use of in disinfecting by steam, special apparatus being made for the purpose. Porous articles to be disinfected are placed in a chamber, steam is passed in and made to displace the air. The steam, in coming in contact with the cooler substances, has a twofold action. It gives out its latent heat to the articles it is in contact with, and, at the same time, the shrinkage which occurs when it condenses allows of further penetration, and, tending to form a vacuum, causes more steam to rush in. This two-fold action goes on until the whole of the articles have reached the same temperature as the steam, owing to the displacement of the air by steam.

The foregoing explains the efficiency of steam as a disinfectant; but steam may be at other than atmospheric pressure, for by increasing the pressure on the surface of boiling water, *e.g.* by throttling the steam outlet, the boiling point is raised in direct ratio to the pressure created by the confined steam. Consequently, the temperature of the steam is raised also; such steam is termed pressure steam.

Various pattern machines are on the market; some work with low-pressure steam ("current steam" machines) and others with high-pressure steam ("confined steam" machines): some use saturated steam, others use superheated steam.

Saturated steam is steam at the temperature of the boiling point of the water from which it was generated; superheated steam is steam which is heated above that temperature. The superheating in the latter is done either by direct heating during its passage through a hotter 'jacket,' or by adding various salts to the water to raise the boiling point above the normal.

The advantages claimed for high-pressure machines are: (1) superior efficiency; (2) lessened time factor; and (3) greater expedition in the drying of articles disinfected. Their disadvantages are: (1) they are more complicated to work than low-pressure machines; (2) they are not "fool-proof"; and (3) they require to be made much stronger than "low-pressure" types, and consequently are more costly.

In all standard types there are arrangements for displacing the air in the disinfecting chamber, prior to disinfection, and provision for drying after disinfection.

In the "current steam" machines air is automatically displaced by the current of steam, and in the "high-pressure" types either a current of steam is allowed to pass through the chamber before confining it, or the air is removed by producing a partial vacuum by means of an ejector.

Drying is obtained by the circulation of hot air: provision for this being made by means of an air inlet and a coil of pipes in the apparatus. In some types the air is filtered through cotton-wool before entering the disinfecting chamber.

A machine of any type should conform to the following standards:—

(1) There must be a uniform distribution of heat

and a constant temperature maintained during the period of disinfection.

(2) There must be visible a register of the temperature reached in the chamber.

(3) There must be efficient means of expelling the air; (a mixture of steam and air has little penetrating power).

(4) There must be doors provided at opposite ends: one for the reception of infected articles, and the other for their removal after disinfection.

(5) There must be efficient provision for drying articles.

(6) There should be provided in the disinfecting chamber rails and hooks, and a wire trolley to give facilities for putting goods in and removing goods from the chamber.

Steam destroys articles containing wax or glue, bound books, leather, india rubber, or felt. Such articles should be disinfected by subjecting them to the action of suitable chemical disinfectants. It also causes certain coloured fabrics to "run," and fixes stains so that they cannot be washed out.

Stained articles should be well soaked in cold water before being either boiled or put in a disinfector. This is especially applicable to articles soiled by discharges from the sick.

General instructions for working the various pattern disinfectors met with are issued by the makers concerned, but the following rules should always be borne in mind:—

(1) Articles are to be put in loosely, the time limit being based on this assumption. (Steam penetration is retarded when articles are packed tightly.)

(2) A mixture of air and steam is to be avoided.

(3) The required temperature must be reached and maintained for the full period.

A simple way of testing the efficiency of a disinfector is to put a medium-sized potato inside the bulk of articles to be disinfected. When the process is completed it should be cooked. Disinfectors are usually placed in a building so that each door opens into separate rooms, one being termed the infected and the other the disinfected side. The articles are put into the infected side, which is then sealed up and the working of the apparatus is carried out from the disinfected side, where they are withdrawn from the chamber.

Washing accommodation and suitable clothing for the operator should always be provided.

Summarised, steam is generally suitable for bedding, blankets, and textile fabrics, and both types of apparatus are efficient, but where choice of type offers, for tropical work, the low-pressure machine is to be preferred for administrative reasons, as it is cheaper, not complicated to work, and more 'fool-proof.'

The following descriptions and illustrations are examples of the different types met with.

"*Current Steam*" *Disinfectors.*—The "Thresh" may be taken as a type of this class of machine. Superheated steam passes through the chamber at atmospheric pressure. The steam is generated in the jacket of the disinfector from a solution of carbonate of soda of such a density as will give a boiling point of 215° F. at sea-level.

The form generally adopted is the furnace-heated type, the disinfector being set in brickwork with a furnace under.

When, however, a supply of high-pressure steam is available, it can be used as the heating medium, and the solution in the jacket brought to boiling point, partly by passing the pressure steam through a battery of copper coils, and partly by means of an injector pipe, the pressure steam being passed into the solution, after the latter has been heated almost to boiling point, by conduction through the coils. The manufacturers claim that the objects attained by using the solution in the jacket are: (*a*) prevention of excessive wetting of the clothing during disinfection, by heating the chamber slightly above the condensing point of steam at atmospheric pressure; (*b*) raising the temperature of the air used for drying after disinfection; and (*c*) preventing incrustation in the jacket of the disinfector.

For drying after disinfection the hot air is introduced at the bottom of the machine.

Fig. 58 is a general view of a "furnace-heated"

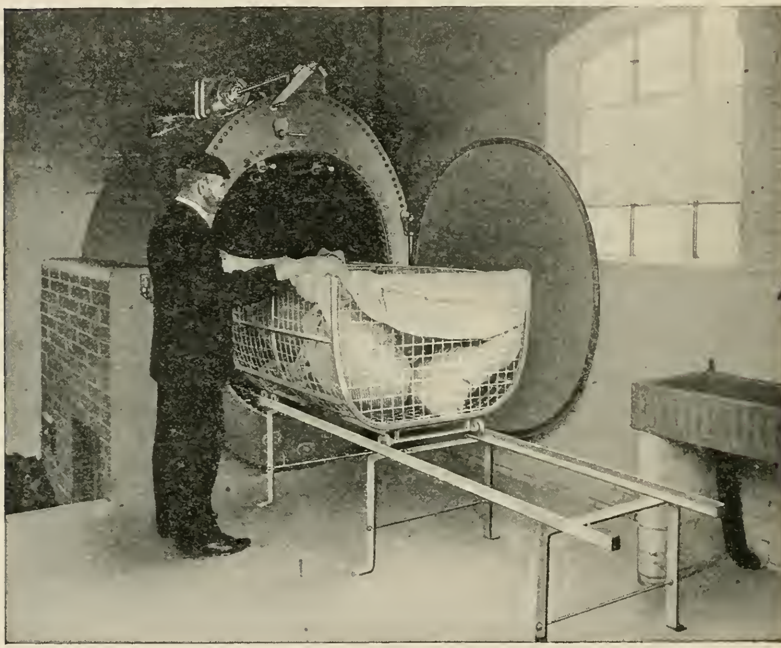


FIG. 58.—'Thresh' Current Steam Disinfector.

machine in use, and Fig. 59 is the plan of the building in which it is housed.

Other types of current steam machines are the "Reck" and the "Velox." The latter can also be used as a high-pressure apparatus.

"*High-pressure Steam*" *Disinfectors.*—As a type of this class, Balmforth's (Luton) saturated steam disinfector may be taken. It is on the 'Geneste Herscher' principle.

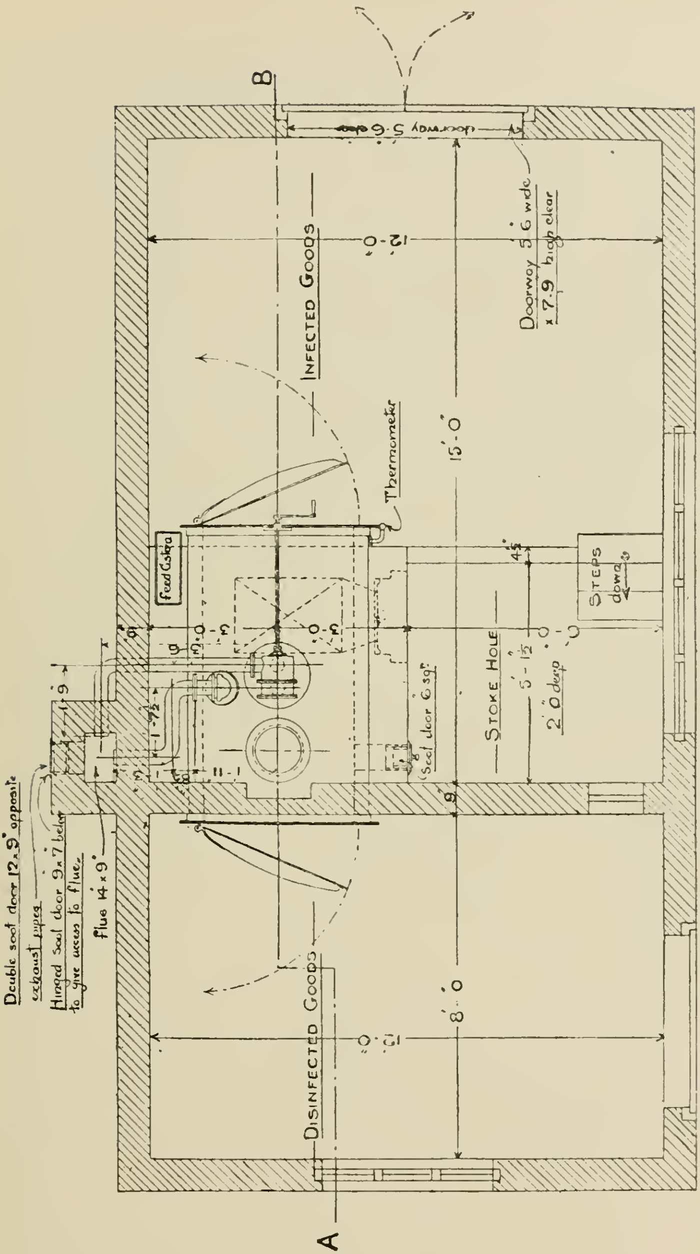


FIG. 59.—Plan of Disinfecting-house.

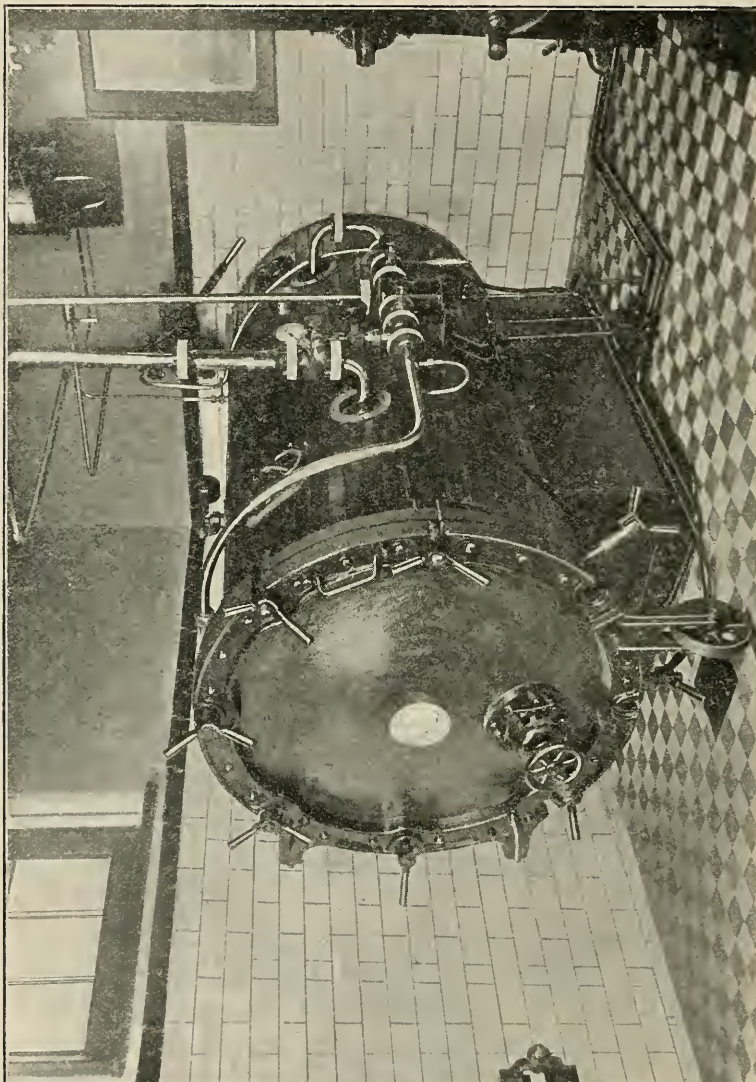


Fig. 60.—High-pressure Steam Disinfector (Balmforth's).

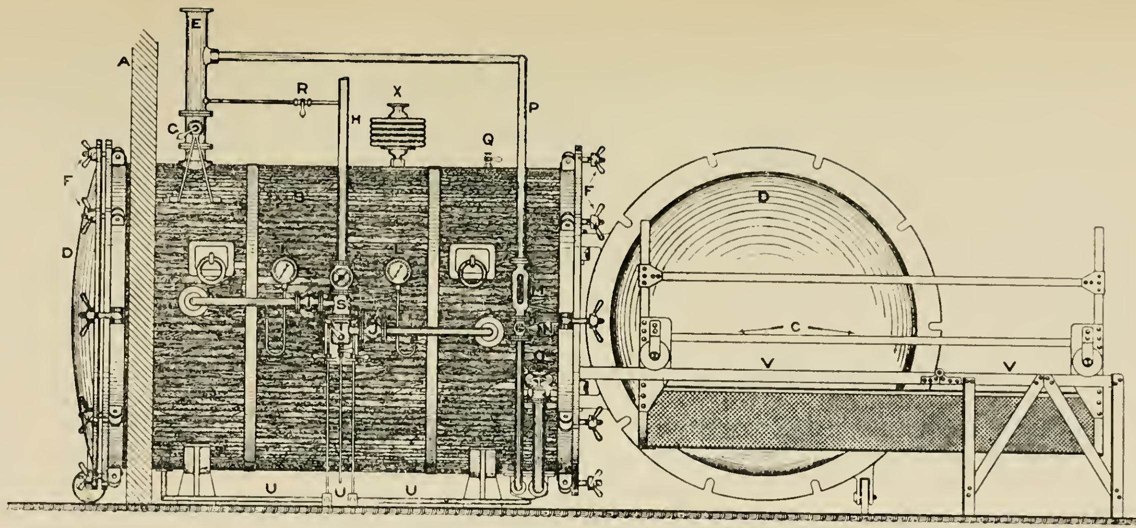


FIG. 61.—Diagrammatic Sketch of Balmforth's Machine.

REFERENCES TO DRAWING.

A—Partition wall.
B—Disinfecting chamber.
C—Wheeled carriage.
D—Doors open and closed.
E—Main exhaust pipe.
F—Safety wing nuts and recesses.
G—Main exhaust valve.
H—Steam pipe from boiler.
I—Steam valve to coils.
J—Steam valve to chamber.
K—Pressure gauge to coils.
L—Pressure gauge to chamber.
M—Thermometer.
N—Air exhaust valve.
O—Air inlet valve for drying.
P—Air exhaust pipe.
Q—Air vent from chamber.
R—Vacuum exhaust valve.
S—Steam dryer.
T—Reducing valve.
U—Drain cocks from pipes.
V—Hinged carriage rail.
X—Chamber safety valve.

DIRECTIONS FOR USE.

Admit steam to coils by valve I so as to warm chamber, then wheel in loaded carriage C, close and fasten the door. Open valve N and admit steam to chamber by valve J. When the thermometer M registers 205° F. close valve N, and the air being then ejected the pressure will rapidly rise to 10 lbs. (239° F.). At the end of five minutes valve J should be closed. Open valve G and close as soon as the pressure on gauge L has fallen nearly to zero, thus re-evaporating the moisture condensed on the objects and ejecting with steam any air remaining in the pores of the articles. Repeat this discharge of steam at end of the second and third intervals of five minutes, thus giving a total of fifteen minutes net to saturated steam at 10 lbs. pressure. In the last case open also valves O R, thus allowing air to be sucked in over steam-heated pipes and carry off last traces of moisture. An ordinary mattress will be dried in five to twelve minutes, and thicker objects with corresponding rapidity.

The chamber is of mild steel, and suitably arranged heating coils are on the lower portion. It is lagged with non-conducting material and pitch pine; an air inlet and outlet and safety valve are provided, also a thermometer and automatic recorder. A general view of the apparatus is seen in Fig. 60, and a diagrammatic sketch in Fig. 61.

Improvisation of a Disinfector.—Where no disinfector exists and the occasion for the use of one arises, an improvised apparatus capable of dealing

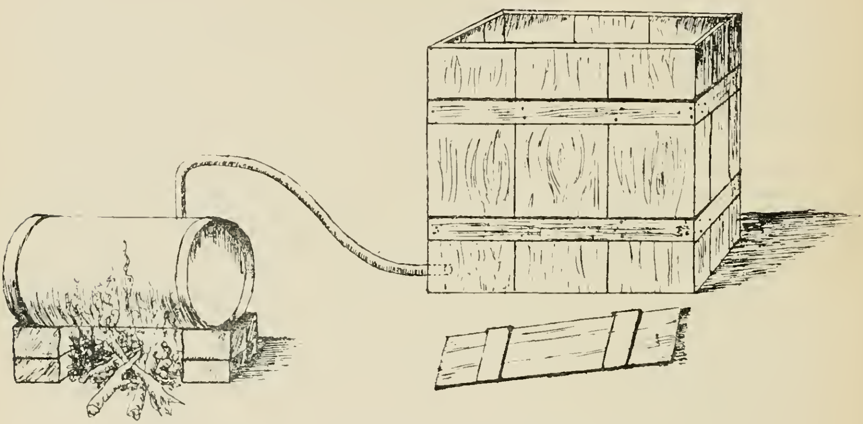


FIG. 62.—An Improvised Steam Disinfector.

with relatively small articles can be readily made. The materials required are, an oil drum (7 or 8 galls. capacity), a stout packing case, and a suitable metal pipe to connect the two. The case should be lined with felt, and provided with a few hooks to hang articles on. In one side a small hole should be cut to take one end of the pipe. Failing a coupling to connect the drum and pipe, a hole to receive it should be cut in the bung. An improvised fire and grate are made; the drum, three parts filled with water, is placed over it, and the pipe coupled up (Fig. 62).

The articles to be disinfected are hung in position, and when a good current of steam is circulating the lid is secured. The articles should be subjected to the action of the steam for at least half an hour from the time the inside of the box reaches a temperature of 100° C., as indicated by a thermometer passed through a small hole in the box side. No provision for outlet of steam need be made, since the joints of the box act as such. To dry the articles, remove them from the container, shake well, and expose to the sun.

Disinfecting Stations. — In large municipalities a properly equipped disinfecting station is a sanitary necessity. Provision for the reception of contacts, and inmates of houses where fumigation is being carried out and whose effects are undergoing disinfection, is arranged, in addition to disinfectors, laundry, vansheds, and quarters for operator or caretaker.

The size of the 'station' depends on local circumstances and requirements. It is usually under the supervision of the Sanitary Inspector.

The following are the headings, etc., of books and form used in connection with infective diseases and disinfecting stations.

Inquiry Form in respect of Notified Diseases.

(PLACE)

Date of Certificate Date the Certificate was received
Name of Patient Sex Age
Address
Description of Disease
Date of Onset
Source of Infection (if ascertained)
Milk Supply
Sanitary Condition of House and Surroundings
Isolation, Home or Hospital
Date of Removal to Hospital
School or Workplace attended by the Patient
" " other Children in House (if any)
Name of Medical Attendant
Name of Officer making the Inspection
General Remarks

This information should be carefully noted, and afterwards entered in the Infective Disease Register as follows:—

Infective Disease Register.

(PLACE)

No. of Case.	Date of Medical Certificate.	Date when Medical Certificate was received.	Name of Patient.	Age.	Sex.	Address.	Disease.	Date of Onset.	Source of Infection (if ascertained).	Milk Supply.	Sanitary Defects.	Where Case is Isolated (Home or Hospital).	School attended by Patient or by other Children in same House.	If Vaccinated (in case of Smallpox).	Particulars of Disinfection.				Name of Medical Practitioner reporting the Case.	Remarks.
															Date of Disinfection.	No. of Rooms Cleansed.	No. of Rooms Fumigated.	No. of Articles Disinfected.		

Disinfecting Register and Receipt Book.

(TOWN)

PUBLIC HEALTH DEPARTMENT.

Particulars of Disinfection, etc., carried out at

Disease   Where isolated, Home or Hospital

Date of Disinfection

No. of Rooms Disinfected

DESCRIPTION AND NUMBER OF ARTICLES DISINFECTED OR DESTROYED.

HOUSE LINEN.	NO.	GENTS'	NO.	CHILDREN'S.	NO.
Beds (feather, flock, wool).		Caps		Boys' Knickers	
Bed Vallance		Coats		,, Jackets	
,, Covers		Collars		,, Suits	
,, Furniture (sets)		Cuffs		Diapers	
Blankets		Drawers		Feeders	
Bolsters		Flannels		Frocks	
Box Covers		Flannel Vests		Pelisses	
Carpets		Hats		Pinafores	
Chair Bed Cushions		Neck Ties			
Chair Covers		Night Shirts			
Chair Backs		Shirts		OTHER ARTICLES.	
Counterpanes		Socks			
Coverlets		Suits of Clothes		Boots	
Cushions		Trousers		Handkerchiefs	
Curtain Tassels and Cords		Ulsters		Shoes	
Dinner Napkins		Waistcoats		Gloves	
D'Oyleys				Slippers	
Dusters					
Fish Napkins		LADIES'.			
Glass Cloths					
Hearth Rugs		Aprons			
Kitchen Cloths		Bodices			
Knife Cloths		Caps			
Mattresses (horsehair, wool, straw, or spring)		Chemises			
		Cloaks			
Mats		Collars			
Matting		Corsets			
Palliasses		Cuffs			
Pillows		Drawers			
Pillow and Bolster Cases		Dresses			
Quilts		Dress Bands			
Round Towels		Dressing Gowns			
Rugs		Dress Material			
Sheets		Fancy Needlework			
Sofa Squabs		Flannel Petticoats			
Table Cloths		,, Vests			
Toilet Covers		Jackets			
Towels		Muffs			
Tray Cloths		Night Dresses			
Window Blinds		Petticoats			
Window Curtains		Petticoat Bodices			
Mosquito Curtains		Sashes			
		Shawls			
		Skirts			
		Sleeves			
		Stockings			
		Ties and Frills			
		Trimmings			
		Woollen Wraps			

19

This is to certify that the above is a correct inventory of the articles removed from for the purpose of disinfection, and I authorise you to destroy such articles as are marked * in the columns.

Signed

19

This is to certify that I have received back in good condition all the articles enumerated in the above inventory, except those which I authorised you to destroy.

Signed

Disinfector's Report.

(NAME OF TOWN)

DISINFECTING STATION.

A Return of the Houses and Articles of Bedding and Clothing Disinfected after Infective Diseases for the ending 19 .

Situation of Premises Disinfected.	Date of Disinfection.	Disinfection carried out.		Disease.	Date when Patient was removed to the Hospital.
		No. of Articles.	No. of Rooms.		

CHEMICAL DISINFECTANTS.

In considering these, one should ascertain how far they approach the following standards and requirements of an ideal chemical disinfectant :—

1. It should be germicidal in a short time. (Twenty to thirty minutes' exposure is usually the maximum period allowed.)
2. It should be capable of intimately mixing with the substances to be disinfected.
3. It should not have properties that render it unserviceable for general use.
4. It must be soluble in, or at least capable of mixing with, water, salt water, and discharges from the body.
5. It should not be very poisonous to human tissues.
6. Its germicidal powers should not be reduced when in contact with albuminous materials.
7. It should be of known definite strength.
8. It should be stable at all reasonable temperatures.
9. It should not be too costly.

The importance of 1, 2, 3, and 4 requires no emphasis; the need for 5 and 9 is very evident; and 6, 7, and 8 deal with conditions often overlooked.

Solid Disinfectants.

Although these may be true disinfectants as previously defined, unless such are soluble in water they cannot be practically applied, for they fail under item 2 of the standards mentioned. They are useful as deodorants only.

Soap.—Although not a true disinfectant it is most useful, as it clears away dirt and foul matter from the skin. The so-called antiseptic or disinfectant soaps are little better than ordinary kinds. They usually contain a small quantity of carbolic acid or other substance sufficient to give them a characteristic odour, but infinitesimal when compared with the requisite amount of the carbolic acid or other chemical necessary for disinfecting purposes.

This may be easily demonstrated: suppose the disinfectant forms one-tenth of the bulk (a proportion much in excess of what usually exists). Assume that, in washing with the soap, one-twentieth part of it is removed and diluted with the bulk of water. Taking the weight of a cake of soap to be 4 ozs., and the contents of a wash-hand basin to be 1 gall., it follows that the strength of the disinfectant in use is 1 in 8000. (The usual standard solution of carbolic acid for disinfecting purposes is 1 in 20.)

Advertisers' announcements regarding these soaps should be read with caution, as a false sense of security is obtained by their use, especially in connection with cases of infective disease amongst any community, native or otherwise.

Mercuric Chloride.—This substance, often termed corrosive sublimate, is a cheap and very powerful disinfectant. It will readily kill spore-bearing organisms. The chief objection to its general use are its toxic properties. It is a very poisonous substance, and for this reason solutions are usually tinted with aniline blue to prevent mistakes being made. Other objections to its use are: (1) it forms inert compounds with metals; and (2) it coagulates albuminous materials, thereby hindering penetration. The former is obviated by storing it or using it, as a disinfecting agent, in glass or earthenware vessels, and the latter is not so marked when acidified with hydrochloric acid. It should not be used for disinfecting discharges when other disinfectants are available.

Carbolic Acid (Phenol).—Though not so powerful as mercuric chloride, it is in more common use. It is not so poisonous, and may be used with organic matter. It is soluble in water up to 1 part in 2, and the usual strength applied is 5 per cent. (1 in 20).

Commercial carbolic acid is a very different substance, containing little phenol, of unknown strength, and useless for efficient disinfection. Carbolic powders act simply as deodorants.

Bleaching Powder.—This is the technical name for chlorinated lime, a mixture of chlorine and hypochlorite of calcium. It is now being heard much of in connection with the disinfection of water during epidemics. Thirty-three per cent. of it is chlorine, the active agent; normally a yellow-coloured gas. Bleaching powder is cheap, powerful, efficient, and non-poisonous: the only objection to its use is the fact that if used in a greater strength than 1 part in 500,000, or 1 part in 1,500,000 chlorine, a distinctive smell and taste is imparted to the water treated.

More is mentioned on this point in Chapter VIII., on Water.

Lime.—Ordinary slaked lime is of no value as a disinfectant. In the solid form it is used as a deodorant only. Quicklime is useful for making a disinfecting lime-wash.

Potassium Permanganate.—This substance is a very feeble disinfectant, and is useless in presence of much organic matter. It has been used for purifying water during cholera epidemics, sufficient being put in to 'pink' the water. It is of doubtful value, and risky to rely on when other methods are available.

Liquid Disinfectants.

Coal-tar Derivatives.—Many of the well-known disinfectants are derivatives of coal-tar: Izal, Cyllin, Kerol, and others. The majority of proprietary disinfectants are cresol preparations made up in different ways, advantages being claimed for each by their respective manufacturers.

Cresol.—This is the most generally useful of all disinfectants. It is non-poisonous, cheap, and easy to handle. It is not soluble in water, and therefore, it is sold emulsified with soap or gums. The soap emulsion is the better, but will not readily mix with salt water, and it is not so stable and homogeneous in the presence of organic matter as the resinous emulsions. If it is found necessary to use salt water with soap emulsions for disinfection, a strong 'solution' should be first made with a small bulk of fresh water, and then diluted to the required strength with the salt water. Prepared in this way it remains emulsified for a reasonable time.

Sodium Hypochlorite.—This solution, to be of use as a disinfectant, should contain at least 5 per cent. of available chlorine.

Chloros contains from 10 to 12 per cent. available chlorine, and it is used as a disinfectant in dilutions of 1 in 20.

Formalin.—This is a 40 per cent. solution of formaldehyde in water. It is a non-poisonous, colourless liquid of about half the bactericidal power of phenol.

Tincture of Iodine.—This is a dark-coloured liquid of definite strength, useful for skin applications, *e.g.*, for disinfecting cuts, bruises, and ringworm and similar affections.

The stated strengths of liquid disinfectants are based on bacteriological tests, comparing the germicidal action of the disinfectant with that of carbolic acid against a known organism: usually a twenty-four hours' culture in broth of *B. typhosus.* The test consists in applying the postulant and the standard in various dilutions to equal portions of the culture, for determinative periods of exposure under identical conditions. The result is observed by sub-culture. The lowest dilutions which kill the test organisms in the same time stand to each other in a ratio which is called the 'carbolic acid coefficient.' This gives a direct indication of the efficiency of the disinfectant, and enables one to determine what dilution is necessary to give results equivalent to a 5 per cent. solution of carbolic acid.

The result of the test is tabulated as follows :—

B. Typhosus, twenty-four hours' culture in Broth at 37° C.
Room temperature, 15° to 18° C.

Sample.	Dilution.	Time culture exposed to action of Disinfectant—Minutes.					Sub-cultures.	
		2½	5	7½	10	12½	Period of incubation.	Temperature.
? Disinfectant	1 : 1900	×					48 hours	37° C.
,,	1 : 2000	×	×				48 ,,	37° ,,
,,	1 : 2100	×	×	×			48 ,,	37° ,,
,,	1 : 2200	×	×	×	×		48 ,,	37° ,,
Carbolic acid .	1 : 100	×	×				48 ,,	37° ,,

(× Signifies 'growth' in Sub-culture.)

Therefore, carbolic coefficient $\frac{2000}{100} = 20{\cdot}0$.

The stated carbolic acid coefficients are not comparable unless the same test has been made for standardisation. Some workers test against 'naked' bacteria, and others test in the presence of organic matter, *i.e.* sterile human fæces. The latter test gives the lower coefficient, but, generally, manufacturers use the former.

To determine the bactericidal dilution of a disinfectant from the stated coefficient, multiply that figure by 20 (the working strength of carbolic acid being 1 in 20). This gives the dilution for 'surface' disinfection, *i.e.* against naked organisms; but where the disinfectant has to be used to disinfect organic matters the carbolic coefficient (unless known to have been tested in the presence of organic matter) is not a reliable guide. Dr Louis C. Parkes has stated that, "Under these conditions it will be prudent to assume that no commercial disinfectant is more than three times as efficient as pure phenol."

From the above it will be apparent that as the powers of different chemicals vary with different organisms under different conditions, the strengths required, and the length of time to be exposed to bring about the desired germicidal action, should be known and understood by all using such chemicals as disinfectants.

The main points to be remembered about liquid disinfectants are :—

(1) The solution added to the article to be disinfected should be such that the strength of the bulk is sufficient to kill the particular organisms.

(2) There must be actual intimate contact with the organisms to be killed; *e.g.*, in disinfecting excreta it should be broken up and thoroughly well mixed.

(3) All require time, this depending on the strength of solution applied; usually fifteen minutes' contact should be allowed.

(4) Efficiency is increased by the application of heat.

Regarding contracts for disinfectants, the question as to the suitability or otherwise of a particular make should be left to the Medical Officer of Health, who in many instances will have opportunities for testing its efficiency.

One of the clauses in such a contract should run :—

> Any disinfectant fluid may be tendered for, provided that its guaranteed bactericidal efficiency is expressed in terms of absolute phenol (100 per cent.) as determined by the Rideal Walker (or other) method, when working with vigorous cultures of *B. typhosus*, and that it is homogeneous, miscible with water in all proportions, does not separate out on standing, and runs freely from the cask or other receptacle at all times.

In some colonies disinfectants must have the carbolic acid coefficient stated on the label; and in others, on those which are at least equal in strength to that of pure carbolic acid, a much smaller duty is imposed. Both are steps in the right direction. A useful addition to the legislation on these matters would be the power to take samples and prosecute offenders where the disinfectant does not come up to the strength stated on the labels.

The following are the approximate carbolic acid coefficients of various disinfectants:—

Mercuric chloride	200	Cyllin (crude)	15
Formalin	.5	Cyllin medical	18-20
Cresol	10-12	Kerol	15-20
Sanitas fluid	10-12	Izal	15-20
Sanitas-bactox	15-20	Lysol	15-20

Gaseous Disinfectants.

The use of gases as disinfecting agents, although in tropical practice regularly carried out, is a survival of the 'aerial convection' theory of disease propagation. Much controversy has existed in the past regarding the disinfection of air in infected rooms, but it is now generally agreed that such a procedure is unnecessary, and that disinfection of surfaces only should be carried out. Such disinfection of surfaces is obtained by gaseous disinfectants when properly applied, but in the hands of an inexperienced operator they cannot be depended upon. The routine use of a spray with a known strength of liquid disinfectant will ensure more reliable results.

Sulphur Dioxide.—In the tropics this is the most general chemical disinfectant in use. In addition to having germicidal properties it is an insecticide, and is of value in operations against rats, etc.

There are three methods of obtaining the gas: (1) by burning crude sulphur in the compartment to be disinfected; (2) by the use of tubes of liquid sulphur dioxide (under pressure); and (3) by generating it in special apparatus outside the compartment. Whichever method is adopted, it is essential that 3 per cent. of gas be obtained; this quantity is the recognised minimum for disinfecting purposes.

The action of the gas depends on the presence of moisture, sulphurous and sulphuric acids (the true disinfecting agents) being formed on the surfaces.

It has little penetrating power, tarnishes metals, and bleaches certain fabrics. Many foodstuffs are more or less injured by its action. It is intensely poisonous to inhale, but its presence is readily detected.

Formaldehyde.—This is seldom used in the tropics for disinfection. It is of considerable value as a germicide, but is expensive to generate. Many workers with it have obtained varying results, some stating that it acts well only in the presence of moisture; others that such moisture is not essential for efficiency.

It is obtained by vaporising paraform tablets in an Alformant lamp, or by the action of formalin on potassium permanganate.

The following are the formulæ for obtaining working solutions of some of the more common disinfectants:—

Corrosive Sublimate Solution (·1 *per cent.*).

Mercuric chloride . .	70 grains
Hydrochloric acid . .	3 drachms
Water . . . . to	1 gallon

(Roughly ½ ounce to a pail (3 gallons) of water.)
Tint with aniline blue (1 grain to the gallon).

Cresol Solution (1 *per cent.*).

Liq. Cresoli sap. Fort. (Saponified Cresol) (German Ph.)	1½ ounces
Water . . . . to	1 gallon

Formalin Solution (4 *per cent. Formaldehyde*).

Formalin	16 ounces
Water . . . . to	1 gallon

Chlorinated Lime-wash.

Chlorinated lime . .		2 ounces
Quicklime . . .		$\frac{1}{2}$ gallon
Water	to	1 gallon

Practical Disinfection.

Clothing, bedding, carpets, and textile fabrics generally should be disinfected by steam where machines are available. Failing such, cotton and linen articles should be boiled for fifteen minutes. Blankets may also be treated in this manner, but other woollen goods require to be soaked in a disinfectant of sufficient strength.

Leather goods and articles containing felt, india-rubber, wax, or glue should be swabbed with cresol or other disinfectant. Exposure to the action of sulphur dioxide or formaldehyde should be the last resort, if it is not expedient to burn the articles. As a rule, all books, toys, and inexpensive articles should be burnt.

The usual practice after a case of smallpox is incineration of all infected articles, the owner receiving suitable compensation from the local authority. In some places the native quarters vacated by smallpox patients are burnt to the ground, temporary accommodation being provided elsewhere.

Utensils from sick-rooms should be immersed in boiling water for ten minutes, or washed with suitable disinfectants.

Sputa may be disinfected by keeping cresol in the spit cup.

Excreta should be thoroughly broken up and mixed with a sufficient quantity of disinfectant for fifteen minutes before being passed into the drains. Where no water-carriage system of sewage removal exists, all infected excreta should be boiled before disposal, or, better still, burnt.

Room Disinfection.—As already indicated, two methods are in vogue: (1) spraying of surfaces with an efficient disinfectant, and (2) fumigation by sulphur dioxide or formaldehyde.

Spraying is usually carried out in the houses of Europeans. Cresol, corrosive sublimate, or formalin (given in their order of merit) may be used. The solutions are applied, by means of a spray of approved pattern, from below upwards, the work being done from side to side. This method avoids staining the wall, and ensures that the whole of the surfaces are equally wetted.

Many sprays are on the market; one of the best is the "Mackenzie" (Fig. 63).

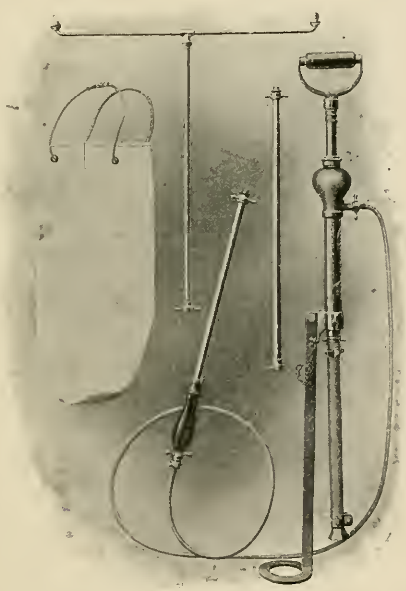


FIG. 63.—Mackenzie Spray.

In working with formalin solutions, the operator should be provided with a veil, to avoid the irritating and smarting action on the eyes of the fine spray of formalin.

One gallon of formalin solution should be used for each 600 sq. ft., one hour being required to do the work.

Fumigation by Sulphur Dioxide.—The usual method is to burn 3 lbs. of sulphur per 1000 cub. ft. of space to be fumigated. The various apertures, windows, doors, ventilators, etc., are sealed up by means of strips of stout paper and flour paste, leaving only one door to be sealed on the exit of the operator. In other words, an attempt is made to make the room "air-tight."

All metal surfaces should be smeared with vaseline or a weak solution of whiting. The room is measured up and the necessary amount of sulphur, plus a margin of safety, obtained. It should be well broken up, and

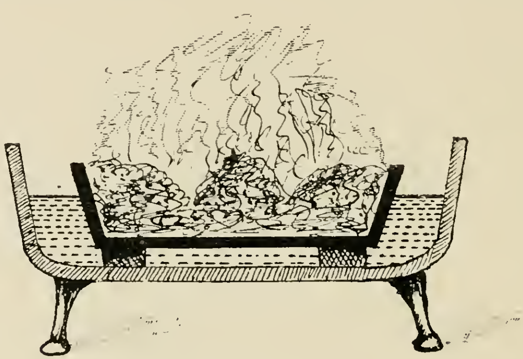


FIG. 64.—Burning Sulphur on Trays. (Sectional view.)

placed about the room on trays supported over water (Fig. 64).

The water is a precaution against fire, and provides a certain amount of moisture in the air of the room. Where practicable, not more than 2 lbs. should be placed on each tray, otherwise combustion may be incomplete. A little methylated spirit is poured on to each tray and a lighted match applied. The exit is sealed on the outside by the operator.

After exposure for twelve hours or longer, the windows and other apertures are opened to admit of free ventilation. The room is then entered and the woodwork scrubbed with cresol or other disinfectant.

Where cylinders of compressed sulphur dioxide gas are available for use, no reliance should be placed on the statements on the labels regarding the amount of space for which one 20-oz. cylinder is sufficient. A sufficient number of tins to produce 6 lbs. of sulphur dioxide per 1000 cub. ft. are necessary. This amount is required to give 3 per cent. of the gas. A number of basins or pails, in which are placed damp cloths, are put about the room. The tube (Fig. 65) is

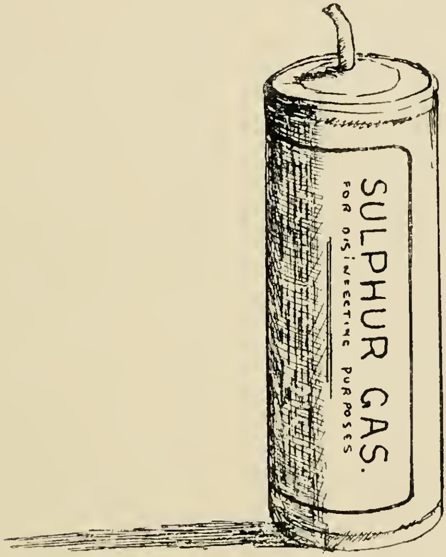


FIG. 65.—Sulphur Dioxide Tube.

discharged by cutting off the vent pipe. They are then placed 'nose' downwards in the vessels, to prevent the too rapid escape of the gas.

In a room of 2000 cub. ft. or over it is unusual for one operator to be able to discharge the total number of tins required. He finds that he has to "bolt" after opening four or five tins; the others remain unopened, and the result is ineffective disinfection.

The most reliable method of fumigating with this gas is by means of the Clayton apparatus, in which the strength of the gas generated is under control throughout the operation. A general description of this machine will be found under "Disinfection of Ships."

When fumigating by formaldehyde the remarks regarding the 'sealing up' of the apartment, mentioned previously, apply.

If paraform tablets and Alformant lamps are to be used, thirty tablets per 1000 cub. ft. and one lamp per 100 sq. ft. of floor space are required for efficient disinfection. The tablets are placed in the upper part of the 'lamp,' and the spirit stove underneath lighted. An exposure of from twelve to twenty-four hours is essential, after which period thorough ventilation is necessary to rid the room of the gas.

An easy way to obtain the gas is by pouring 10 ozs. of formalin on 5 ozs. of potassium permanganate per 1000 cub. ft. This should be done in an iron container. Formaldehyde is liberated rapidly. This method is very serviceable for disinfecting leather and other goods affected by steam, using the chamber of a disinfecting machine or a well-made packing case as the container; the proportion of the reagents must be reduced accordingly.

Routine House Disinfection.

Where the disinfection of a house is ordered by the Medical Officer of Health or Sanitary Officer, the following is in brief the procedure:—

1. Accompanied by a trained 'disinfector' proceed to the house, measure the various rooms and calculate the amount of materials required, according to the method directed to be carried out.

2. Note requirements for the removal of articles to the disinfector, and arrange for transport.

3 Obtain the disinfectants, equipment, and staff necessary for the work. If a vehicle is available it should take the equipment, etc., to the house, and return with articles to be disinfected by steam or other method at the disinfecting station.

4. Check and enter in the book provided a record of the articles removed for disinfection.

5. If fumigation is to be carried out, seal up all outlets and place the necessary materials suitably about the room. Set alight and retire, sealing the exit. (If a Clayton apparatus were available it would be worked from the outside, suction and delivery pipes being connected to the room undergoing fumigation.) All cupboards, etc., should be thrown open; mirrors, pictures, and the like taken down from walls and placed in the centre of floor.

6. After fumigation, open windows, etc., to ventilate the room. Then enter and supervise the scrubbing with a disinfectant of all wood surfaces. Pictures and similar articles should be wiped over with a swab soaked in disinfectant, and exposed to the sun.

If spraying or swabbing of walls, etc., is ordered in place of fumigation, the amount of disinfectant required is calculated from the superficial wall and floor spaces. Worthless articles are, of course, burnt on the spot.

Temporary accommodation for the shelter of those turned out of doors during the process of disinfection may have to be provided.

All receipt and issue vouchers concerning articles disinfected should be carefully preserved.

In settled districts the practice of disinfection differs but little from that carried out elsewhere. The following extract from a report of an English Medical Officer of Health is well worth quoting:—

> There is too great a tendency to disinfectants, as being less expensive than thorough cleaning. The use of disinfectants is an excellent practice when they are applied to clean rooms; but it must be understood that they do not remove dirt, and therefore cannot take the place of cleaning, nor can disinfectants kill infection when it lies buried in layers of dust. Disinfection should be applied after cleaning, not in place of cleaning.

Disinfection of Ships.

The disinfection of bedding, clothing, etc., may be carried out by such of the methods already described as are applicable. Many ships now carry small types of steam disinfectors on board. When in port, the disinfection of such articles may be carried out by the Port Sanitary Authority.

For disinfecting cabins and decks, the use of a spray has been found to give good results. For the disinfection of bilges, use is made of a strong solution of caustic soda followed by a solution of carbolic acid (1 in 20) or other disinfectant.

For the disinfection of holds and in some cases cabins also, fumigation is relied on. Many gases have been tried, but sulphur dioxide has been found the most useful. The others are objected to on various grounds: some are bad insecticides and bactericides, others are expensive, do not penetrate, and have no characteristic smell. The latter is an important point in ship disinfection, where the absence of an indicative odour during the disinfection of holds may result in loss of life.

The apparatus in general use is made by the Clayton Fire Extinguishing and Ventilating Company, Ltd., of London. It is installed in many ships as a fire-fighting apparatus. Permanently fitted suction and delivery pipes leading from and to the holds, etc., are connected to the apparatus.

The general method of equipment, when vessels are permanently fitted, is shown in Fig. 66.

At coast towns the apparatus is usually of a portable type, being used for disinfecting dwellings, stores on wharves, etc., or taken on a tug to a ship's side to carry out disinfection when necessary. Various sizes and types are to be met with, but the principle underlying all is the same. Fig. 67 gives a diagrammatic sketch of the apparatus, and Fig. 68 a photograph of the type in use on the West Coast of Africa.

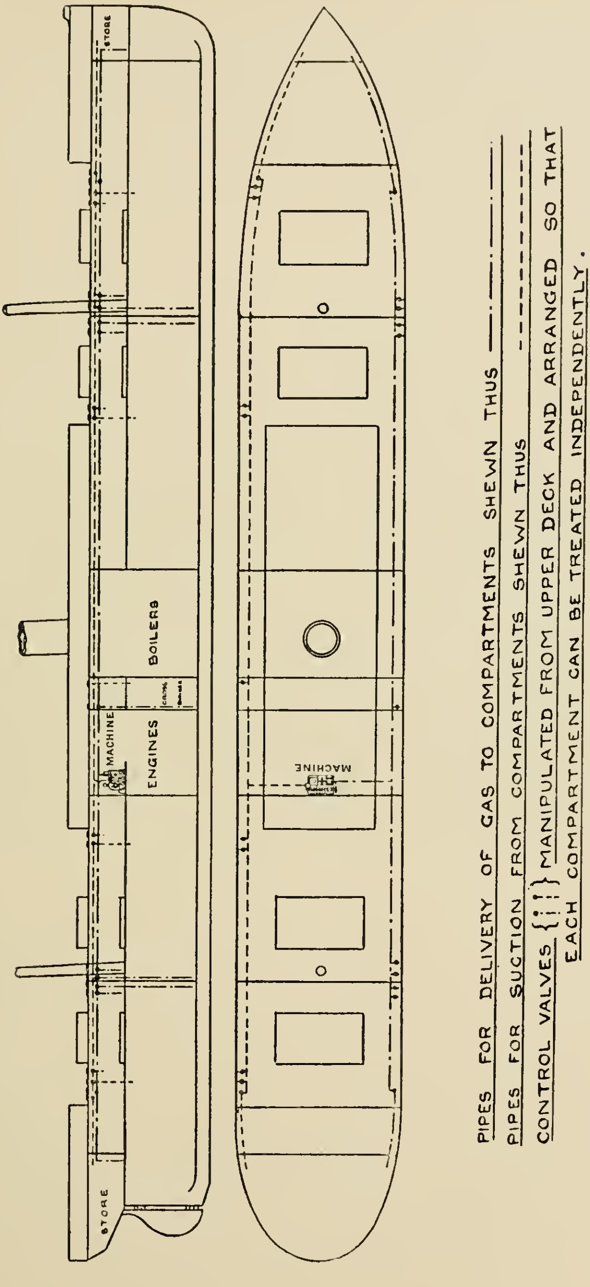


FIG. 66.—Clayton Apparatus; General Method of Equipment on Ships.

By the Clayton system the air in the compartment undergoing fumigation is extracted, and as it is drawn through the machine becomes converted into sulphur dioxide at a high temperature, by passing over burning sulphur in a specially constructed generator; it is then cooled and forced back into the compartment. Delivery and suction operations, which

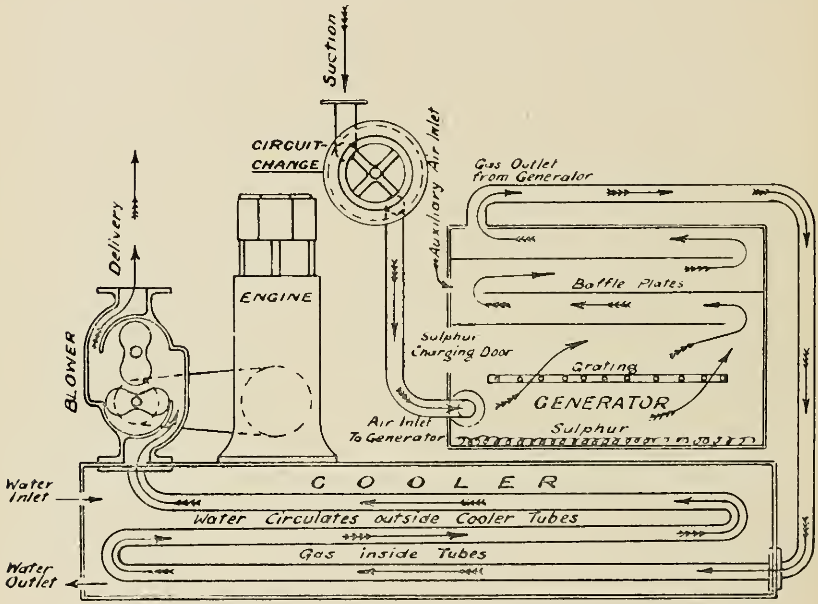


FIG. 67.—Diagrammatic Sketch of Clayton Apparatus.

are produced by a powerful blower, proceed simultaneously, and the volume of air withdrawn is equal to the volume of disinfecting gas delivered into the chamber; if any leakage occurs it is only due to diffusion. The compartment should, of course, be properly closed.

When fumigating any enclosed space, a rough idea of the minimum quantity of sulphur required may be obtained from the volume (viz., 12 cub. ft.) of sulphur dioxide which will be produced from 1 lb. of sulphur. This amount is not produced as a pure gas, but is mixed with the nitrogen and excess oxygen of the atmosphere, and delivered from the machine at a maximum strength of 15 per cent. to 18 per cent., giving a volume of 80 to 66 cub. ft. per pound respectively. A further dilution takes place by mixture with the atmosphere in the compartment, and a varying amount of escape always occurs, so that it is preferable to rely on

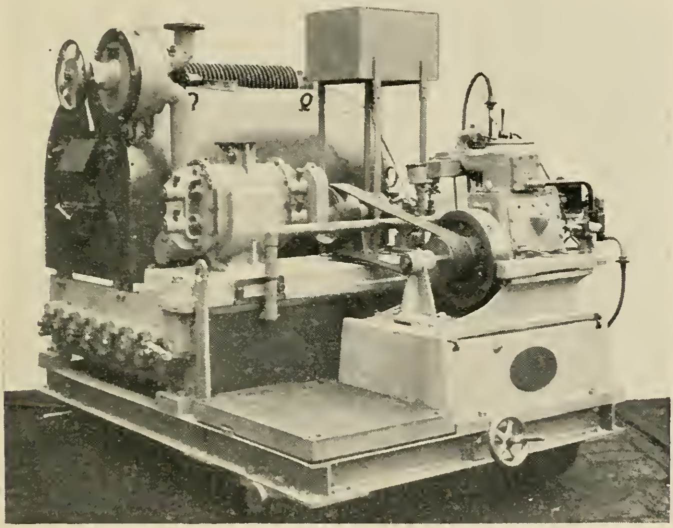


FIG. 68.—Clayton Apparatus in use in West Africa.

tests of the sulphur dioxide strength attained and kept up for the requisite time in the compartment, rather than on the amount of sulphur consumed. The 'charge' of sulphur varies with the type of machine in use. The first charge for the "A" type machine is 100 lbs.; for the "B" type machine, 250 lbs.; and for the "E" type, 200 lbs.

Empty compartments which require treatment will be thoroughly disinfected if a minimum strength of 3 per cent. gas is maintained everywhere within them for not less than two hours. If loaded compartments are being treated, it is better and more expeditious to introduce a large volume of gas with a strength not exceeding say 3 per cent., rather than the same volume, at a higher percentage. This applies especially to absorbent cargoes, such as cotton, jute, or wool, which hinder the diffusion and disinfecting properties of a high percentage of gas much more than the low strength of 3 per cent. already mentioned. On the other hand the fumigation of empty compartments can be better accomplished by introducing a high strength of gas (say 15 per cent.) continuously, and allowing this to diffuse and mix with the air in the compartment, to give say 3 per cent. throughout same.

To avoid possible damage when treating grain, either to destroy weevil, or for any other purpose, it is necessary that the strength of gas should never be allowed to exceed 3 per cent. in the delivery, and it may with advantage be kept down to 2 per cent. Flour and wheat in bags are especially sensitive to the action of the gas, and should not be treated when it is possible to avoid doing so.

The following are general instructions regarding vessels or houses being fumigated:—

For the effectual fumigation of hospitals or houses, it is advisable to divide them into convenient sections, which should be made as air-tight as possible by pasting up doors, windows, and openings; or, for convenience in cleaning, the paper may be pasted on with vaseline, which is also a good protection for metal work. Two apertures must be left for the insertion of pipes, as far from each other as can be arranged, and as high as possible in the compartment.

When a vessel is to be fumigated, it should be divided into convenient sections, each being fumigated separately. Each hold between bulkheads is generally a separate section; and before commencing, water-tight doors should be closed and ventilator cowls covered with canvas, one corner of the hatch and one ventilator being left open for insertion of pipes.

Cabins, saloons, store-rooms, forecastle, etc., have as a rule to be fumigated separately: lockers, cupboards, etc., should be left open, and all portholes, skylights, ventilators, etc., closed or covered to prevent leakage as much as possible. In the case of open alley-ways with galleys, cabins, etc., on either side, the open ends should be stopped with canvas or tarpaulin.

Any dry, unbroken stores, except flour, can remain whilst fumigation is going on, but stores required for immediate use, such as tea, sugar, etc., should be removed.

Where steam disinfection cannot be carried out, clothes may be left in lockers or drawers during fumigation, but special care should be taken to see that they are quite dry. The articles should afterwards be exposed to the air, or placed in a dry, warm, and well-ventilated room, in order that any smell left by the gas may be removed.

When a house is opened up after fumigation, as much ventilation as possible should be given to all sections. In the case of a vessel, wingsails into the hold will greatly accelerate the clearance of the gas. The machine is provided with a ventilating attachment which can be used if desired.

To obtain any desired strength of gas in a compartment, it is essential that the same or a higher strength of gas should be maintained at the delivery pipe until the compartment becomes fully charged. For this purpose frequent tests should be made at the delivery pipe, until the desired percentage of gas is reached, which percentage of gas can be maintained by careful attention to the supply of sulphur to the generator and the regulating of controlling valves.

During a 'run,' sufficient sulphur should be added to keep about one inch molten on the bottom of the generator. Towards the end of a 'run' this should be burnt right out.

The testing of the gas should be done regularly at intervals of not more than fifteen minutes as soon as the generator has become well heated, and rather more frequently just after starting or recharging, especially when the strength of gas is rising above 10 per cent.

In addition to the reason already given for testing, it is also necessary to ascertain the strength of gas coming from the compartment, so as to know when to cease from taking the supply of air from the compartment to the generator, and to allow fresh air to enter the generator. This should be done when the strength of gas reaches 3 per cent., otherwise combustion in the generator would become less rapid and ultimately cease, owing to the fire-extinguishing properties of any atmosphere containing 5 per cent. of sulphur dioxide.

FIG. 69.—Glass Burette for Testing Percentage of Sulphur Dioxide.

The test, carried out by means of a burette graduated in hundredths (Fig. 69), is based on the fact that water will absorb many times its own volume of sulphur dioxide, and consists of filling the body of the burette with gas (from the generator or compartment as required), admitting water, and, after agitation, noting the amount of water drawn into the burette: this will equal the volume of sulphur dioxide absorbed, and may be read off directly as a percentage.

The method of measuring the gas is as follows:—

Attach glass burette to pet-cock on blower delivery by means of the small rubber tube; open both cocks of burette (which should be held with the cup downwards) and allow gas to pass through for about half a minute. Close the cock nearest the cup first, and then the cock next to the blower; immerse the burette in a bucket of water and fill up the cup with the same water, keeping the burette immersed for about half a minute to bring the gas and water to the same temperature. Remove the burette from the water for sufficient time to open and close the bottom cock, replacing the burette immediately, so that the pressure in the latter may be equalised with that of the atmosphere, and the temperature with that of the water. Open the top cock to allow some water from the cup to flow into the body of burette, and, after closing the cock remove the burette, place the palm of one hand over the cup, two fingers of the other hand under the bottom cock, and shake up the water in the burette to absorb the gas quickly. Replace the burette in the water, and open the top cock until water ceases to run in. Remove the burette. The quantity of water contained therein, as indicated on the graduated scale, corresponds to the percentage strength of sulphur dioxide.

CHAPTER VII

AIR AND VENTILATION

It has been said that "one can live without air for three minutes, without water for three days, and without food for three weeks." This truism sufficiently indicates that air is a vital necessity of life, and taken in conjunction with the fact already dealt with that it is a common channel of infection in certain diseases, it will be obvious that the subject matter of this chapter, though commonplace, requires careful consideration by the sanitarian whether working in the tropics or elsewhere.

A pure air supply for the proper aeration of the blood is of first importance to maintain health. An impure supply adversely affects the health of any community. This is to be seen from statistics dealing with overcrowding, which demonstrate clearly that the mortality increases with the density of a population, whether of men or animals.

To understand the part played by air and its impurities, it is necessary to know its composition and relation to the physiological processes going on in one's body.

Air normally consists of oxygen, nitrogen, and carbon dioxide in the following average proportion :—

Oxygen	209.6
Nitrogen	790.0
Carbon dioxide	.4
	1000.0

There are also traces of organic matters and watery vapour.

Analytical reports on the composition of air in different parts of the world show constant results. This constancy is due to the diffusion of gases, influence of air currents, differences of temperature in atmospheric air, and other factors.

Oxygen, the most important constituent of air, though only one-fifth of the whole, is a necessity for the maintenance of every kind of life and combustion.

Nitrogen, the main constituent of air, acts as a diluent of the oxygen, and possibly forms a source of nourishment for certain plants.

Carbon dioxide is a product of combustion, *i.e.* the result of the action of oxygen upon organic tissues.

Organic matters are constant impurities in air, and in the past have been considered causal agents of disease.

Watery vapour, though a variable constituent largely governed by climatic conditions, is always present in air. It is spoken of as "humidity," and is an important factor in the effects of a tropical climate on man. When it is relatively high, *i.e.* approaching saturation point, evaporation from the body is considerably diminished, and thus the heat-regulating mechanism is interfered with. To a large extent this effect is lessened and made more bearable, in places where winds are frequent. All authorities agree that excessive humidity lowers one's resistance to disease, and is the main predisposing cause in the maintenance of a high incidence of disease in places where such excess pertains.

In the process of breathing, changes in the blood occur. Some of the oxygen is used up in the lungs, where it is conveyed to all parts of the body by the red blood corpuscles, and returned to the lungs in the form of carbon dioxide. The expired air therefore contains less oxygen and more carbon dioxide. In addition, the organic vapours and moisture are increased; these are perceptible in crowded rooms.

The composition of expired air is :—

Oxygen	170.0
Nitrogen	790.0
Carbon dioxide . . .	40.0
	1000.0

This shows a loss of oxygen to t extent of 3·9 per cent., and an increase of a like amount of carbon dioxide. It should be borne in mind that this variation in the composition of air occurs as it leaves the body, from which time it diffuses in the surrounding air and again approaches its average composition.

If a case of infective disease, *e.g.* diphtheria or tuberculosis, is present in a room, amongst the organic matters may be included pathogenic organisms.

It is this fact which makes a vitiated atmosphere a potential danger.

Apart from the part played by these organisms of infective diseases in overcrowded buildings, the "bad effects of close, crowded, and confined places" are due to the excess of moisture, high temperature, and want of movement of the air, and not to chemical impurities, *i.e.*, excess of carbon dioxide, the diminished quantity of oxygen, or the presence of organic poisons.

These facts have been ably demonstrated by many experiments carried out by Professor Leonard Hill, of London University, whose results are embodied in this chapter.

Excess of Carbon Dioxide.—Much has been made of this in the past, but it is now recognised that it plays no part in the ill effects produced in crowded rooms ; for it is proved that an excess of carbon dioxide cannot get into the body, owing to the mechanism controlling respiration keeping the percentage of carbon dioxide constantly the same. The only effect of excess of carbon dioxide in the air a person breathes is "to make him breathe a little more deeply, and ventilate his lungs a little more fully."

Diminution of Oxygen.—This is never more than 1 per cent. It is constantly being replaced by outside air coming in through windows, cracks, under doors, etc. At various health resorts on high mountains there is less oxygen than in a crowded room, volume for volume, yet no ill effects are shown. The hæmoglobin in the blood in some way adapts itself (in regard to its work of supplying oxygen) to the altered conditions.

The existence of organic poisons in expired air has not yet been demonstrated. Carefully guarded experiments on animals (over prolonged periods), made to test this theory, failed; the animals living for "weeks and weeks."

Bad smells in crowded rooms do not cause disease. They are the result of the organic matters given off from the lungs and skin. They may have a depressing effect upon sensitive people in whom imagination plays the major part.

The excess of heat and moisture in the air of crowded rooms has a bad effect upon the metabolism of the body, and tends to bring about inactivity, with a resulting faulty circulation of the blood. In addition the body does not require the usual amount of food; that not required becomes decomposed by bacteria, and produces toxic products which, if absorbed, cause headache and possibly anæmia.

No one denies that under abnormal conditions the excess of carbon dioxide may be in poisonous quantities, and the loss of oxygen may be such that people die of suffocation (for instance, the oft-quoted historical Black Hole of Calcutta). But these quantities never obtain under ordinary conditions of life.

The real danger in crowded rooms is spray infection of saliva direct from infected to healthy.

It is extraordinary to what a distance droplets of saliva can be projected by a person speaking normally. It is proved by culture experiments that they cover an area many yards away from the speaker.

Common colds, pneumonia, and other diseases of the lungs and air-passages are often spread in this way; many people having pathogenic organisms in their saliva, yet otherwise healthy, unwittingly infect others by organisms in such droplets of saliva.

Ideal conditions are not always obtainable; but sufficient movement of normal air properly maintained is an essential in all circumstances, more particularly in places where the cubic space and floor space per head are below requirements.

If the part played by air in the spread of disease is as described in the preceding paragraphs, it naturally follows that the more space (both floor and cubic) a person has, the less will be the chance of his being affected by a vitiated atmosphere, and of infection from others occupying the same room. This naturally leads to the consideration of the necessity for a standard minimum.

It has been shown that the carbon dioxide in vitiated air is increased; this increase bears a direct relation to the number of users of that air.

The organisms and organic matters also increase in direct ratio to the amount of carbon dioxide present as the result of breathing.

As it is impracticable to measure and make use of the amount of organisms and organic matter in air as a standard, the amount of carbon dioxide present is taken as the indicator of the sanitary state of the air of a room and used as a basis for calculating the amount of air necessary (per person per hour) to be delivered in a room, and the initial amount of space required to ensure it being maintained.

The generally accepted permissible limit of impurity (as judged by the odour of closeness) is ·6 parts of carbon dioxide per 1000 parts of air.

Supposing a room is 10 ft. cube, *i.e.* 1000 cub. ft., it will contain ·4 cub. ft. of carbon dioxide. If a person stays in that room for an hour the amount of carbon dioxide will be raised to 1 cub. ft. (a man exhales ·6 cub. ft. of carbon dioxide in one hour, $\therefore \cdot 4 + \cdot 6 = 1$). This amount would be in excess of the limit; in fact, the air in that room would require changing every twenty minutes to maintain the standard. In other words, the man would require 3000 cub. ft. of air each hour.

Cubic space regulations are based on this, *i.e.*, giving each inhabitant of a room as far as possible a sufficient quantity of air.

It is impracticable to give each person in a dwelling 3000 cub. ft. air space, and change the air only once per hour; houses would be much too expensive built on this plan. The alternative of a smaller initial air space and more frequent changing of the air is always adopted in practice.

In the tropics the question of draughts, the bugbear of sanitarians in other climates, is not a determinative factor.

In addition to cubic space, floor space is also important, for the more floor space per person the more occupants of rooms are spread out, and the chances of infection lessened accordingly. The relation of floor to cubic space should be as 1 is to 12, and no lack of floor space should be made up by height in a room.

Ventilation.

"Incessant movement of the air is a law of nature. We have only to allow the air in our cities and dwellings to take share in this constant change, and ventilation will go on uninterruptedly without our care" (Parkes).

Ventilation may be defined as the constant act of changing impure air for pure air in a room or apartment.

This may be natural or artificial. Both are made use of in the tropics.

Natural ventilation is the effect: (1) of perflation, or of the blowing of the wind; and (2) the difference of density between the outside and the inside air. Free perflation through windows, doors, etc., affords the best kind of ventilation in the tropics, as elsewhere. Windows should extend from floor to ceiling, should be of the "French" type, and should be provided with jalousies or venetian blinds to control the tropical light.

Ventilators are contrivances to aid the changing of air; they may be 'inlets' or 'outlets,' according to position and construction. Ridge ventilators are common in tropical buildings. They consist of an opening extending along the apex of the roof, protected against flies and rain, etc., by a screened hood.

The free openings of windows and doors form the best inlets known, and *via* the ridge ventilators the aspirating effect of the wind is relied on for the renewal of air.

Artificial ventilation embraces the use of mechanical contrivances to assist the natural circulation of air. The punkah, thermantidote, and Blackman propeller (Fig. 70) are examples of mechanical ventilators. The punkah is simply a framework of wood and canvas having a fringe. It is swung backwards and forwards from the ceiling by a rope worked by hand. The thermantidote and Blackman propeller consist of fans worked by electricity or other motive power, and according to their arrangement they may either force air into, or extract air from, the room in which they are situated.

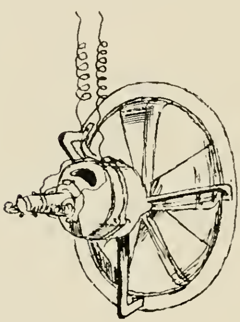


Fig. 70.—Blackman Propeller.

In ventilating by air-propellers it is more satisfactory if the fans or blowers can be used without air-ducts; these harbour dirt, and are generally difficult of access. Exhausting fans are the most suitable, for then the provision of special inlets is unnecessary, except in rooms which are tightly closed.

Where ducts are necessary, engineers usually make them of sufficient size for the air velocity not to exceed 6 ft. per second. A common practice is to allow 1 sq. in. pipe area per 20 cub. ft. of air passing per minute.

Law on Ventilation and Overcrowding.

In primitive districts, *e.g.* many parts of West Africa, no laws on these subjects exist. In settled districts such legislation as may be in force is based on British law, which may be thus summarised :—

"Local Authorities may make bye-lays with respect to the ventilation of buildings." The requirements are left to the discretion of such authority.

Dealt with as a nuisance, the owner or occupier of "any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates" is liable to a penalty on conviction. No legal standard is given to fix overcrowding.

Unofficially it has been defined as follows :—"A room is said to be overcrowded when the inmates do not obtain a sufficient quantity of fresh air." This occurs when the space in a room does not allow of at least 250 cub. ft. per person.

The following are desirable cubic space standards per person in the tropics :—

	cub. ft.
Dwelling-houses	600
Workshops	400
Schools	250
Barracks	1000
Hospitals	2400

Unfortunately, the duties of health officials in regard to these matters in many tropical places are practically *nil.* Finance and native customs operate against ridding a district of overcrowding by the enforcement of suitable legislation.

CHAPTER VIII

WATER AND WATER SUPPLIES

The problems connected with the supply of water to a tropical community present similar general features to those met with elsewhere.

The supply requires consideration in regard to (*a*) quantity and (*b*) quality; the former should be sufficient for all purposes, and the latter as pure as possible. Injury to health may directly occur through a deficiency in quantity, or as a result of consuming impure water, and, indirectly, through improper storage.

General Facts regarding Water.

Water is a liquid under ordinary temperatures and pressure, but it may be met with in other states; *e.g.*, as a gaseous substance it is known as steam or vapour, and as a solid substance it is known as ice, hail, or snow. It is a chemical compound consisting of two parts of hydrogen and one of oxygen (by volume), and its physical characteristics are as follows:—tasteless, colourless, inodorous, clear, and transparent.

It covers two-thirds of the surface of the earth, and enters largely into the structure of all animal and vegetable life, and is a necessity for the maintenance of such life.

It freezes at 0° C. (32° F.), and boils at 100° C. (212° F.) under normal conditions. The latent heat of water, *i.e.* the amount used to convert it from ice, is 80 thermal units, and the latent heat of steam is 536 thermal units. (The British thermal unit is the amount of heat required to raise 1 lb. of water through 1° F.)

Water is taken as the standard of comparison in regard to density or specific gravity, and specific heat.

One cubic foot (measuring approximately 6¼ galls.) weighs 1000 ozs. One gallon weighs 10 lbs., and one foot 'head' exerts a pressure of ·434 lb. on the square inch.

It evaporates at all temperatures under varying conditions. It is one of the best known solvents, dissolving the majority of known substances; the relative solubility of such substances varies enormously, and the solubility of each one is affected by temperature.

Quantity of Water Required.

This is reckoned as so many gallons per head per day, and is usually a liberal scale based on the requirements for drinking, cooking, washing of persons, clothing, and utensils, watering of animals, cleansing of houses, yards, and streets, manufacturing purposes, for sewage removal, where a water-carriage system exists, etc. In addition to the above, there is always a certain amount of waste.

The amounts used vary in different communities: the average in primitive places is about 20 galls. per head per day. In settled districts where water-carriage of sewage exists, and where additional supplies are required for municipal and trade purposes, some 15 or more gallons per head have to be provided for.

The following table shows amounts used for the various purposes :—

	galls.
Cooking	0.7
Drinking	0.3
Washing	5.0
Domestic purposes	7.0
Baths	4.0
Waste	3.0
	20.0
Water-closets	5.0
Trade purposes	5.0
Municipal	5.0
	35.0

In hospitals the amount of water used per head per day approximates 50 galls.

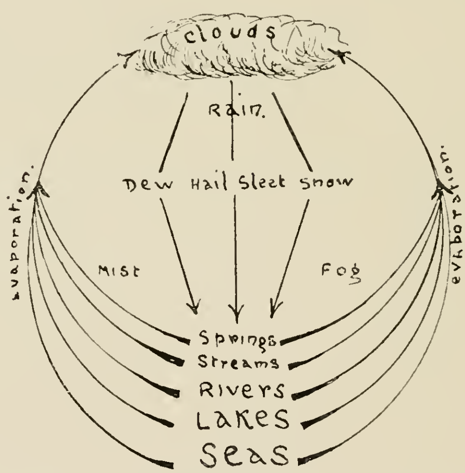
The following are the usual allowances for animals :—

	galls.
Oxen and mules	5
Horses	15
Camels	20
Elephants	25

Sources of Supply.

Rain is the origin of all sources of water supply; or, to vary this mode of expression, all supplies are dependent upon the rainfall for replenishment.

Constant evaporation from the surfaces of land,



Governing Factors :
Temperature and Elecrical Disturbances.

Fig. 71.—Water Circle.

lakes, rivers, etc., gives rise to the continuous circulation of water, diagrammatically shown in Fig. 71.

The amount absorbed by the atmosphere is governed by temperature and occurs, to a certain extent, in direct ratio. Formations of clouds occur on a fall of temperature in the high atmospheric air, and rain falls on further reduction in temperature and production of electrical disturbances.

Part of the rain-water evaporates; part sinks into the soil, forming underground waters; and part flows over the soil, forming streams, rivers, and lakes. The extent of each is regulated by temperature, porosity of the soil, slope of the ground, and nature of vegetation.

From the above it will be seen that there are three main sources of supply: (1) rain-water, (2) surface waters, and (3) underground waters.

Rain-water.—To a limited extent this is a good source of supply provided that the catchment area is clean: such an area may be the roofs of buildings or prepared surfaces of impervious material specially constructed. Included also in the term catchment area are the various forms of storage vessels and containers.

The characteristics of rain-water are its softness and unpalatability. Its disadvantages, as a source of supply for settled districts, are: (*a*) its uncertainty, (*b*) its erosive action on lead, (*c*) the length of the dry season, and (*d*) the large-sized storage reservoirs required. In manufacturing districts it takes into solution various gaseous impurities existing in the air through which it falls; but practically these are negligible. A clean catchment area is of first importance.

In many places where rain has to be depended upon as a source of supply, some form of automatic apparatus is generally used which decants the first surface washings before directing the remainder into storage vessels. (Fig. 72.)

One of the best materials for small storage tanks is galvanised iron: lead should never be used. Large storage vessels may be constructed of brickwork or concrete. They should be covered over, ventilated, and built in sections, to facilitate cleansing and prevent waste.

The rainfall is measured by means of a rain-gauge, which is examined daily and the amount registered. (See notes on Meteorology in Appendix.)

To calculate the amount of water given by rain, the area of the receiving surface and the rainfall in

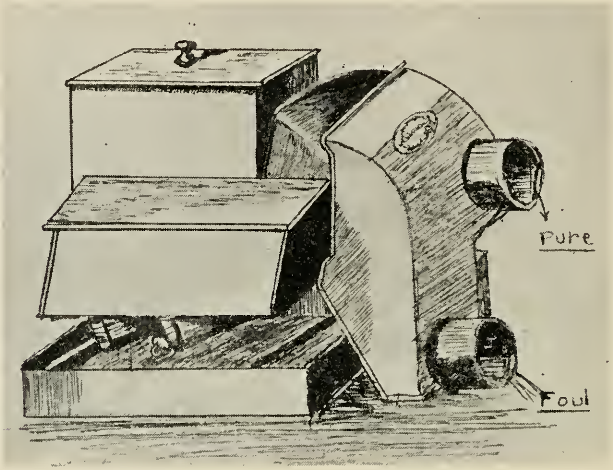


FIG. 72.—Roberts' Rain-water Separator.

inches being known, the following formula is made use of:—

$$\frac{\text{Area in square feet} \times 144 \times \text{rainfall in inches}}{1728} \times 6.23 = \text{gallons.}$$

In calculating the amount received on a roof, the slope of the roof is not taken into account, only the flat area covered by such roof.

In arranging for water storage, engineers base their calculations on the amount available for storage, which varies from $\frac{1}{2}$ to $\frac{7}{8}$ of the actual rainfall. The annual yield is usually based on the records of the three driest years in twenty.

The following are other formulæ dealing with amount of rainfall:—

Inches of rainfall $\times 14\frac{1}{2}$ = Millions of gallons per square mile.
Inches of rainfall per acre = 22,617 gallons.

Surface Waters.—This class of waters generally supplies large communities, and includes lakes, rivers, and streams.

Upland surface waters, in hilly districts, away from habitations and cultivated lands, are usually soft and of great purity. They are, naturally as lakes, or artificially as dams and reservoirs, made use of to supply inhabited areas by gravity.

Surface waters in inhabited districts are dangerous sources of supply, unless purification is carried out, owing to the chances of pollution by organic matter and discharges from men and animals. They may become, more or less, open sewers on passing through towns and villages.

The following formulæ are used in calculating the yield from streams :—

For large streams :

$$\frac{25\,(V \times A)}{4} = \text{gallons per second.}$$

V = means surface velocity (in feet per second), *i.e.* $\frac{4}{5}$ actual velocity as timed by a chip of wood over a measured distance where the channel is uniform ; and

A = sectional area in feet, averaged from several measurements of breadth and depth taken at different places.

For small streams :

Get a plank and cut in it a triangular notch with sides at 90 degrees. Dam up the stream so that it is nearly at rest behind the dam and flows away through the notch. Measure the height from the bottom of the notch to the surface of the water where it is not affected by the overflow ; then,

$$1.978H^2\sqrt{H} = \text{discharge in gallons per minute.}$$

H = depth of water above apex of notch in inches (Firth).

Underground Water.—This is the portion of the rainfall which penetrates the soil, and is eventually diverted from direct vertical penetration by an impermeable stratum. Its fall is then coincident with the fall of the stratum ; usually this leads to the natural water outlet of the area. The flow in such underground water is governed by the obstruction offered in the soil through which it passes. The different formations of strata and the occurrence of fissures in such strata account for the fact that water may be found on other than the first impermeable one (see Fig. 73).

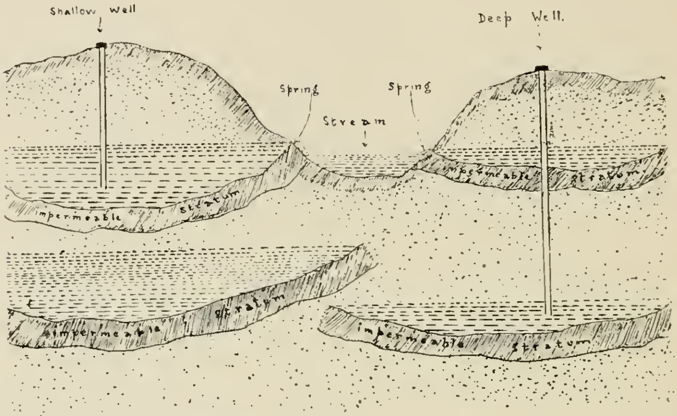


FIG. 73.—Diagrammatic Sketch of Water Sources.

Underground waters are obtained for use as supplies, either naturally as springs, or artificially by sinking wells or bore-holes.

Spring Water.—This is the spontaneous appearance of subterranean water at the surface of the soil, and

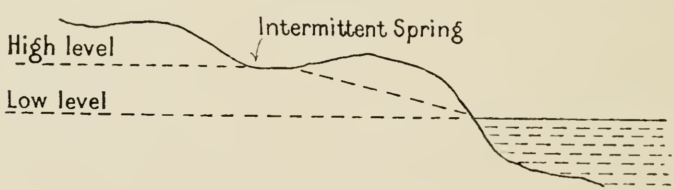


FIG. 74.—Intermittent Spring.

occurs where the water-bearing stratum outcrops at ground-level. Briefly, a spring may be defined a natural outcrop of underground water.

There are two kinds of springs: land springs and main springs. The former generally occurs in a superficial bed of gravel or sand overlying a stratum of clay; the latter are deep-seated outlets issuing usually from a stratum of chalk or sandstone, the water from which is frequently hard. Some land springs are intermittent: they occur in certain formations of strata where the ground water rises considerably during the rainy season (see Fig. 74).

Well Water.—This is subterranean water obtained by sinking a shaft or tube to a water-bearing stratum, and except in the case of artesian wells, such water has to be raised to the ground-level.

Wells may be defined as shafts or tubes sunk into the ground to tap subsoil waters. They are of two kinds, shallow and deep. Those which tap the water on the first impermeable stratum are termed shallow

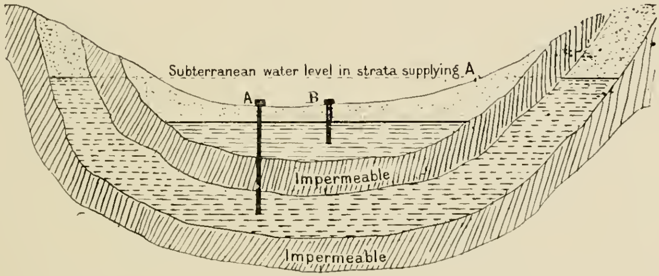


FIG. 75.—(A) Artesian Well and (B) Shallow Well.

wells, and those which tap water below are termed deep wells.

An artesian well is a tubular well of great depth which taps a water-bearing stratum, the level of the water in which is higher than that of the ground at the mouth of the well. The formation is shown in Fig. 75.

It occurs where one impervious stratum is superimposed on another. The subterranean pressure and resultant yield are often sufficient to supply towns some distance away.

Shallow wells are usually 'sunk' wells, though the tubular ones are to be preferred owing to the absence of risk of surface and subsoil contamination. Deep wells may be bore-holes or sunk wells part of the way, and then a bore-hole to the water-bearing stratum. The 'sunk' portion properly steined is sometimes used as an underground reservoir. Water in artesian wells, as already indicated, is raised by underground pressure; in shallow wells it is raised by pump or windlass and bucket by manual labour, and in deep wells by what is known as the 'air-lift' system, or some form of bore-hole pump.

The following is a brief description of one of the methods adopted in well-sinking, the place where the shaft has to be sunk having been determined by trial borings :—

The soil is thrown out by hand, in stages, for about 8 yds. down; after that the debris is raised by mechanical power from the pithead. When rock is met with, shot-holes are drilled, some high explosive is put in, and, fired from the surface, breaks up the rock. During excavations a temporary lining of iron rings—taken down in parts—supported on pegs, with planks driven in behind, acts as a protection against subsidence of the cavity walls.

On the rock a bed is prepared to take the curb on which the brick lining is built to the ground-level. Excavation is then continued and other curbs are put in where considered necessary, brickwork being built to the curb above. The temporary lining is removed in sections and the interspace filled with puddled clay.

Where ground water is near the surface, shallow wells may be sunk as follows :—Excavations are carried out as far as practicable without a lining; then a curb with a cutting edge is inserted, and a wall of masonry built on this. More earth is removed, and the ring of brickwork sinks; other courses are added as required, and the curbs, inserted at intervals, are bolted together.

The yield of a well may be determined by the use of the following formula :—

$$\frac{D \times A \times 6.23}{T} = \text{gallons per hour.}$$

D = Distance in feet between the normal water-level and the mark to which it has been pumped down for the purpose of the test (this should be considerable);

A = Sectional area of well in square feet; and

T = Time in hours taken to regain the normal water-level.

The water in shallow wells, sunk in populous districts, is usually polluted by both surface and subsoil contaminations. Fig. 76 shows how such

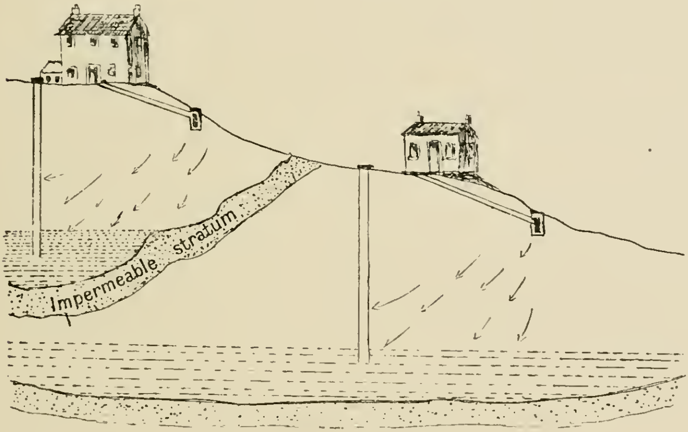


FIG. 76.—Pollution of Wells.

contaminations may occur; it also serves to demonstrate how a cesspool above a well may not contaminate it, yet one below does so.

A common practice in the tropics is to dispose of excreta and provide for the water supply in the compound or yard of each house or pair of houses. In effect, two holes exist, one for reception of dejecta, and the other, tapping a water-bearing stratum near the surface, provides the water for domestic use. Not infrequently they are within five yards of each other.

The result is the contamination of the whole of the subsoil water of the area.

Deep wells properly constructed are usually good sources of supply, owing to the great degree of filtration, through the soil, undergone by these waters. They often produce a hard though palatable water, and are well fitted for general purposes.

Shallow wells may be from 10 to 50 or more feet in depth. Deep wells are usually 100 ft. or more.

The area drained by a well is, roughly, that of an inverted cone, having its apex at the bottom of the well; but such area may be extended by a rise in the ground water or heavy pumping of the well.

In comparing the values of various sources of supply, they should be judged by the evidence of pollution and chances of pollution. No general classification of water supplies can be made unless the local conditions around each source are known. The table usually quoted,[1] based only on the nature of the sources, was drawn up in 1868 by the Rivers Pollution Commissioners for Great Britain, and referred to the state of the water supplies of Great Britain at that period. Although this classification holds good at the present time, with certain reservations, with regard to British waters, it is not a satisfactory guide fit for general application in the tropics.

Impurities in Water.

Pure water is never found in nature; the only pure water is distilled water.

The rain in passing through the air takes into solution traces of gases, and on reaching the ground or other surface the impurities increase; soot, dust,

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[1] Wholesome.	1. Spring water.
	2. Deep well water.
	3. Upland surface water.
Suspicious.	4 Stored rain-water.
	5. Surface water from cultivated lands.
Dangerous.	6. River water to which sewage gains access.
	7. Shallow well water.

decayed vegetation, etc., all add their quota. The same thing occurs underground, the amount of the impurities depending on the condition of the surface area and the geological formation of the district.

They may be classified as :—

(*a*) Impurities in solution ; and
(*b*) Impurities in suspension.

Both may be of mineral or organic origin. Those in suspension may be further subdivided into: (i.) dead visible matter; and (ii.) living invisible matter; the latter in the form of bacteria, ova of parasitic worms, and other water organisms.

The dissolved impurities are largely mineral, though organic dissolved impurities exist as nitrogenous compounds, etc., the result of decomposition of sewage and other forms of organic matter.

With few exceptions the impurities in solution, from a sanitary point of view, are negligible; it is largely a question of dosage, and these impurities are seldom present in a sufficiently large quantity to be hurtful.

The possible exceptions are certain metals, the chief of which is lead, dissolved out of pipes and cisterns made of that material, by soft waters and waters from peaty districts.

The well-known condition of hardness in a water is due to the presence of certain salts of lime and magnesia in solution in such quantities as will hinder the formation of a lather with soap. Soft waters are those which lather freely with soap, *i.e.* they contain little of the salts mentioned.

The carbonates, precipitated by boiling, form the temporary hardness, and are to be seen in vessels used to boil hard waters. The sulphates, which are not precipitated by boiling, form what is termed the permanent hardness.

On an analyst's report on a water sample it may be noted that a quantitative chemical analysis has been made. This statement of the dissolved impurities is not given by reason of any danger from such substances direct, but to establish from the result of the analysis whether organic matter is present or not; whether, if present, it is animal or vegetable; and if animal, whether of old or recent origin.

The impurities in suspension dangerous to health are pathogenic bacteria, and the ova of parasitic worms. Other forms of suspended impurities, mud, sand, grit, decayed vegetable matter, etc., are the cause of turbidity —a frequent result of tropical rain.

The latter class of suspended matters do not directly produce disease in man, yet, for general reasons, *e.g.* palatability, appearance, etc., they are usually removed prior to use.

Dangerous suspended impurities are invariably the result of improper disposal of the discharges of men and animals. Sewage in itself is not necessarily dangerous in water supplies, but it is the potential danger (the risk of infective organisms being in such sewage) which causes it to be prevented from entering water supplies in the raw state.

The *Bacillus coli*—the common intestinal bacillus—is present in all sewage matters, and this knowledge is made use of by bacteriologists. They use the *B. coli* 'content' as an index of contamination of a water. "Good" waters are those which do not show *B. coli* in 100 c.c. (cubic centimetres).

In the words of Dr Houston, the *B. coli* quantitative tests for excremental pollution directly measure the quality of water as regards undesirable germs, and indirectly its potential ability to cause disease.

As will be seen later, impurities may be:—

(1) Derived from the source;
(2) Added during transit;
(3) Acquired during storage; and
(4) The result of faulty distribution.

The chief diseases which may be directly water-borne are cholera, dysentery, enteric fever, ankylostomiasis, bilharzia, and Guinea-worm.

It has been definitely established that pathogenic bacteria do not flourish in water, but tend to lose their vitality, therefore recent contamination by sewage matters is the most dangerous.

Mental and physical weakness are the direct effects of an insufficient supply of water.

Collection, Storage, and Delivery.

The question of a town's water supply is an engineering one, but as the inspection of existing supplies, so far as they might be 'channels of infection,' comes within the varied duties of the Sanitary Inspector, he should be familiar with the general arrangements made from catchment area or other source to final distribution.

The various sources, methods, and systems of water supply met with in different parts of the tropics recapitulate in one stage and another the evolution of the present-day systems used in connection with municipal water supplies of large cities in temperate climates.

Villages and towns in primitive districts are always found by the side of some natural water supply, either rivers, lakes, streams or springs, or in situations where large quantities of water may be obtained by sinking wells.

The collection of water is either from a defined catchment area, an impounded stream or spring, or pumped from a river into storage reservoirs.

From a catchment area the water flows in conduits or channels into an impounding reservoir, and from there by pipe-line to the service reservoirs. If purification is necessary, the water goes to settling 'tanks' and filter-beds, prior to running into the service reservoirs.

The iron pipes used in connection with water supplies, varying in size according to requirements, are usually treated by some special process, such as Barff's or Dr Angus Smith's, to prevent rusting. They are laid at an average depth of 3 ft.

In places where the wet and dry seasons are well defined, the storage of large quantities of water in the impounding reservoirs is necessary to meet the requirements during the dry season. If not, a shortage of safe water may occur, resulting in polluted sources being used.

The impounding reservoirs or dams have earthwork retaining embankments. They vary in size according to the storage required: this is ascertained by the use of Hawksley's formula:—

$$\text{No. of days' storage} = \frac{1000}{\sqrt{F.}},$$

F. = the mean annual rainfall in three dry years.

Service reservoirs are relatively small, holding a few days' supply, and constructed near to site of distribution. They are: (1) usually below ground; (2) constructed of impervious material; (3) rectangular in shape and divided into compartments to facilitate cleansing; (4) roofed over if in the vicinity of towns and provision made for ventilation, light, and access; (5) provided with an inlet near the top and outlet near the floor on opposite sides, a "wash-out," and necessary sluice valves and overflow pipes.

Distribution is by gravitation, or the water is pumped to a water tower of sufficient height, and from there is supplied by gravity to the town.

In some municipalities the public obtain all their water from the stand-pipes in the street; in others, the drinking-water only is obtained from the stand-pipes, and water for other domestic purposes is pumped from shallow wells in the yards of their houses.

In settled districts the methods in vogue are similar to those at home, *i.e.* the water is (by pipes) laid on to the houses on the constant or intermittent system.

From every point of view in a tropical country, especially a malarious one, the constant system is the better one. That abomination of the tropics, the 'storage tank,' is eliminated, and the shallow well danger need no longer exist, for the wells can be forthwith filled in on publication of the necessary Ordinance.

Small villages and country districts depend largely on streams, springs, and wells as sources of supply.

On agricultural estates and plantations, the drinking-water is obtained either from: (1) a jungle catchment area by pipe-line; (2) wells or springs in the district; (3) rivers or streams; or (4) rain-water. As a rule, where the supply is questionable, purification is carried out by the application of heat or filtration.

Whichever system is in use, the governing factor is usually a financial one.

No mention in a work of this kind need be made of the various fittings connected with distribution, excepting that they should be the best procurable.

Fig. 77 is a diagrammatic sketch to illustrate the collection of water supplies.

FIG. 77.—Diagrammatic Sketch illustrating Collection of Water Supplies.

R. Upland Reservoir or Lake. H.L.R. High Level Reservoir, or Settling Tank. F.B. Filter-beds. S.R. Service Reservoirs.

The supply of a safe and potable water includes:—

1. Selection of sources.
2. Protection of supplies at source.
3. Protection during collection, storage, and distribution.
4. Purification of supplies where necessary.

Selection of Sources.—This is usually done by engineers of the Public Works Department in conjunction with the Medical Officer of Health of the district. In selecting supplies, apart from the question of 'yield,' a catchment area that will supply by gravitation methods and has an uninhabited gathering ground is of prime importance.

If from an impounded stream, the banks for a considerable distance above the dam should either be fenced or suitably policed. The guiding principle in all cases is the chance or chances of fæcal pollution.

On gathering grounds there should be no habitation or ground cultivation, and grazing of animals should not be permitted. The collection of the water is provided for by land drains and channels laid to intercept surface flows. These channels connect up to a main drain leading to the impounding reservoir.

Rivers used as supplies are practically always purified by storage and filtration before being supplied to towns. The intake is selected as far away as possible from any source of pollution, for in addition to the fact, already mentioned, that the more recent the contamination the greater the risk, it is also true that the greater the dilution of such pollution the less will be the danger.

In selecting springs and wells as sources of supply, an inspection of the surroundings is necessary, and with regard to wells their general construction should be noted. In examining wells, remove the cover and note the sides for evidence of subsoil pollution: also the depth of water and distance from water to ground-level, condition of steining (*i.e.* lining), coping, cover, and pump.

It should be remembered that it is impossible to say whether a water supply is good or bad, simply by looking at a sample of the water. Analyses are usually done—both chemical and bacteriological. These are lengthy processes, taking five or six days to do thoroughly, and though a good indication as to whether a water is safe or not, they are not sufficient. No analysis will indicate chances of pollution; this can only be done by an examination of the source and its surroundings.

Protection of Supplies.—Rain-water is protected by having a clean catchment area and storage vessels.

Upland surface waters are usually good supplies, being free from contamination. The catchment area is protected, where necessary, by fencing or efficient policing. If isolated houses or estates exist in the area, the proper disposal of waste matters should be ensured.

Rivers and streams vary enormously as regards purity. Methods of sewage disposal of towns and villages on their banks are usually known, also the distance of intakes from disposal works, and purification is carried out where necessary.

Well water varies in purity according to: (1) the condition of the surrounding ground; (2) protection at the mouth of the well; (3) condition of the steining; and (4) depth. All wells are liable to surface contamination and subsoil drainage, if not properly protected.

Artesian wells in inhabited districts require impermeable linings.

Protection of a well embraces proper steining in brickwork and cement down to the water-level, or impermeable stratum in the case of a deep well; a backing of cement concrete to a depth of 12 ft., and, below that, puddled clay; a coping to raise the mouth of the well; an access cover, benching, and means of pumping the water. In the case of a well used as a common supply, it should have a fenced area of 25 yds. diameter enclosing it. Proper disposal of excreta, and sewage matters generally, from houses in the vicinity of wells used as supplies, is a necessity.

With regard to the methods of raising water, it should be remembered that the ordinary suction pump has a maximum lift of 25 to 30 ft.; in a well beyond that depth the valves of the pump require to be staged within 25 ft. of the normal water-level, or the more expensive bore-hole pump is made use of. Failing suitable pumps recourse has to be made to the pernicious system of bucket and windlass.

The following diagram, Fig. 78, illustrates the requirements of a properly protected well. It will be noted that a pipe leads from the pump to a storage tank outside the fenced area, where the well water may be drawn off. In this way pollution at the mouth of the well is avoided.

In country districts the following points should be

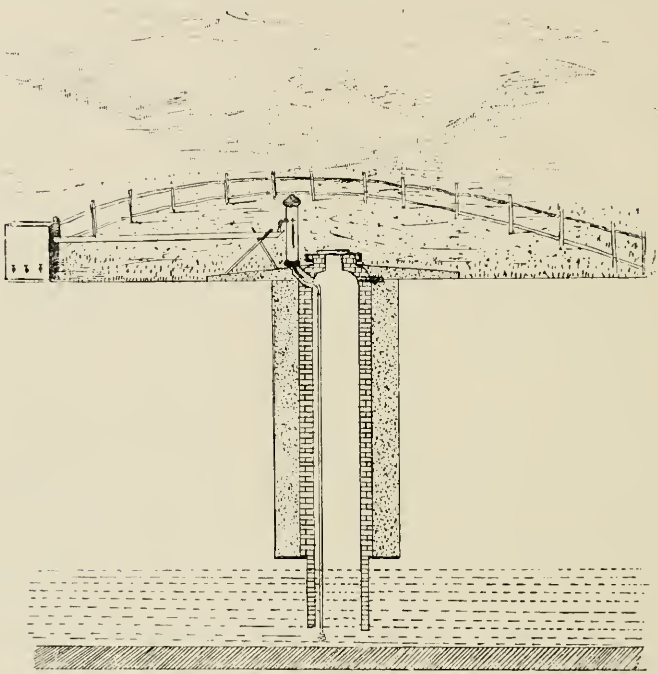

FIG. 78.—Illustrating a Properly Protected Well.

noted when considering the suitability of a well as a source of supply :—

1. Opinion of the local inhabitants.
2. Interpretation of the analyses of the well water.
3. Means of prevention against surface pollution.
4. Depth of the well—whether surface or deep well.
5. Depression caused by pumping, and time required to regain original level.
6. Distance from possible source of pollution.

7. Slope of ground, from or towards such source.
8. Methods of sewage disposal of all houses in the vicinity, and position of cesspools, if any.
9. Means available for drawing water.

Springs are usually good supplies; water obtained from this source, although in some cases coming from the same stratum as water tapped by shallow wells, undergoes a greater degree of filtration in its passage through the soil to the natural water outlet. All springs are liable to surface contamination, and for that reason

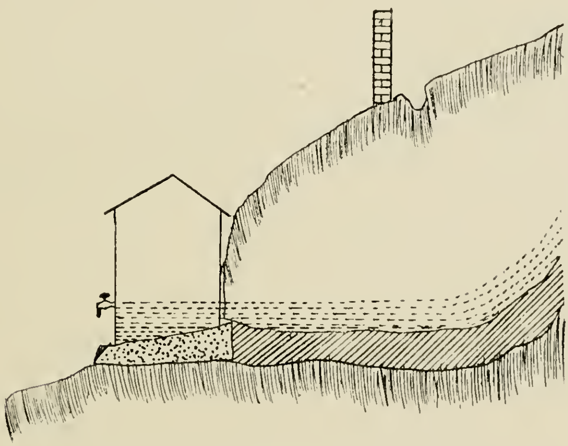

FIG. 79.—Protection of Spring.

protection from surface washings by trenching or the erection of a parapet, or both, is necessary where the likelihood of pollution occurring exists. Those forming part of town supplies are walled in, the spring-head filled in with sand, and the water piped to the service reservoirs.

In sparsely populated districts where springs are made use of, in addition to the protection mentioned the spring-head should be built in, and an overflow provided, or so arranged that the water constantly runs away, as shown in Figs. 79 and 80.

The construction of a miniature dam below the spring, which permits of the dipping in of promiscuous vessels, should be forbidden.

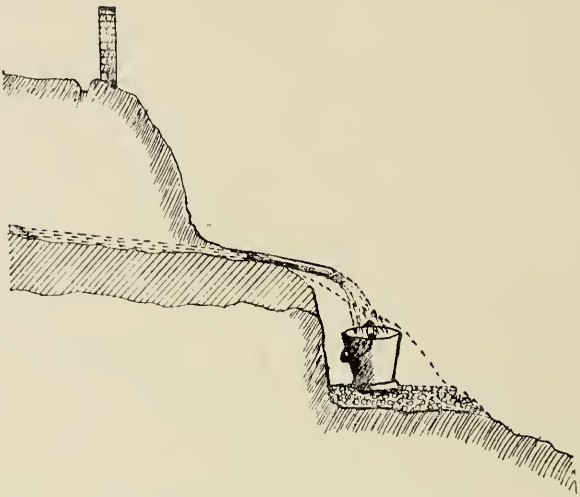

FIG. 80.—Improvised Protection of Spring.

Fig. 81 illustrates the 'tapping' and policing of a jungle catchment area.

Protection during collection, storage, and delivery aims at keeping out organic matters, especially those of animal origin. As already indicated, the main provisions are fenced catchment areas, impervious walls, etc., to reservoirs ; efficient storage, well-laid mains and branches, disconnection of the water-closet supply where such exists, and sound internal fittings.

Purification of Water.

It cannot be too strongly emphasised that a good water supply properly protected is a safer supply than one where protection at the source is neglected and purification solely relied upon.

Purification aims at the removal of suspended matters, and in some cases the removal of hardness for trade purposes.

FIG. 81.—Tapping and Policing of a Jungle Catchment Area.

[*Face p.* 156.

For the latter, "softening plants" are used, the basis of which is the addition of lime in solution to the supply in quantities governed by the degrees of hardness. The lime combines with the carbon dioxide and forms calcium carbonate, which is precipitated with the whole of the carbonates originally in solution. Usually 1 oz. of lime is added per 100 galls. for each degree of temporary hardness in the water. Permanent hardness is reduced by the addition of lime and sodium carbonate.

The removal of suspended matters, including organisms, may be carried out by: (1) sedimentation and storage; (2) precipitation; (3) straining or filtration; (4) clarification and the application of heat; and (5) clarification and the addition of chemicals. Other methods not yet in practice on a large scale are the application of ultra violet rays, and the production of ozone by electricity.

1. *Sedimentation and Storage.*—This is by far the simplest method, and when the necessary precautions are taken it is usually efficient. The customary period of storage is thirty days, during which time the solid particles and bacteria fall down. According to a report on experiments with Thames water by Dr Houston, the latter die out. Another observer, Dr Coplans, has more recently stated that the organisms do not necessarily die, but may agglutinate and adhere to the gross sedimented matter and sides of the storage chamber. For this reason care should be exercised in drawing off such stored water so that the bulk is not agitated or the sedimented matter disturbed.

2. *Precipitation.*—This is done by the addition of chemicals, usually alum, to form a precipitate which in falling entangles suspended matters, bringing them down with it. Alum in the presence of sodium or other carbonate forms aluminium hydrate in the water, a colloidal precipitate. One grain of aluminium sulphate per gallon of water is sufficient; in soft waters it is necessary to add half a grain of sodium carbonate per gallon, to form the required hydrate. They should be

powdered and thoroughly mixed with the water. The removal of all organisms by this method is not to be relied on.

3. *Straining or Filtration.*—This is the most common method of dealing with doubtful supplies.

Small quantities of water may be strained, to remove gross suspended matters only, by some improvised apparatus, such as passing it through cloths of fine texture, with the addition of alum, if necessary, to improve the clarification. This method, in the case of doubtful waters, should be merely a preliminary to boiling or the addition of chemicals.

Filtration on a large scale is carried out in connection with town supplies. Sand and gravel are used as filtering media. In some towns the new practice of sedimentation and storage, followed by filtration, is being adopted. This is based on the work of Dr Houston and others in connection with municipal supplies, where they depend on the water reaching the filter-beds as a result of storage in a reasonably safe condition antecedent to filtration.

Filter-beds are rectangular pits varying in area (usually such a size that one can be skimmed in a day), but of an average depth of about 8 ft. The containing walls and floors are impermeable. The pits are filled, from above downwards, with 3 ft. fine sand and 2 ft. of gravel, varying in coarseness and large at the bottom. The water after passing through the sand and gravel is collected in earthenware drains and run to the service reservoirs.

The usual head of water on the bed is from 1 to 2 ft., and the rate of flow through the beds 4 ins. per hour, giving a delivery of 60 galls. per square foot or 2,000,000 galls. per acre of filter-beds per day. From 90 to 99 per cent. reduction of organisms is obtained by this method.

The efficient working of a sand filter depends on the formation of a slimy layer—a zooglœa mass—on the surface of the sand, consisting of suspended gross matters, water organisms, and bacteria. An increased head of water, and consequent breaking up of this layer, interferes with efficient filtration. In time the layer reduces the output of water so much that it has to be removed by skimming off the top half-inch of sand. When by repeated skimming the sand is only 18 ins. deep, the filter is thrown out of action and the bed remade, for it is found that below this limit the arrangement of the materials is apt to be disturbed by the weight of the men engaged in scraping the bed. After the bed is remade it is filled with water slowly from below upwards until the requisite head is obtained, and until an efficient scum or layer is formed the filtrate is not directed into the storage reservoirs. The 'life' of a sand filter-bed varies according to the state of the water and the atmospheric conditions.

The actual purification of the water is found to take place at or near the surface of the sand. The remainder of the sand is more or less a reserve of filtering material. It is doubtful if the gravel plays any part in the purification of the water: it simply prevents the escape of sand through the drains at the bottom. Fig. 82 shows a filter-bed in the making, and Fig. 83 a diagrammatic section.

Sand filters have been described as mechanical devices which bring 2½ to 5 pints of filtered water to the same plane of bacteriological quality as 1 oz. of unfiltered water.

Various inventions to take the place of sand filters are on the market: all claim certain advantages over the older method. There are (1) graded filters from coarse to fine, *e.g.* Puech-Chabal system; (2) mechanical devices for attending to and cleansing the materials, *e.g.* Jewell's, Bell's, etc. Most of these use some coagulant—chiefly alum.

As a rule, most water-engineers prefer sand filters where such are possible.

On estates where much sediment occurs in a water, an improvised clarifier on the lines of that shown in Fig. 84 will be found a useful preliminary to further treatment. It consists of a wooden framework on

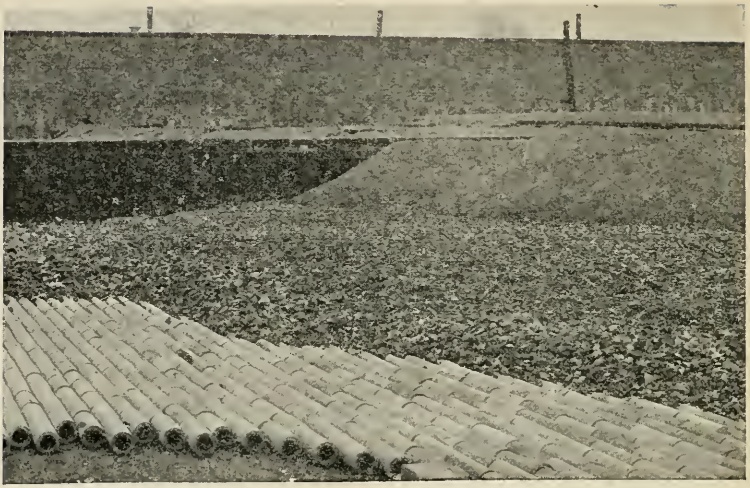

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FIG. 82.—The Making of a Filter-bed.

A filter-bed in course of construction, showing how a water supply is filtered. The water has to pass through a layer of fine sand, then fine gravel, then coarser gravel, before it finally runs into the pipes which convey it to the taps.

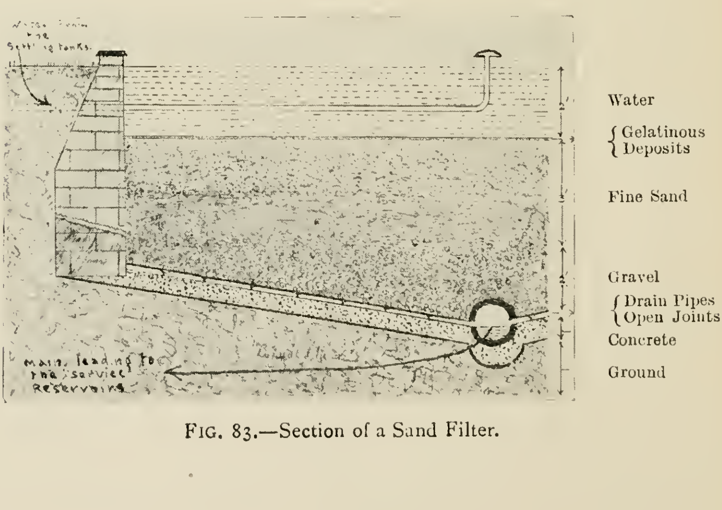

FIG. 83.—Section of a Sand Filter.

which is pouched ordinary sheeting. The water, dosed with alum, is poured on to the sheets. It passes through under its own 'head' to a trough, down which it runs to a small storage tank.

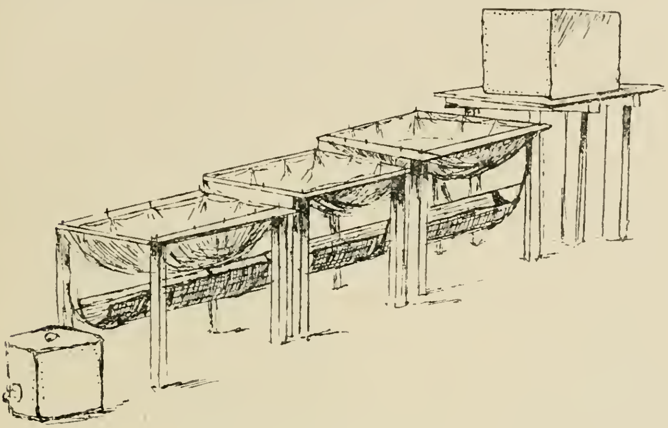

FIG. 84.—Improvised Clarification of Turbid Waters.

Domestic Filters.—Various makes of these filters are in use in the tropics. The best are the bougie or candle filters—sand filters in 'tabloid' form. The filtering tubes are made of kieselguhr, porcelain, or earthenware. When in use they are enclosed in metal

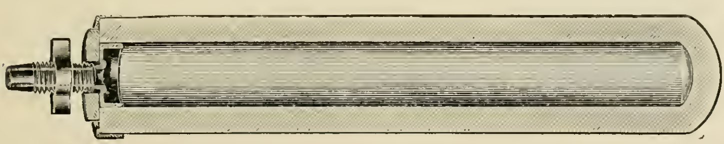

FIG. 85.—Section of 'Berkfeld' Filter Tube.

These filtering cylinders or candles are completely closed at one end, and the other end is fitted into a metal mount. The water passes through the walls from outside to the inside, leaving all impurities on the external surface, and then out through the small aperture of the mount.

jackets, and the water either passes through the material under its own 'head,' as in the drip filter, or under pressure from the main, or created by a pump.

Fig. 85 shows a longitudinal section of one of the Berkfeld filter tubes.

Fig. 86 shows a section of a 'Drip filter,' and Fig. 87 is a section of the ordinary type of pump filter, in general use in the tropics.

In these filters the suspended matters are retained on the outside of the candle and form a slimy coating: they require frequent cleansing with a loofah or soft brush. To guard against the growth of organisms

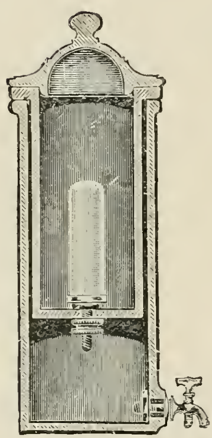

Fig. 86.—Section through 'Drip' Filter.

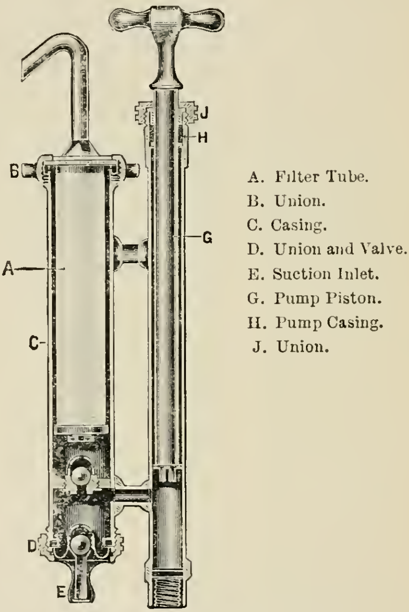

Fig. 87.—Section of 'Pump' Filter.

through the material, the tubes should be boiled every third day, *i.e.* they should be sterilised, otherwise contamination of the filtrate will occur if used with polluted waters.

For dealing with relatively large quantities of water, multiple filters, *i.e.* batteries of candles, are used.

Doulton's, Pasteur-Chamberland's, and Slack and Brownlow's filters are other types met with.

No matter which pattern may be in use, all fail to deal with turbid waters: they rapidly clog, and therefore previous rough clarification is necessary.

It is important to remember that, where the use of these bougie filters is relied on to give a safe water, their care should never be entrusted to a native servant.

The disadvantage of these filters is that they fracture with rough usage, and, on many, the line of fracture is invisible to the naked eye, and can only be detected by submitting them regularly, say every week, to a test by internal air-pressure. It may be carried out as follows:—Soak the candle in water for five minutes, then connect the open end to a bicycle pump by means of a piece of rubber tubing. Leave the candle immersed in the water, and slowly pump air in until it is seen to escape through the pores of the material. Note the size and formation of the bubbles: if sound, there should be fine bubbles issuing from the surface of the candle. Cracks and weak joints, a common fault in candle filters, can be detected readily, as a line of large bubbles will rise from the defective place before rising generally.

The charcoal filters, still to be met with in the tropics, are useless, because, although acting for a time as clarifiers, they favour the growth of organisms, and after being in use some time, they give a filtrate containing more bacteria than the ingoing water. In all government departments they have been replaced by the more modern type of candle filter.

Improvisation of miniature sand filters should not be relied upon to provide a safe water, even in small quantities, such as might be required on estates or isolated institutions. One of the methods described by some authorities consists of placing one barrel within another, and filling the interspace with graduated gravel and sand from below upwards. The inner one is perforated at the bottom, and the water to be treated, poured on to the sand, percolates through, rising in time to its own level.

The writer has had an extended experience with improvisation of filters, but has had no success with the method described. The filtering surface is extremely small.

Using one cask (56 galls.) as a filter, as sketched in Fig. 88 (where the surface area is 3·5 sq. ft.), with a slightly turbid water, delivery was very slow. It ceased after 20 galls. had passed through in three hours. The sand and gravel were carefully washed before commencing the trial, but the reduction in organisms was practically *nil.*

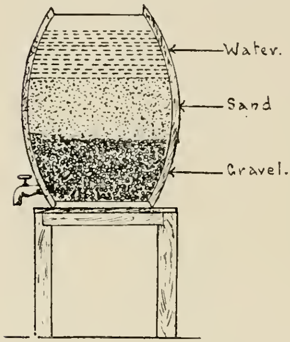

FIG. 88.—Improvised 'Cask' Filter.

It should be remembered that a true filter, as applied to water, is one capable of removing the micro-organisms, and giving a germ-free water.

Summarised, the efficient working of any filter—improvised or otherwise—is governed by fixed laws, both with regard to quantity and quality.

The factors operating are :—

1. Area of the filtering surface.
2. Porosity of the filtering medium.
3. Condition of water to be treated.
4. Head of water, or pressure at which it is put through.

Other things being equal, the first governs delivery, and the second, third, and fourth largely govern the quality of the filtrate; with the second the delivery is in inverse ratio to the density; with the third the delivery is in inverse ratio to the amount of turbidity; and with the fourth the delivery is in direct ratio to the head or pressure applied.

Application of Heat.—This aims at killing the infective organisms existing in a water. It is carried out by distillation, boiling, or heating in a special apparatus to such a temperature as will kill pathogenic bacteria. Whichever method is in use, clarification is a necessary preliminary with turbid waters.

Distillation is usually carried out on board ship, but rarely elsewhere, to provide a potable water. The cost of a plant sufficient to deal with large quantities would be prohibitive.

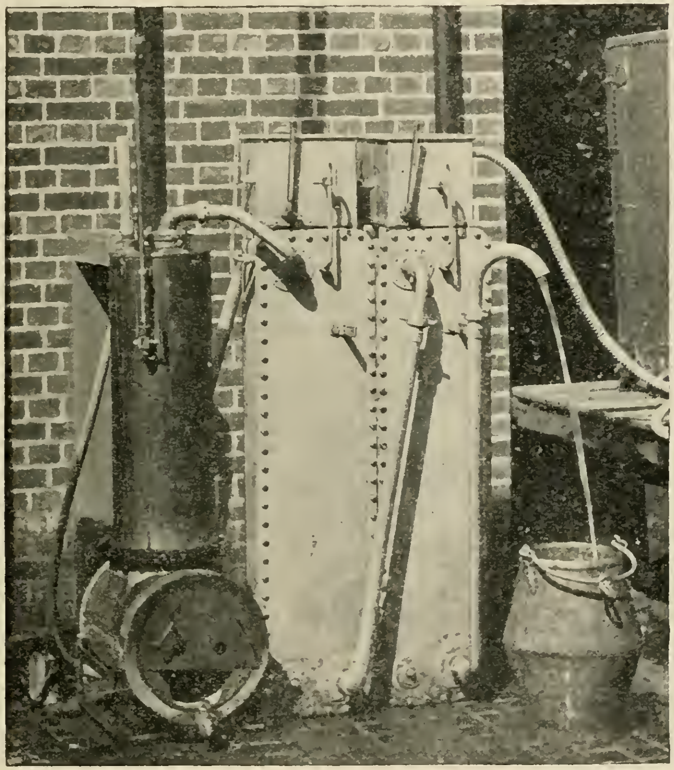

FIG. 89.—" Griffith " Water Purifier.

Boiling kills bacteria in a water. At first sight, therefore, it appears a simple and efficient method. Such is true applied to small quantities, but many difficulties present themselves when dealing with large bulks, *e.g.* prime cost of apparatus, large amount of fuel required, and the problem of cooling the water.

Various apparatus are on the market designed on the heat-exchange principle, to overcome the objections to heat methods. The Lawrence's, Forbes's, Royles', and Griffith's are examples of these machines. The advantages of a heat-exchange attachment are: (1) economy of fuel; and (2) low temperature of the water issuing from the apparatus. In a heat-exchange chamber the ingoing water is separated from the outgoing hot water by a thin sheet of metal, or, as in some machines, the chamber is packed with thin tubing. The ingoing water passes through the tubes, and the outgoing water surrounds them.

An exchange of heat takes place between the waters through the dividing metal. The hot water, giving up its heat to the cold, becomes cool; the cold water, receiving such heat, becomes hot. Thus the necessary amount of fuel that would have been required to heat the ingoing water to the temperature attained is saved.

Recognising the fact that organisms of water-borne diseases are killed on a few seconds' exposure to a temperature of 80° C., Dr Griffith has designed an apparatus in which the treated water is automatically discharged through a heat-exchange chamber when it reaches the temperature named (Fig. 89). It has been a success in dealing with relatively small quantities (200 to 400 galls. an hour), but has not yet been tried on a large scale.

Addition of Chemicals.—That certain chemicals will sterilise a water, is now definitely established; but in considering their general use, certain standards should be borne in mind. These are:—

1. They must not be costly.
2. They must be simple to use.
3. They must kill germs quickly (10 to 20 minutes).
4. They must be non-poisonous, and should give no objectionable taste or smell to the treated water.

Permanganate of Potash.—This substance is useful, but takes some two or three hours to kill organisms. For this reason it is unreliable, except where storage for twenty-four to forty-eight hours can be carried out. Sufficient is put into water to make it distinctly pink.

Chlorine.—This is a very powerful germicide, and has given very good results. It may be obtained in several ways; the best is in the form of bleaching powder, of which 33 per cent. is available chlorine. One part of chlorine in 2,000,000 parts of water will kill pathogenic organisms, providing no turbidity is present.

It was used for treating contaminated water in reservoirs at Lincoln in 1905, during a water-borne epidemic of enteric fever, with excellent results.

Three parts of bleaching powder per 2,000,000 parts of water are required for efficiency. This is obtained by using 12½ grains per 100 galls. of water.

It should be made in a concentrated solution first, then stirred into the water, and left at least for twenty minutes before use. Used in these amounts, no appreciable taste is given to the water.

Where the water can be stored for, say, twenty-four hours, double quantities should be used, as after that period the taste is inappreciable, and a margin of safety is ensured.

Iodine, *Bromine*, and other chemicals have been tried, but the majority are complicated to use, and give an unpleasant taste to the water.

An ideal chemical would be one answering to the standards given, and in addition capable of precipitating gross suspended matters. Such a substance has not yet been found.

The other methods mentioned (see p. 157) are still in the experimental stage, although it has been demonstrated that they are capable of killing organisms in clear water. The presence of turbidity in any degree renders them useless.

In settled districts an Inspector's duties with regard to water supply are usually limited to the inspection of house connections and public stand-pipes. In primitive districts he may be concerned with the general supervision of supplies, particularly in guarding against pollution of springs, streams, and wells. Details regarding the collecting of water samples for analysis are given in the Appendix.

Officials working in malarious districts are here again reminded, regarding anti-mosquito work, that not only is a proper water supply desirable, but a properly controlled system of disposal is an absolute necessity, and the larger the supply the greater the effort required to accomplish it.

CHAPTER IX

FOOD

A SUFFICIENCY of good food is another sanitary necessity, and the fitness of articles intended for food of man has to be determined largely by the health officials, amongst whom the Sanitary Inspector plays no small part.

This subject may be conveniently dealt with in two parts: (1) the physiological aspect of food, or its action on the body; and (2) diseases communicable to man by food. The former, concerning the Inspector as an individual and possible educationalist only, is briefly summarised; and the latter, concerning him as an official, is more fully dealt with.

Physiological Aspect of Food.

Food has been defined as "Anything which, when taken into the body, is capable either of repairing its waste, or of furnishing it with material from which to produce heat, or nervous and muscular work": *i.e.* food to the body is as fuel to an engine.

Thus it will be seen that food has two main functions: firstly, to provide for the growth and repair of tissues; and secondly, to act as a source of energy which can be converted into heat and work.

Varying factors, such as atmospheric temperature, altitude, etc., govern to a certain extent the quantity and quality of food suitable to one's need; but diet is based mainly on the amount of work an individual has to do, and is composed of a mixture of foods simply to give variety. All the varied forms are broken up, when inside the body, into simpler ones, some carrying out the first, and some the second of the functions mentioned.

Food Constituents.—These may be classified into: (1) those that contain nitrogen; (2) those that do not contain nitrogen, but contain (*a*) starch and sugar, or (*b*) fats, animal or vegetable; (3) salts; and (4) water.

1. *Nitrogenous Foods* (*proteid*) alone build up and repair tissues. Energy is supplied by both nitrogenous and non-nitrogenous foods. In other words, nitrogenous foods may fulfil both functions: without them life is impossible. The main supply is from flesh, milk, cheese, eggs, and the pulses. They contain little of fats, starches, or sugars.

2. (*a*) *Starches and Sugars.*—These constituents are classed together because they are chemically similar: the heat and energy from these sources are stored up in the body fats. They are obtained chiefly from grain foods such as bread, potatoes, flour, cane sugar, etc.

(*b*) *Fats.*—These are sources of heat and energy also; they build up the fats in the body, and are taken in the form of butter, meat, oils, margarine, etc.

To a certain extent (*a*) and (*b*) are interchangeable in the body. In diets where starches and sugars are deficient, fats may be substituted, and *vice versa* to a lesser extent.

3. *Salts* are essential to health. Various salts are present in the body, such as calcium, iron, sodium, potassium, and phosphorus. These are taken into the body in small quantities with the food. Vitamines are an active principle in fresh foods; the absence of this leads to threadbare tissues, and, it is said, scurvy results.

4. *Water.*—Apart from that taken as a beverage, water is a large constituent of foodstuffs, and is necessary for the solution and conveyance of food to the various parts of the body, and also for the excretion of residual and useless products.

The value of a food as a source of tissue-building material and energy may be obtained by chemical analysis, but it is usual to estimate the energy value of a food by means of the amount of heat produced when it is completely burnt or oxidised. There is a definite relation between heat produced and work done.

The standard employed is the amount of heat which is required to raise 1 lb. of water 4° F. (or 1 kilo. of water 1° C.). This unit is called a Calorie (capital C, to distinguish it from the small calorie, which is the amount of heat required to raise 1 gramme of water 1° C.). In comparing food values the number of Calories yielded per gramme (15·5 grains) of food completely burnt is usually ascertained. Factors are commonly used for converting analytical results into terms of Calories, instead of direct estimation by a calorimeter: *e.g.*, Proteids and Carbohydrates × 4·1, Fat × 9·3.

Man's work expressed as energy varies according to work done; on an average, for a man at rest it equals about 410 Calories; but the body requires more than this amount in the form of food, for only one-sixth of the energy in food is capable of being transformed into work, the rest being lost in the form of heat. Therefore a man must have food in sufficient quantity and quality to produce or yield 2500 Calories in his body per day. This amount of energy is contained in 300 grains of nitrogen, and 4000 grains of carbon; or, expressed in terms of food constituents: nitrogenous foods, 4 ozs.; fats, 2 ozs.; starch and sugars, 18 ozs.

These quantities are contained in an ordinary diet.

Dr Hutchinson in his book, *Food and the Principles of Dietetics*, says, regarding diet in tropical regions: "As the external temperature rises the amount of heat which the body requires becomes less and less, but already as little is being produced as is compatible with health, so that in order to adjust the balance one must not try to diminish the production by eating less food, but rather to increase the loss by wearing thinner clothes. In harmony with this, one finds as a matter of fact that the consumption of food by the inhabitants of the tropics is not notably less than that of those who live in the temperate zone." In a footnote he points out the chief differences: "The diet of tropical dwellers usually contains relatively less proteid and fat, and more carbohydrates, especially sugar."

The following diet, given by Dr Prout, C.M.G., is considered a suitable one for a native doing a moderate amount of physical work:—1 lb. maize or yam, 12 ozs. rice, 3 ozs. beef or 8 ozs. fish, 5 ozs. greens, 2 ozs. palm oil, ½ oz. salt, and necessary condiments; to this diet 2 ozs. split peas or beans should be added three times a week.

The purse is the governing factor in the choice of foodstuffs forming a diet, but such a diet, whether of rich or poor, is based on the facts mentioned, and averages the same number of Calories for the same kind of work performed.

Diseases communicable to Man by Food.

These diseases may be divided into four groups: (1) Diseases which are common to man and animals whose products are used as food; (2) Food poisoning; (3) Diseases caused by eating food infected by infected persons handling it, by flies, dust, or infected water; (4) Diseases due to deficiencies in quality or quantity of food.

In the first group are diseases caused by different kinds of parasitic worms.

Tapeworms have two hosts; they attack animals in one stage and man in another. Some infest the ox tribe, others infect the pig. The ova or eggs are swallowed by the animal and develop from this stage into embryos, which pass from the intestines and become encysted in the muscle fibre (such meat is known to butchers as "measly"). It is hard to detect such infection in animals during life, but in the carcass the cysts are well marked, and should always be looked for in fleshy parts.

Such meat, when eaten insufficiently cooked, is broken down and the embryos develop in man's intestines. These consist of numerous segments and a head; the head (Fig. 90) remains attached to man, but the segments containing the eggs are passed in his dejecta. Thus they get into sewage and eventually on land, where they are picked up by animals, and other cycles are commenced.

The common forms of tapeworm are, in the ox, *Tænia saginata*, or *mediocanellata;* in the pig, *Tænia solium*.

Fig. 90.—Head of Tapeworm.

Trichinosis is a disease caused by a worm which has a primal stage in pigs and develops in man. The cysts are sometimes seen in the flesh of pigs, and when such flesh, insufficiently cooked, is eaten by man the cysts are dissolved by the gastric juice and the worms are set free. They embed themselves in the muscle fibre and give rise to high fever.

It is a disease fortunately uncommon in many tropical countries. It can be prevented by (1) proper inspection to avoid encysted meat being exposed for sale, and (2) the proper cooking of meat. (A temperature of 150° F. kills the embryos, but this is not always reached inside a large joint.)

Tuberculosis may be communicated to man by animals in two ways: (1) in milk of tubercular cows, and (2) in the flesh of cows or pigs suffering from tuberculosis.

This disease has already been dealt with in Chapter III. It is now generally admitted that bovine infection occurs chiefly in children. It is of relatively infrequent occurrence amongst adults.

Malta Fever.—This is a disease spread by goats' milk. The goats act as carriers, but are otherwise healthy. Prevention consists of sterilising all milk from goats used as a supply.

Anthrax, often termed 'wool-sorters' disease,' is contracted by: (*a*) handling the hides or carcasses of animals which have died from the disease; (*b*) handling wool from animals suffering from anthrax; and (*c*) eating the flesh of such animals.

2. Food Poisoning. This was formerly known as ptomaine poisoning, but is not so described now, as it has been proved to be caused by an infection with germs, or by toxins which germs have pre-formed in the meat.[1]

The carcass from which the flesh (causing the poisoning) was taken, if found, often shows signs of disease; but it is not always possible to trace the remains.

Three or four different bacteria associated with this disease have been isolated. These bacteria present in the meat in some cases are not killed in the process of cooking, and in other cases they get into the meat after cooking, and enter the system when the meat is eaten cold.

Sausages, pork pies, and the like, and possibly diseased shell-fish also, are associated with this disease. The cases occur in definite outbreaks amongst a number of people; *e.g.* a house or a number of households served by one butcher.

The usual symptoms are, diarrhœa, vomiting, intense abdominal pain, and collapse, sometimes ending fatally. The incubation period may be from a few hours to three or four days.

To trace the source of infection, systematic enquiry is necessary. The food prepared for the various meals should be tabulated, and statements as to food consumed taken from all in the household, etc., whether infected or not. It will usually be noticed that the infected persons have partaken of some part of a meal in which the non-infected persons did not join.

The quality of tinned goods, if partaken of, should be carefully enquired into.

3. Food infected by (*a*) handling by infected persons; (*b*) flies; (*c*) dust; or (*d*) infected water.

Cooks, servants, and others, who are "carriers," may spread diseases such as enteric fever, diphtheria, etc., by infecting food handled by them. The part

[1] Ptomaines only occur in meat undergoing putrefaction.

played by flies and dust in food infection has already been explained.

Infected water may contaminate food in a variety of ways: by washing dishes, milk vessels, and the like, in infected water, or by growing vegetables in such water.

Diphtheria may be spread by milk coming from a dairy where a case exists; milk is an excellent culture medium, and for this reason great attention should be paid to dairies and their staffs.

Protection.—Protect food before, during, and after preparation. Strict examination is necessary, and proper storage of food is of first importance.

4. Diseases due to deficiencies in quality or quantity of food.

(*a*) Starvation; (*b*) indigestion and like diseases; (*c*) a class of diseases the result of deficiencies of certain ingredients from foodstuffs, *e.g.* scurvy.

Scurvy is a wasting disease; the gums of patients bleed, ulceration of the skin appears, there is great pain in the bones and joints, and the tissues get "threadbare."

It attacks persons fed on a grain diet or on "preserved" rations, in which, therefore, the absence of certain substances which are present in fresh meat, vegetables, etc., is evident.

Prevention consists in providing fresh food, jams, pickles, and leaves and roots of vegetables.

Beri-beri is a disease having symptoms similar to those of scurvy, and has always been associated with the eating of milled rice.

Regarding beri-beri, at the International Congress of Medicine, 1913, held in London, the 'Section of Tropical Medicine and Hygiene' passed the following resolutions:—

> (1) The Section is of opinion that beri-beri among natives who live principally on rice is brought about by the continuous and too exclusive use of rice submitted to a too complete milling, which removes the cortical layers of the grain.

(2) The Section urges all authorities charged with the health of native communities to restrain by every means in their power the use of this rice in the dietary of coolies.

(3) In view of the proved non-infectiousness of beri-beri the Section suggests that all port and sanitary authorities should abolish foreign quarantine and other restrictive measures against this disease.

Pellagra is a disease which attacks "field workers," and has been associated with maize.

Notes in connection with Animals whose Products are used as Foods.

Cattle, sheep, goats, and pigs are the more common animals whose products are used as food of man.

In connection with these animals, many terms are used with which the Inspector should be familiar.

Their usage differs in some places, but the following are the generally accepted definitions :—

'Beast,' may mean a bovine of either sex.

'Calf,' a young animal, *i.e.* up to twelve months.

'Stirk,' an animal older than a calf, but younger than a heifer or bullock.

'Heifer,' an animal which has calved once.

'Cow,' an animal which has calved twice.

'Bullock,' a young castrated bull.

'Steer,' a 'bullock' when two and a half years old.

'Lamb,' a young sheep up to six months old.

'Hog,' a term used to describe a young sheep from six to twelve months old, but more frequently used in relation to a castrated boar (male pig).

'Wether,' a castrated ram.

'Ewe,' a sheep which has had lambs.

'Gilt,' a female pig up to the time of having young.

'Sow,' a female pig that has had young.

'Offal.'—(*a*) Beast—includes the skin, head, and tongue, internal organs, and fat and feet. (*b*) Sheep—includes the skin, head, pluck, entrails, and fat. Pluck—the heart, lungs, liver, and spleen.

Roughly, the offal of any animal is about one-third of its total weight.

In examining animals their general condition should be noted, and those which appear sick eliminated from the herd for further examination; and if for slaughter, particular attention should be paid to the carcasses and organs of such animals.

A healthy animal *looks* healthy, *i.e.* it looks contented and well fed. Its flesh feels firm and its coat is supple, glossy, and soft, and has often been described as having an 'oily feel.' Its eyes are clear and not watery, the lining of the nostrils is moist and red. The tongue does not protrude from the mouth. Its 'action' is easy, and it moves without pain. Breathing is regular and not laboured, and it is constantly "chewing the cud." Its dejecta appear normal.

A sick animal looks miserable and distressed. Its coat is tight, dry, and rough, and has no gloss. There is often a discharge from the eyes, nostrils, or mouth, and from the latter a dirty tongue usually protrudes. Its general movements are slow and irregular, its breathing laboured.

In sheep, looseness of wool, dropping of the ears, and absence of the fatty secretion in the skin, should always be looked upon with suspicion.

Slaughterhouses.—The place where animals are slaughtered should be under the personal supervision of the Inspector, where no veterinary service exists. In most districts slaughterhouses are built on modern lines. The floor should be of impervious material, and so laid that it drains into a trapped gully outside, where a water-carriage system of sewage exists, or to a surface drain leading to a soak-pit.

The walls should also be of impervious material, and should, if not covered on the inside with glazed tiles or bricks, be whitewashed frequently. There should be an efficient water supply properly protected, and provision for lighting and ventilation.

Adjacent to the slaughtering room, lairs for cattle, etc., awaiting slaughter should be arranged for, which should be so constructed that the animals do not see slaughtering in process.

Receptacles for refuse and dung should be provided, also a small incinerator, in which diseased or unwholesome meat, blood, etc., not required for trade purposes, may be burnt.

The situation of a slaughterhouse is a matter for local consideration; the usual minimum distance from a dwelling is 100 ft., but it is doubtful if any harm accrues from a well-conducted slaughterhouse being adjacent to dwellings.

With regard to the provision for ventilation, the simplest and best method is that of open windows and a series of louvres in the roof.

Animals are usually deprived of food for some twelve hours before being slaughtered. If overdriven before being slaughtered, they do not bleed well.

A butcher, with two assistants, will kill and dress a bullock in about forty-five minutes, and with one assistant will kill and dress a sheep in twelve to fifteen minutes.

Cattle are 'knocked down' with the pole-axe, mask and mallet, or other method. A cane is then passed, through the hole made, down the spinal cord. In the hands of a skilled butcher death is instantaneous. The animal is then bled, the jugular veins being cut through. The horns are cut off, and the head is skinned. The animal is then trussed up on its back, the legs are jointed off at the knees and hocks, and the skin removed.

The carcass is partly divided and wound up (*i.e.* raised). The urethra is removed, also the tail and offal.

Finally, the carcass is completely divided and wiped out, and is ready for issue, after inspection, in about twelve hours.

Calves are usually strung up by the hind legs and stunned by a blow on the head. They are then bled and dressed.

The method of killing pigs is similar to that employed in the case of oxen, but the carcass is not divided until ready for sale.

Sheep are killed on a cradle by being 'stuck' with a knife in the neck, severing the jugular veins, the neck is then broken, and the sheep bled. It is then placed on its back and skinned, the legs being jointed off. The animal is then hung up and dressed, the offal being removed and the carcass wiped out.

Goats are slaughtered in a somewhat similar way.

To enable routine inspections to be properly carried out, a system of marking the carcasses and their associated organs, head, hide, etc., should be in vogue, each butcher having a number allotted to him which he marks on the carcass and viscera by superficial cuts with his knife; and, in addition to his mark, the number of the animal 'butchered' is also marked on the carcass, etc. Given a butcher's number as two, and the carcass to be examined as the fifth he had killed on the day of examination, the marks on the carcass would be—

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and like marks on the head, stomach, liver, etc., would enable these parts to be examined also, and seized, should such a procedure be necessary.

Apart from the carcass, there are the head and tongue, the lungs and heart, the liver and gall bladder, the kidneys (usually left in the dressed carcass), the stomach (the four compartments of the stomach in the ox are called the rumen, the reticulum, the omasum, and the abomasum); the caul, the membrane which invests the viscera; and the mesentery, a fatty membrane which suspends the intestines in position.

The carcass, inside, is divided into two parts by the skirt or diaphragm, which separates the chest from the abdomen. The lining of the chest is termed the pleura, and that of the abdominal cavity the peritoneum.

The organs of the various animals, although resembling one another in general features, differ in many respects. Practical observation will enable the Inspector to distinguish one from another.

In connection with the humane slaughtering of animals, an Admiralty Committee, formed to report on the matter, suggested the universal enforcement of the following regulations :—

1. All animals without exception must be stunned, or otherwise rendered unconscious, before blood is drawn.
2. Animals awaiting slaughter must be so placed that they cannot see into the slaughterhouse, and the doors of the latter must be kept closed whilst slaughtering is going on.
3. The drainage of the slaughterhouse must be so arranged that no blood or other refuse can flow out within sight or smell of animals waiting slaughter, and no such refuse shall be deposited in proximity to the waiting-pens.
4. If more animals than one are being slaughtered in one slaughterhouse at the same time, they must not be within view of each other.
5. None but licensed men shall be employed in or about the slaughterhouse.

For the accomplishment of the above, municipal slaughterhouses are a necessity in the tropics, as elsewhere. In many towns, separate slaughterhouses are erected for killing and dressing (*a*) animals intended for native consumption; and (*b*) those intended for consumption by Europeans.

A knowledge of the various joints in a carcass will be found of service. Fig. 91 illustrates the method of dividing an ox as practised in the Government Services.

The two halves of a carcass are spoken of as 'sides'; each side is divided between the twelfth and thirteenth ribs into quarters. The 'fore' quarter, therefore, has twelve ribs, and the 'hind' quarter only one.

In the fore quarter are :—

1. The sticking piece.
2. The chuck rib.
3. The middle rib.
4. The fore rib.
5. The plate.
6. The brisket.
7. The 'leg of mutton piece.'
8. The shin.

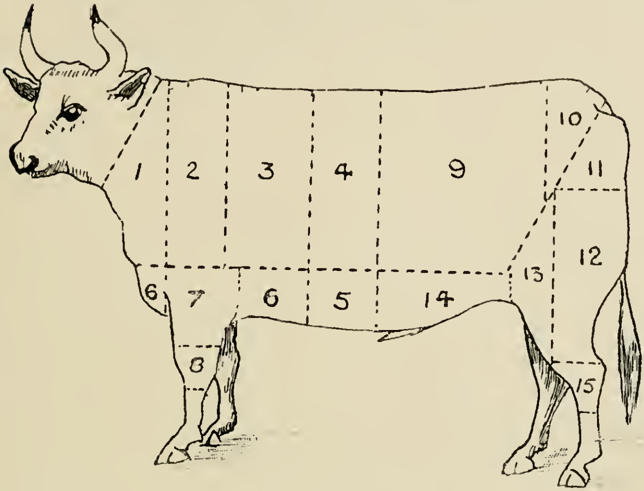


FIG. 91.—"Joints" of Ox.

In the hind quarter are :—

9. The loin.
10. The rump.
11. The aitch bone.
12. The buttock.
13. The thick flank.
14. The thin flank.
15. The shank.

A carcass of mutton is not divided until it is cut up for sale. The joints are (see Fig. 92) :—

1. Neck, scrag end.
2. Neck, best end.
3. Shoulder.
4. Breast.
5. Loin.
6 Leg.

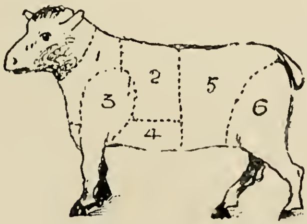
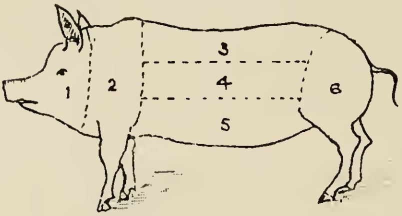


FIG. 92.—"Joints" of Mutton.

Goats and mutton are similarly jointed.

Pork also is usually hung whole, when dressed. The joints are (Fig. 93) :—



1. Head.
2. Shoulder.
3. Back.
4. Middle cut.
5. Belly.
6. Leg.

FIG. 93 —"Joints" of Pork.

The shoulder is usually divided into the 'spare ribs and blade bone piece,' and the spring-hand. The back also is divided into loin, best end ; and loin, chump end.

Glands.—By the Inspector, the importance of a knowledge of the situation of the most important lymphatic glands cannot be over estimated, for no inspection of a carcass may be considered complete until some of these glands have been examined.

Their condition usually confirms, but sometimes contradicts, external evidence of certain diseases, and in any case is a valuable guide to the examiner. When healthy, they are soft and 'springy,' and, on section, show a greyish brown tinting. Diseased glands may be 'cheesy' or 'gritty.'

Glands vary enormously in size (some being as large as a walnut, others as small as a pin's head), and are so numerous that only the most important of the superficial and deep-seated glands can be referred to here.

Superficial Glands.—In the head are the pharyngeal, sub-maxillary, and sub-lingual. The first at the entrance of the pharynx, the second in the cheek, and the third under the tongue (Fig. 94).

In the tissue between the lungs are the 'bronchial' (right and left), and the 'mediastinal' (anterior and posterior) (Fig. 95).

On the liver are the 'portal' glands (Fig. 96). Numerous 'mesenteric' glands are found in the mesentery.

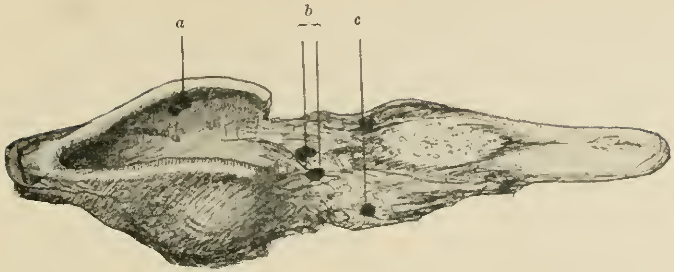


FIG. 94.—Head of Ox.

(*a*) Sub-maxillary Glands. (*b*) Pharyngeal Glands. (*c*) Sub-lingual Glands.

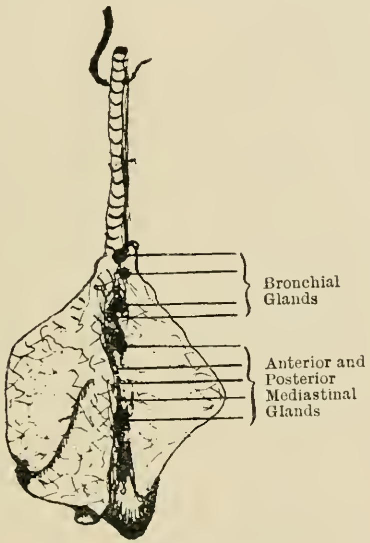


FIG. 95.—Lungs and Heart of Ox, showing Site of chief Glands.

FIG. 96.—Liver of Ox, showing Site of Portal Glands.

In the hind quarter are the 'inguinal,' situated in the male cod fat; or the 'mammary,' in the udder of the female.

The 'iliac,' at the entrance of the pelvis; the 'sub-lumbar,' close to the lumbar vertebræ. In the fore

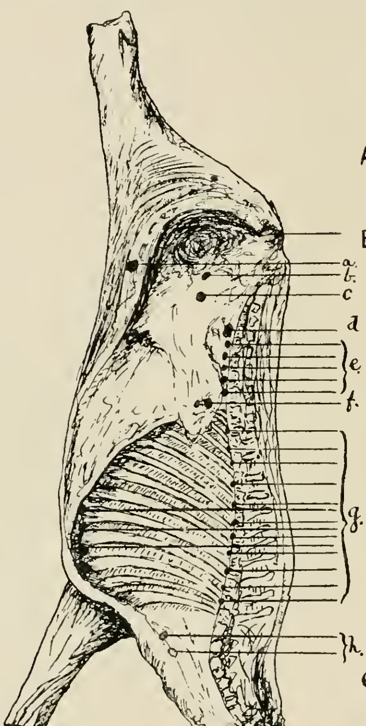


FIG. 97.—Showing Site of Glands in Carcass (inside view).

a, Deep inguinal glands (mammary, in cow). *b*, Deep inguinal glands. *c*, Iliac glands. *d*, Iliac glands. *e*, Lumbar glands. *f*, Renal glands. *g*, Thoracic and sub-sternal glands. *h*, Cervical glands.

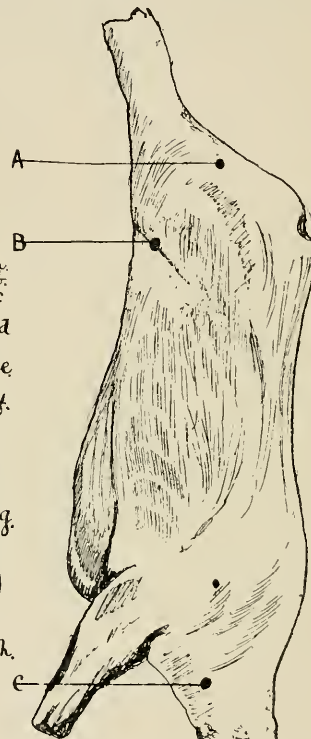


FIG. 97A.—Showing Site of Glands in Carcass (outside view).

A, Popliteal glands. B, Precrural glands. C, Prescapular glands.

quarter are the 'sub-dorsal' and the 'supra-sternal,' the former under the dorsal vertebræ, the latter inside the ribs above the brisket bone.

Deep-seated Glands.—The 'popliteal,' 'precrural,' and 'prescapula' are found in the centre of the buttock, in the flank, and at the point of the shoulder respectively. Figs. 97 and 97A show their relative positions in the carcass.

It will readily be seen that in many tropical regions a useful field of work lies before the Inspector who has a sound practical knowledge of this part of his work, in attempting to bring into line with modern ideals the varied practices of inhumane slaughtering of animals, slaughterhouse routine, methods of cutting up carcasses for sale, proper disposal of offal, and like matters.

Meat Inspection and Notes on Diseases of Animals.

The problems connected with food inspection in the tropics present few features other than those met with elsewhere. An inexperienced Inspector, therefore, before proceeding to take up his duties in the tropics, should attend some large abattoirs and markets, to gain that practical experience necessary to enable him to recognise diseased conditions met with in both the live animal and the dressed carcass. Although an attempt is made here to describe some of the diseased conditions likely to be met with, the numerous deviations from the usual signs can only be recognised by previous practical work.

It should be remembered that in primitive places there will be no veterinary or medical officer to refer to; the Inspector will have to act without hesitation, and his judgment, fairness, and honesty of purpose must never be in question.

It hardly requires stating, that the whole object of food inspection is to ensure that such food is "fit for food of man," and that it is not exposed for sale when "diseased, unwholesome, or unsound." As the major portion of this branch of an Inspector's work concerns meat inspection, it necessarily follows that the normal conditions of a healthy carcass and viscera should be well understood.

This was emphasised by a Royal Commission in 1898 (on tuberculosis). They recommended, with regard to meat inspection, that an Inspector should pass an examination in :—

1. Law of meat inspection, including byelaws and regulations in force.
2. Names and situation of the organs of the body.
3. Signs of health and disease in animals destined for food, both when alive and after slaughter.
4. Appearance and character of fresh meat, organs, fat, blood, and the conditions rendering them, or preparations from them, fit or unfit for food.

Characteristics of Good Meat.—Good meat is firm, elastic to the touch, and not 'doughy.' It does not pit. It has a dry surface, and except in the case of lamb, pork, and veal, is red in colour. It has an agreeable odour and, in section, a somewhat marbled appearance. The fat should be firm, and white or pale yellow in colour. The reaction of good meat is faintly acid.

It should be remembered that in the tropics meat goes bad quickly. It is usually eaten within twelve hours after the animal is killed.

Pork, veal, and lamb, the so-called 'white meats,' are pale pink in colour.

Frozen meat has not the characteristic bright colour of fresh meat: it is usually paler. It is cold to the touch and somewhat moist. Carcasses, quite healthy, often have musty odours. The fat is of a deadly white colour and not stained, but when thawed out it is often tinged with red, due to the permeation of serum.

Horse flesh is of coarse texture and dark in colour, and the fat is oily and yellow. It has a characteristic sickly smell and 'soapy' feeling.

Goat flesh is much darker than mutton, and, excepting in the loins, the fat is less abundant. If newly dressed, it has a distinctly 'goaty' odour. The dorsal vertebræ are arched; the body is narrower and deeper, and the leg bones are thinner and longer than in the sheep. The fat is somewhat yellow, excepting that around the kidneys, which is hard and white.

Kid flesh closely resembles lamb.

Characteristics of Bad Meat.—Bad meat is usually wet, sodden, dark in colour, and flabby. The fat is soft, dark, and has a bad odour. Its reaction is alkaline.

In all cases such meat should be seized.

'Fevered' carcasses are usually of the above description; the flesh does not bleed well. "Dropsical" meat is pale in colour, and is usually derived from the emaciated carcass of an animal that has had internal derangements, or of a choked or drowned animal. "Fevered" and "Dropsical" are two terms often used to describe the two general conditions of carcasses of animals in the later stages of certain diseases.

In case of doubt arising regarding seizure, the Inspector should always err on the side which will safeguard the public, a temporary seizure being made, and the disposal of doubtful meat referred to the Medical Officer of Health for a decision.

In examining animals, Inspectors should be careful and thorough. When necessary, whole carcasses should be cut up and the glands examined.

In routine inspections at slaughterhouses, of carcasses and offal, the following system may be followed. Commence with the head, examining the lymphatic glands first, then note if any enlargements of the jaws or tongue exist; the latter should be felt for abscess formation. Evidence of tuberculosis is often found in the sub-maxillary glands. Note throughout if any glands have been removed, and enquire the reason.

Next examine the lungs and heart. They should be felt for swellings, lumps, etc., and the condition of the bronchial and mediastinal glands noted. The portal glands are next examined, and the ducts of the liver noted for the presence of flukes. The 'fluky' portions are usually removed. Any suspicious circumstance, such as absence of glands, or part of offal, noted at this stage, should entail further examination of the mesentery and its glands, the stomach, spleen, etc. The carcass is next examined in a good light. The colour, condition, and smell of the flesh and fat should be noted. Evidence of stripping of the pleura or peritoneum should be enquired into: it may be because of body sticking by unskilled men; if so, it is usual for one side only to be stripped, namely, that on which the animal lay when slaughtered.

If stripping has been done, the surface of the chest walls will be found to tear off in small strips and not whole, as is the case when the pleura is removed.

Such of the superficial or deep-seated glands as may be deemed necessary are next examined, care being taken to avoid impairing the saleable value of the carcass.

If tænia are common in animals in the district, they should be looked for in the fleshy parts, especially in the region of the aitch bone.

The knives or other instruments used in connection with meat inspection should be kept specially for that purpose, and not used for other work. After cutting into tubercular or other diseased parts, another knife should be used for the next examination. The infected knife, etc., should be sterilised in boiling water on the completion of the inspection of the diseased carcass, etc.

If the carcass is sound, it is usually stamped as having been inspected satisfactorily. Parts considered unfit for food should be seized, immersed in a suitable disinfectant, or put in a padlocked container and removed for condemnation by a magistrate, and eventually burnt in an incinerator.

The seizure, etc., of unfit meat and other foods at markets, shops, etc., is carried out in a similar manner. The detailed procedure varies somewhat in different localities, according to the legislation and organisation in force.

It cannot be too strongly stated that it is no justification for seizure that meat is from 'old,' 'physicked,' or 'ill-fed' animals; that it is emaciated, or of an inferior quality. The only criterion is its condition as a potential danger to health. The clause in the Public Health Ordinance governing meat inspection and seizure usually states that seizure shall be made of food which is "diseased, unwholesome, or unsound."

Abnormal conditions usually indicate disease, but not always; the carcass showing such should be looked upon with suspicion. Other suspicious signs are the 'making away' of internal organs; the slaughtering of a cow shortly after calving, and the selling of meat below its market value. As already stated, stripping of the pleura or peritoneum may be done to remove discolorations, but, usually, it is a sign indicating removal of tubercular deposits or old adhesions.

The following is a classification (after Dr Hime) of meat which is regarded as unfit for food :—

1. Animals which have died of an internal disease or have been slaughtered while suffering from such.

2. Animals which have died in consequence of excessive exertion and exhaustion. The blood of such animals is blackish red and rapidly becomes putrid, and is sometimes toxic.

3. Animals suffering from any infective disease communicable to man. Among these are anthrax (malignant pustule, splenic fever, or splenic apoplexy), braxy of sheep, hydrophobia, glanders, pock and tuberculosis if generalised, actinomycosis, cattle plague (rinderpest), nagana, swine fever, or measles.

4. Animals which have died of pyæmia, septicæmia, infective pneumo-enteritis, erysipelas, or other disease of the same type. (Cows may suffer, after calving, from pyæmia, and young calves from gangrene of the navel.)

5. Animals suffering from parasites which undergo metamorphosis in man, e.g., *Trichina spiralis* and *Cysticercus cellulosæ* (pig measles of the pig), the latter producing *Tænia solium;* or *Cysticercus bovis* (beef

measles), producing *Tænia saginata* or *mediocanellata*: *Fasciola hepatica* (distoma), the fluke of sheep (occurs rarely in man).

6. Animals suffering from lymphosarcoma or other malignant disease.

7. Rotten or putrid meat. The occurrence of putrefaction is marked in most cases by an unpleasant smell and taste, also by the unnatural colour of the meat.

8. Animals killed accidentally by choking or drowning, etc.; unless consumed soon after death, their flesh is liable to putrefy quickly.

Some seizures are recommended on general grounds only, no evidence being available that meat of animals suffering from certain diseases will, when eaten, cause disease in man: *e.g.*, fluked meat, meat of animals suffering from nagana as indicated by the presence of trypanosomes in the blood, meat of animals recently bitten by another animal suffering from rabies.

Diseases of Animals used for Food.—The causal agents of disease in cattle may be tabulated in a manner similar to the agents of infective disease in man. Some are bacterial in origin, *e.g.* tuberculosis, anthrax, etc.; others are caused by chlamydozoa, *e.g.* foot-and-mouth disease, rinderpest, etc.; while others are the result of an infection of animal organisms, *e.g.* cysticersi.

Diseases likely to be met with on inspections are tuberculosis, anthrax, puerperal fever, rinderpest or cattle plague, pleuro-pneumonia, nagana in Africa, foot-and-mouth disease, actinomycosis, sheep-pox, swine fever, and measles, encysted meat parasites.

Tuberculosis.—This infective disease is characterised by the formation of tubercles or nodules, small greyish bodies called "grapes" in the trade. It may affect the lungs, pleura, peritoneum, mesentery, bones, udder, and the various lymphatic glands. The symptoms in the living animal vary according to the situation of affected part or parts, and, in the early stages of the disease, are unreliable.

The predisposing causes are, overcrowding or insufficient air space, and bad ventilation. The disease is common among stall-fed cattle in towns. A discharge is coughed up; this soon dries, becomes pulverised, and then is blown about and inhaled by healthy animals, producing in them tuberculosis.

The only satisfactory guide is "Tuberculin," a glycerin extract of tubercle bacilli, which, injected, produces a distinct rise in temperature in tuberculous animals, but not in healthy ones.

The prevention of bovine tuberculosis includes ample air space and ventilation in cowsheds, an open-air life where possible, and good sanitary conditions in and about cowsheds.

In the dressed carcass and offal of the ox tubercular (cheesy) deposits may be found in the glands, and, less frequently, in the bones; pea-like nodules (often termed "Nuts" by native butchers) may exist on the diaphragm, pleura, or peritoneum. There may be adhesions between the lungs and the chest wall, and in cows the udder may be affected.

Butchers are met with who are skilled in the art of removing the signs of this disease, *e.g.* dissecting out the glands, and 'stripping.' The use of a skewer or stitches should arouse suspicion.

In the pig the lymphatic glands, especially the renal and mesenteric, are affected, also the pleura, lungs, liver, etc. Tuberculosis also occurs in poultry, but is very rare amongst sheep.

Regarding the question of seizure of tubercular meat, the following recommendations of a Royal Commission on Tuberculosis are adopted by some Local Authorities:—That the entire carcass and all the organs shall be seized—

1. When there is miliary (general infection) tuberculosis of both lungs.
2. When tubercular lesions are present on the pleura and peritoneum.
3. When tubercular lesions are present in the muscular system, or in the lymphatic glands embedded in or between the muscles.

4. When tubercular lesions exist in any part of an emaciated carcass.

The carcass if otherwise healthy shall not be condemned, but every part of it containing tubercular lesions shall be seized—

1. When the lesions are confined to the lungs and the thoracic lymphatic glands.
2. When the lesions are confined to the liver.
3. When the lesions are confined to the pharyngeal lymphatic glands.
4. When the lesions are confined to any combination of the foregoing, but are collectively small in extent.

The Commission also recommended that the presence of tubercular deposits in any degree in the pig should involve seizure of the whole carcass and organs; and in respect of foreign meat in which the pleura has been stripped seizure should be made.

Anthrax.—This disease affects cattle, sheep, and, less frequently, pigs. It takes several forms, and may be general or local. It is variously known as splenic fever, producing 'staggers' due to apoplexy, carbuncular fever, black quarter, or quarter ill. In the live animal, it may be recognised, if in the carbuncular form, by the occurrence of large boils. If suffering from quarter ill or black quarter, it may be easily seen, as one of the fore or hind quarters is dark in colour, often swollen, and the animal appears lame.

In the carcass of animals suffering from splenic fever the meat is dark and stained with bile throughout. There are exudations into the pleural and other cavities, enlargement of the spleen and liver, and congestion of the intestines. The carcass rapidly putrefies.

Splenic apoplexy in sheep is termed 'braxy,' and infected carcasses and offal are always seized, and, after condemnation, destroyed by fire or buried 6 ft. deep in lime.

Puerperal Fever.—This disease does not necessarily render the carcass of an affected animal unfit for food;

the condition of the carcass must be taken into consideration.

Rinderpest or Cattle Plague.—This is a highly infective and very fatal disease. In the live animal it is characterised by high fever, rapid pulse, fits of shivering, cessation of rumination and milk secretion, discharge from eyes, nose, mouth, and vagina in females, offensive 'loose' dejecta, patches on the mucus membranes of the mouth, developing into ulcers, and great prostration.

The slaughter of infected animals and destruction of carcasses, and thorough measures of disinfection, are necessary to stamp out an outbreak of this disease.

In the carcass the flesh does not appear changed except in advanced cases, when it appears dark and has a disagreeable odour. The bowels and air-passages are intensely inflamed. The hide will show signs of a pustular eruption. The flesh of animals suffering from this disease is considered unfit for food.

Pleuro-pneumonia.—This disease is peculiar to bovines alone, and affects the lungs and pleura. It is very difficult to distinguish from other diseases of the lungs in the live animal.

The lungs of an infected animal will be found to be congested and heavy—they will sink in water. They are yellowish brown on the surface and marbled in section. The pleura is often covered with flaky exudations. In the advanced stages the flesh is dark and ill-bled. The general condition of the carcass will determine whether seizure should be made.

Nagana.—This is the trypanosome disease of African cattle. The carcasses of infected animals are usually emaciated, and smears of blood showing trypanosomes on microscopic examination confirm diagnosis.

A photograph of infected animals is seen in Fig. 98 (page 194).

Actinomycosis.—This disease is chiefly met with in cattle. It is caused by the "ray-fungus," which leads to the formation of large tumours in the tongue, jaw, and neck; these tumours often suppurate. It is variously known as lumpy jaw or wooden tongue, according to the part affected.

The usual practice is to condemn the affected parts only, if the carcass is otherwise in good condition; but if generalised, as indicated by an emaciated carcass, the whole is seized.

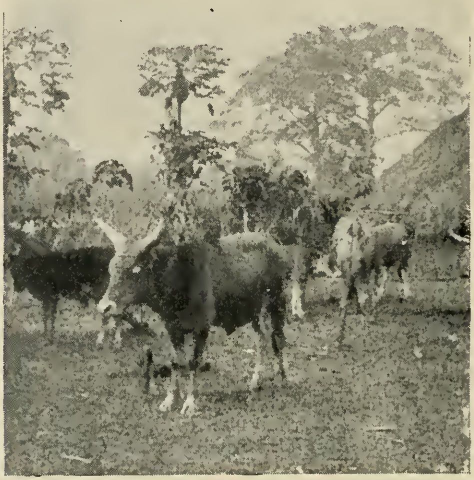


FIG. 98.—Cattle Suffering from Nagana.

Sheep-pox.—This disease is characterised by an eruption of red spots on the hairless parts, giving the sheep a flea-bitten appearance, shedding of wool, high fever, and sometimes paralysis. The flesh of animals suffering from this disease has a nauseating smell, and is soft, pale, and moist. It is unfit for food.

Swine Fever.—This disease is also known as hog cholera, red soldier, pig typhoid, swine plague, etc. Young pigs are most frequently attacked, but older animals may suffer from this disease. The usual symptoms are hurried breathing, discharge from the eyes and nose, drooping ears, loss of apetite, fever, red patches on the under parts of abdomen, inside of thighs, and on the ears.

In advanced stages the animal staggers, and frequently falls down. The intestines are chiefly affected, ulceration being well defined. The lungs may be conjested and the fat beneath the skin may be reddened through to the flesh. The flesh is unfit for food and should always be seized and condemned.

Foot-and-Mouth Disease.—This disease is very infective amongst animals, and is characterised by bladder-like eruptions in the mouth, on tongue, lips, feet, and teats. The vesicles burst and leave red patches with a sore surface. Affected animals are stiff, and lame, and become emaciated. In cows, the secretion of milk is reduced enormously.

The flesh appears perfectly healthy, and only the parts affected should be seized.

Meat Parasites.—Some of the parasites affecting 'food' animals have already been mentioned. Another is the echynococcus, which may be seen encysted in the muscle fibres.

All encysted meat should be seized. Fluky livers are (as previously stated) usually seized, but the carcass of an animal otherwise healthy should be passed.

The fitness for food of frozen, refrigerated, or chilled meat should be judged by its general condition. A routine practice of testing for bone taint or evidence of decomposition by thrusting a skewer into thick parts near the bones, withdrawing and smelling it, should always be carried out.

All parts of carcasses damaged by injuries and bruises should be seized and destroyed.

In connection with slaughterhouse routine, blood smears are frequently taken, and the result of the microscopic examinations are tabulated monthly on the following form by the Veterinary or Sanitary Officer. A copy of it is forwarded to the Chief Sanitary Officer, where such an official exists.

SANITARY RETURN, No.

*For the month of*____________________19

Results of periodical examination of blood smears taken from the slaughterhouse or site used for slaughtering animals. These examinations should be made at least once a week, and, when there is any reason to suspect the presence of any infective or epidemic disease among the animals in a district, daily examinations of smears should be made.

Dates. Results.

Cattle____________________

Sheep____________________

Goats____________________

Pigs____________________

____

Veterinary or Sanitary Officer.

Station________________

Date________________

To the Senior Sanitary Officer,

Fish should be firm and stiff, with red gills and bright eyes.

If fish are limp, pit on pressure, having dull eyes, pale gills, and an appreciable smell, they should be seized.

Unsound eggs may be detected by placing them in a salt solution (2 ozs. to 1 pt. of water). They will be found to float, while sound ones sink. Another test is to hold them up to the light; bad ones are transparent at the ends, and sound ones at the middle.

No standard of freshness in regard to fruit, vegetables, corn, etc., can be laid down. The Inspector should be guided by the general condition of the articles as to their fitness for food.

Some Common Articles of Diet in the Tropics.

Canned Foods.—The various methods of preparing these foods are based on the recognition of the fact that they can be preserved for long periods of time in sealed tins by the application of heat sufficient to kill the contained bacteria. Meat for 'canning' is freed from bone and placed in tins which are heated to a temperature exceeding the normal boiling point of water. When sufficiently heated to kill the organisms and expel the air, the tins are sealed. Fruits are preserved in a similar way. They may be 'tinned' or 'bottled.'

Some foods, such as sardines, are cooked and preserved in oil.

In examining tinned foods, attention should be paid to solder-marks, nail-holes, rust, stains on labels, bulging ends, and sound produced when struck.

In examining tinned goods in bulk, the recognised custom is to have 10 per cent. of the cases opened. If found in good condition, it is assumed that the whole bulk is satisfactory. Stains on cases usually indicate leaky tins, probably 'nail-punctured' when being packed. Bulging cases should always be examined for blown tins.

Rusted tins should be rejected or condemned, according to reason for examination. These are very often covered with new labels. The date of packing should be noted; it is usually stamped on the tins. The number of solder-marks on tins should be observed. If the majority of the tins in one consignment have one solder-mark only, examine tins with two or more marks; if they have two, examine those with three. Suspected tins should be put in a row and their ends struck lightly, unusual sounds being noted. If good, they give a metallic ring; if 'blown' at all, a drum-like sound will be heard. 'Blown' tins denote decomposition.

If the examination of the selected cases is not satisfactory, the remainder should be examined.

Flour is obtained from wheat, and should be of a whitish colour and not markedly yellow. It usually contains a little bran, ground up. There should be no grit or lumps, the latter indicate dampness. When made into dough it should draw out into long strings, showing that the gluten, the nitrogenous matter in flour, is not changed. When made into bread, the rising of this sticky mass is due to the percolation of gas through it.

Flour should not smell mouldy and should be free from insects, which eat out the nutriment and cause the flour to deteriorate.

Bread consists of dough from wheat flour through which the carbonic gas (formed by the action of the yeast plant in the dough) passes. This makes the dough spongy (it is said to have 'risen'), and it is then baked. The yeast plants break up solutions of sugar into alcohol (a very small quantity) and carbon dioxide, which bubbles throughout the dough; this process is termed 'fermentation.' Carbon dioxide can also be formed by using baking powder or sour milk; in the latter the lactic bacillus causes the fermentation. In West Africa, palm wine is used for this purpose.

In aerated bread the carbon dioxide is made separately, and forced by pressure into the dough.

One sack (280 lbs.) of flour should make from 170 to 180 2-lb. loaves; if more loaves are obtained per sack of flour used, the bread is often "sodden," too much moisture being in it. This usually indicates that the baker is making extra profit. Bread should be light and elastic to the touch, having small cavities throughout. The crust should be of a good brown colour, and not burnt. The crumb should be creamy, and have no acid taste.

Milk.—This is the only food which contains the main food constituents in due proportion for nutriment.

It is an emulsion of fat with casein (proteid), milk sugar, and salts in solution.

The souring of milk is due to bacterial action, which throws the casein out of solution, settling as curd.

Bacteria, commonly found in milk, get there in many ways. In model dairies, refrigerating and cooling plants, through which the milk is passed, are installed to reduce their growth.

Preservatives.—There are various ways of preserving milk :—

(1) Sterilising ; *i.e.*, heating to the temperature necessary to kill all the organisms in the milk ; boiling for half an hour will secure this.

(2) Pasteurising ; this will kill the pathogenic and fermenting bacteria (see page 31).

(3) Boiling ; *i.e.* as done in an ordinary household. This kills pathogenic and other organisms, but does not necessarily sterilise.

(4) Chemical preservatives ; these should be prohibited. Formalin and boric acid are chiefly used.

Composition of Milk.—Certain standards have been laid down by the British Board of Agriculture, and are generally adopted where legislation on the subject exists.

These are, the presence of not less than 3 per cent. of fat, and not less than 8·5 per cent. total solids not fat. If milk is not up to this standard, it is presumed to be not genuine.

The average cow gives milk having a higher percentage than those mentioned. The most common adulteration is water, which, when added, lowers the specific gravity of the milk 3 points for every 10 per cent. of water added. Milk-sellers sometimes know this fact, and bring the specific gravity to normal again by removing sufficient of the cream, so the specific gravity of the milk—1027 to 1034 at 15° C.—is of little use as a test, for by judicious manipulation a dairyman may add water and remove part of the cream, without altering the specific gravity. The only test is by analysis.

Butter is really the fat of milk (with little or no casein or curd) with salt, and water.

The cream is "soured," *i.e.* the fat undergoes a change brought about by bacteria; this gives a distinctive taste to the product when churned. If cream is churned up "fresh" it has little taste. 'Standard' butter should not have more than 16 per cent. of water in it. Butter is not likely to be a channel of infection, as bacteria do not flourish in it.

Margarine is a substance made in imitation of butter from (*a*) beef fats and milk, or (*b*) vegetable fats. The amount of butter fats in margarine should not exceed 10 per cent. It is an excellent substitute for butter, doing the same work in the body, though much cheaper; for this reason its use should be advocated amongst the poor.

Rice in many tropical countries forms the staple diet of the native. It should be whole, clean, and without grit. It varies in colour according to place of culture. There should be a certain amount of the bran remaining after removal of the husk; this always occurs with native or 'country' rice ground in a mortar.

Maize or Indian corn is extensively used in the tropics. In West Africa the corn is soaked, it is then crushed, strained, and cooked. The product is termed agidi.

Foofoo is a mixture of native foodstuffs, the basis of which is cassava, and yam.

Akara is a name given to cakes of pounded beans and rice, fried in oil.

In the tropics vegetable oils and fats are largely used by natives; and a very wide range of vegetables, fruits, and condiments are available for the use of Europeans.

Inspections.

When inspecting premises used as markets, shops, food stores, etc., attention should be paid to their general cleanliness, available water supply, provisions for ventilation, and protection against flies and dust; state of vessels used in the preparation of food, and means of washing up; the use and abuse of food stores as living rooms; and sources of materials before reaching retailers.

It is particularly important that the Inspector should keep in touch with the general health of families of persons purveying food of any kind. Prompt measures, including isolation, disinfection, etc., on the occurrence of a case of infective disease, may localise a threatened epidemic.

In municipalities all cowsheds should be licensed, the license being granted only after inspection by the Inspector; the necessary standards being borne in mind by him. These include :—

1. Impervious walls to a height of at least 6 feet, and a properly paved impervious floor, so graded that the liquid filth runs into a channel, and thence to a drain trapped outside the cowshed.
2. Where cows are not habitually grazed, the cubic space per cow should equal at least 800 cubic feet.
3. Proper provision for ventilation and lighting.
4. Good water supply.
5. If the cowshed has a yard attached, the surface should be impermeable, and properly drained.

In addition to the above, byelaws regarding cowsheds should provide for :—

1. Proper storage of manure outside the premises, and frequent removal (weekly).
2. Periodical washing of floors (daily), and limewashing of walls (bi-annually).
3. Cleanliness of cows, milkers, milk vessels, and milk stores.

The sanitary states of cowsheds may be classed into four groups :—

1. Those which are satisfactory and pass the Inspector's examination, licenses being granted.
2. Those which have small defects, easily remedied. Notice of these defects is issued, and, when the defects are remedied, licenses are granted.

3. Those requiring structural alterations, *i.e.* entailing a large outlay. Notices are served if occupation as such is continued.
4. Those buildings unfitted altogether to be used as cowsheds, either by reason of site, construction, or other cause.

Dairies should be inspected frequently, and all should be registered. Attention should be paid to the building and its surroundings, water supply available, state of animals and stalls, ventilation, disposal of excreta, housing of attendants, presence of infective disease amongst employees, etc., cleanliness of milk vessels, methods of cleansing, evidence of flies in sheds and dairy.

An infected milk supply may cause outbreaks of enteric fever. The so-called native dairy is often a centre of infection. One instance of a limited outbreak may be quoted.

The dairy which the writer has in mind was a dark and ill-ventilated house situated close to a native latrine, and between them was a large vessel full of water, which was used for ablutionary purposes by the natives visiting the latrine, and also by the milkman washing out his cans. Examination of some of the water actually found in one of his milk-cans showed it to be fæcally contaminated.

In attempting to obtain an ideal milk supply in a district, the following are the more important points which require attention :—

1. The cows should be well groomed, healthy, and have passed the 'tuberculin' test. They should be frequently inspected.
2. The cowshed should be in a sanitary state; provision for lighting, air space, ventilation, and water supply should be adequate.
3. The milkers should be healthy and of cleanly habits: they should not be "carriers." The cowman should keep the cowsheds and surroundings clean, and free from manure, filth, etc.

4. All utensils should be kept clean, and sterilised daily.
5. The milk should be transmitted as soon as possible to a central depôt, where it is filtered, pasteurised, and bottled, in clean air-tight bottles, ready for delivery to customers.

Summary of Law affecting Food.

The law regarding this subject varies in different tropical countries according to local circumstances, but as the majority of such laws, regulations, etc., are based on British law, a short summary of it may not be out of place in this manual.

Generally speaking, although special powers under Public Health Acts, etc., deal with this question, to have with intent to sell or to expose for sale any human food which is unfit is actionable at Common Law as a nuisance. Conviction follows if such is proved, and if it is demonstrated that the seller knew such article was unsound at the time.

The Public Health Ordinances give to Inspectors power to examine any article of food for man exposed for sale or sold; and if on examination it appears diseased, unwholesome, or unsound, it may be seized and carried away in order to have it dealt with by a magistrate, who may order its destruction. Whether action is taken against the owner rests with the Sanitary Authority, *i.e.*, the Local Council, to whom the matter is reported by the Inspector.

In municipalities where public abattoirs exist, it is usual for owners of carcasses to accept the decisions of the Inspector on duty there, regarding parts unfit for food; and to allow the destruction on the spot of such diseased portions, without resorting to a magistrate's order.

The inspection and registration of private slaughter-houses, cowsheds, milk shops, dairies, markets, and other places where food is prepared is also legislated for.

Regulations, etc., regarding the "Sale of Food and

Drugs" are in force in civilised tropical communities, like the "Sale of Food and Drugs Acts" at home; they provide for such sale in a pure state, and govern procedure in connection with the purchase of samples. The most important section usually runs :—"No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded."

In purchasing samples, the Inspector should make a definite purchase, and after purchase he (1) states his intention to have the article analysed by the public analyst; (2) divides the purchase into three equal parts, each part sealed and marked; (3) gives one part to vendor, sends another part to the analyst, and keeps the third part, in case the latter's analysis is disputed.

Samples should be numbered and recorded in a book kept for the purpose. No name or distinctive mark should appear on the label of the sample sent to the analyst; but (1) No. of sample, (2) date of purchase, (3) nature of article, and (4) name of Inspector taking sample should be stated thereon.

The Inspector should record in his pocket-book :— (1) No. of sample; (2) date taken; (3) name and address of vendor; (4) description of article; (5) place of purchase; (6) price paid; (7) quantity purchased; (8) date sample sent to analyst; (9) signature.

Square jars with tight-fitting lids should be used for butter, margarine, and the like; 8-oz. bottles are suitable for milk samples.

The following are the quantities of some common articles, required to enable division of sample and analysis to be carried out :—

Beer, ½ gall.	Spirit, 1 pint.
Bread, 4-lb. loaf.	Sugar, ½ lb.
Butter, ½ lb.	Tea, ½ lb.
Cheese, ½ lb.	Wines, 1 pint.
Cocoa, 4 ozs.	Pepper, 2 ozs.
Coffee, 4 ozs.	Flour, 2 lbs.
Milk, 1 pint.	Drugs, usually 4 ozs.

A register of samples taken should be kept, with the following headings :—

(1) Number; (2) description of article; (3) vendor's name and address; (4) date of purchase; (5) date sent to analyst; (6) result of prosecution (if any); (7) remarks.

The result of the analysis is submitted to the Health Committee of the Local Authority, which determines whether a prosecution is to be instituted or otherwise.

In large municipalities practically all the work in connection with meat inspection, up to the time it is exposed for sale, is carried out by a veterinary staff, the Sanitary Inspector being concerned with routine inspection of food exposed for sale.

Summarised, an Inspector's duties, in connection with the subject matter of this chapter, may include any or all of the following :—

Inspection of imported animals—a very important duty.

Inspection of animals before slaughter.

Inspection of carcasses and offal before leaving slaughterhouse.

Condemnation and seizure of diseased, stale, or decomposed meat, and its disposal.

Inspection of slaughterhouses, and registration of same.

Inspection of the methods of slaughtering.

Inspection of markets, food stores, etc.

Inspection of foods other than meat.

Inspection of cowsheds and dairies.

Taking of samples under "Food and Drugs Act," etc.

CHAPTER X

THE COLLECTION, REMOVAL, AND DISPOSAL OF EXCRETA AND REFUSE

This is a very difficult problem in the tropics, and requires strict and constant supervision.

The object to be aimed at is, the removal of effete matter of men and animals from the surroundings of habitations, and the disposal of these matters in such a manner as will neither be a nuisance nor be injurious to health.

Excreta.

The danger from excreta lies in the fact that at some time or another it may contain organisms of infective disease, and so become a 'centre of infection.' In addition, it affords a breeding place for flies.

The principles underlying any system should be (*a*) rapidity of removal, and (*b*) proper disposal. The former, except in places where incineration 'on the spot' is feasible, is the more important.

There are two systems of removal in vogue, namely, the water-carriage methods, and the "conservancy" methods. The latter includes (1) cesspits; (2) privy-middens; and (3) pail system.

In the water-carriage system, the waste matters, including rain and slop-water, are removed by means of certain sanitary fittings in habitations, drains, and sewers, to some form of disposal works.

In the various conservancy methods no foul drains or sewers exist; the excreta, if not trenched, is removed by hand or cart.

Slop waters are usually thrown into the street drains or on the surrounding ground.

Undoubtedly, water-carriage is the best where practicable, but in many parts of the tropics with a scattered community, and no piped water supply, other methods prevail. Additional barriers to the universal application of water-carriage are the enormous initial outlay, the defective civilisation of certain communities, and the absence of skilled labour. In many large municipalities in civilised places these difficulties have been found insurmountable.

As a water-carriage system, therefore, is by no means general in the tropics, and the available space to deal with this subject is limited, only a brief survey of the various components of the system is here attempted. For fuller descriptions the reader is referred to any of the elementary text-books on sanitation.

The following go to make up the system. (1) Roof gutters and rain-water pipes. (2) Sinks and waste-pipes. (3) Water-closets and soil-pipes. (4) House drains. (5) Manholes at junctions. (6) Disconnecting chamber with intercepting trap between house drains and cesspit or sewer. (7) Cesspit or sewer leading to final disposal. A composite sketch of the system is shown in Fig. 99.

Rain-water pipes extend from roof gutters to ground-level, usually discharging under or over the grating of a gulley trap. They are made of iron, and are usually 3 ins. in diameter. A hopper head on a line of rain-water pipe is often placed to receive bath and other waste-water from upper stories of buildings. This is a bad practice, and should be discouraged.

Sinks and Baths.—These should be of enamelled ware, the waste-pipes should be trapped just below the outlet from the sinks or baths, and made to discharge outside into a channel leading to a trapped gulley. Waste-pipes are usually 1 to 2 ins. in diameter, and made of lead. All gullies should be provided with gratings, especially in 'plague districts,' to prevent the escape of rats. To this point special attention should be paid.

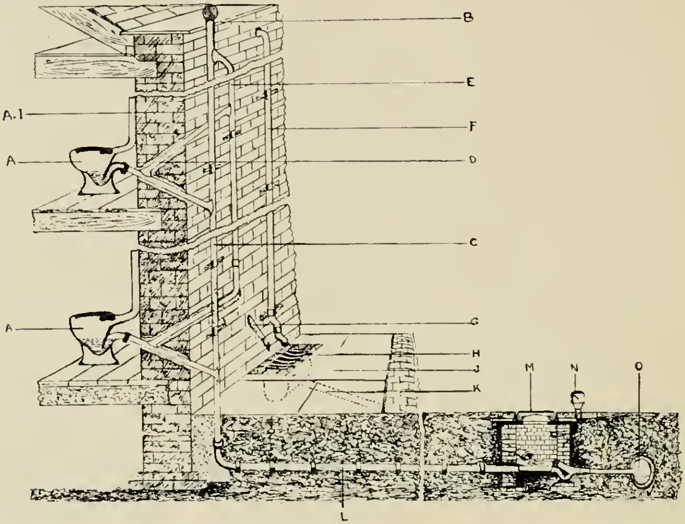


FIG. 99.—Composite Sketch of Water-Carriage System of Sewage Removal.

A, W.-C. pan (trapped). A1, Flush pipe from water cistern. B, Ventilating soil-pipe. C, Soil-pipe. D, Antisyphonage branch pipe. E, Antisyphonage pipe. F, Rain-water pipe (from roof gutters). G, Waste-pipe from sink. H, Trapped gulley (with surface grating). J, Yard. K, Branch drain from gulley. L, House drain. M, Disconnecting chamber. N, Ventilating inlet to drain. O, Sewer.

Traps are barriers placed on drains or waste-pipes, to prevent the return of sewer air, yet so as to allow the flow of sewage. They are considered necessary evils. A bend is placed on the line of pipe or drain, so that the liquid remaining in the bend forms a seal. There are numerous patterns on the market; the best have a free way for sewage to pass yet efficiently seal the drain. Figs. 100 to 102 show different forms of traps met with.

A water-closet may be described as "a room having a hopper, flushed and discharged by means of water." It should, on at least one side, be external. Many different kinds of pans or hoppers are to be seen in use; the simplest and best is the 'pedestal' or wash-down pattern. Each should be provided with a 3-gall. water-flush. The pan is trapped, and the outlet taken through an outer wall, and connected up to the soil-pipe. If two or more water-closets are connected, one beneath the other, on the same soil-pipe, provision has to be made to prevent syphonage; this is done by means of an anti-syphonage pipe, as shown in Fig. 99.

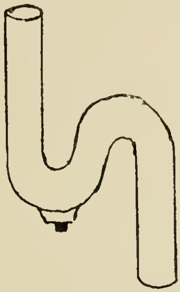


FIG. 100.—"S" Trap.

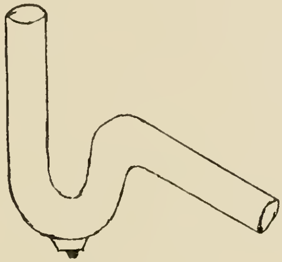


FIG. 101.—"P" Trap.

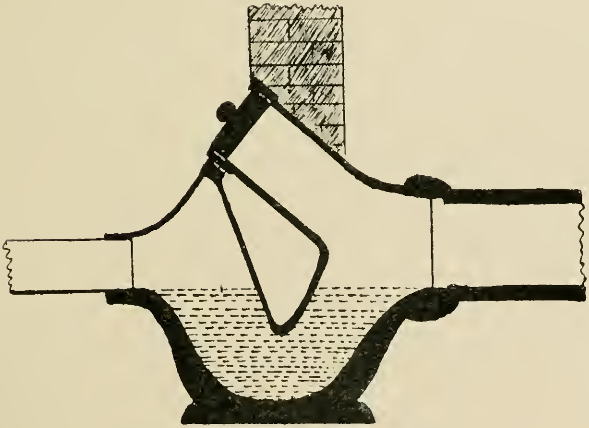


FIG. 102.—Disconnecting Trap.

Trough latrines are sometimes used in public conveniences, tenements, schools, and barracks. They consist of an earthenware or metal trough, under a series of seats. The trough is slightly inclined to the outlet, at which there is a weir, and beyond that a trap and fitting, connecting the outlet to the soil-pipe. It is flushed by discharges of tanks, sometimes automatically. The main essential to good drainage, *i.e.* rapidity, is absent in this form of closet.

Soil-pipe.—This may be of lead or iron, usually the latter, and is 4 ins. in diameter. It extends from the connection with the water-closet branch pipe down to the house drain (underground), without trapping, and receives the discharges from the pan. It is continued full bore above the eaves, and acts as a ventilating soil-pipe. The open end is usually protected by a wire cowl. (It really acts as an outlet ventilator for the house drain.)

House Drain.—Usually this is 4 ins. in diameter, and made of earthenware or iron; the former being more commonly in use. In laying a house drain, great care has to be taken in (*a*) making the joints water-tight; (*b*) obtaining an even and good gradient; (*c*) avoiding fractures of pipes on filling the trenches in, after passing the water test; and (*d*) arrangements for flushing where necessary.

Junctions in drain-pipes are always in the direction of the flow, and not at right angles. Manholes for inspection are provided at junctions, and lamp-holes at bends. Small drains join larger ones by means of a taper pipe. The joints of earthenware drain-pipes are made with spun yarn and cement; and those of iron with molten lead, which is run into a clay mould around the joints, allowed to cool, and then caulked. The gradient of a house drain is usually 1 in 40. The diameter of the drain-pipe multiplied by 10 will give the length of 'run' in feet there should be for each foot of fall, for any sized drain; *i.e.*, 4 in. drain, $4 \times 10 = 1$ in 40; 6 in. drain, $6 \times 10 = 1$ in 60; and so on.

Plans of all drainage systems in a district are filed for reference.

Disconnecting chambers are impermeable chambers (brick sides, concrete base, and iron cover), which receive the sewage from the house drains into half-channel inverts. The sewage passes through a disconnecting trap before entering the sewer or cesspool.

The chamber is connected usually with an inlet ventilator (with mica flap), situated above the ground-level, to secure thorough ventilation of the whole length of drain; the outlet being the ventilating soil-pipe.

Cesspools are used to receive the sewage from isolated houses in country districts. The pits should be large and deep enough for requirements, and constructed of impermeable material to prevent soakage and draining of contents through the subsoil into water supplies. They should be covered in, and provided with a pump. The contents are pumped out from time to time and put on to land.

Sewers are simply large drains, which connect up the house drains with the final disposal works.

Final disposal is carried out in many different ways. At coast towns it is usually discharged into the sea at high tide. At other places it is distributed on to land, or receives biological treatment or chemical treatment, then on to land or 'breeze' filters: whichever method is adopted, the effluent is finally discharged into streams.

Testing of drains and connections is carried out by either the water, smoke, or chemical test. These tests consist of filling the drains, etc., with either of the substances named, and noticing if any escapes. The water test is a most severe one, and is usually applied to new drainage work before the trenches are filled in.

An Inspector's duty regarding drainage consists of routine inspections and investigating complaints regarding nuisances from leaky drains and fitments, specifications of works necessary to abate the same, and supervision of such work. An Inspector has no concern with the drainage of buildings under construction—this affects the Building Inspector, Surveyor, or Municipal Engineer—until such time as they are inhabited.

Stoppages in drains are indicated by the overflowing of gullies and manholes; and leakages, by the distinctive smell in the vicinity of the leak.

Inspections should be made at manholes and disconnecting chambers to localise any suspected stoppage. Failing such access to the drain, the ground will have to be dug out and the drain broken into in one or more places, until the stoppage or leak is located. Drain-cleaning instruments are used to remove obstructions, if flushing fails.

In some places, estate managers make use of a modified form of water-carriage. The labourers' latrines consist of shallow trenches, connected up to a main trench which runs out to the sea, the whole being frequently flushed. In others, a similar system is in vogue, the irrigation channels being made use of.

Conservancy Systems.

In native quarters, cesspits and middens are the rule, while various modifications of the 'pail' system will be found in the public latrines, Europeans' quarters, and those of the educated native.

Cesspits.—A cesspit is simply a hole dug in the yard of the compound; a ring of masonry is usually put round the top, a seat is fixed, and it is ready for use. They are generally roofed over. The contents soak away into the soil, or, if such soil is not very permeable, it is used until filled up, when another is dug. They are a favourite breeding place for flies and mosquitoes, and, while in use, require frequent oiling. The proximity of wells to cesspits in native compounds has already been dealt with.

Middens have fixed receptacles into which solid refuse, additional to excreta, is often placed. The contents are removed periodically and buried.

Both the above methods are very unsatisfactory, and as funds permit they should be abolished and a pail system adopted. In connection with middens, the use of dry earth or other deodorant to cover dejecta should be made compulsory.

The "Pail" System.—This is the best of the so-called "dry methods" of removal, and when properly organised and supervised, it is found workable without creating a nuisance. It is really a system of middens with movable receptacles, in which (*a*) the buckets may have tight-fitting covers; or (*b*) provision is made for the application of dry earth or a suitable deodorant to the excrement.

In systems in which no provision for deodorisation is made, automatic closing covers are a decided improvement on those which require replacement by hand.

A dry-earth system includes provision for the application of dry earth, either by an automatic hopper, or more frequently by a box of earth and scoop. The earth should be dry, and finely powdered. The objects of its application to excreta are to assist decomposition, and to keep flies from the filth.

In places where the wet and dry seasons are well defined, a sufficient stock should be laid in and stored during the dry season, for use during the rains. Otherwise, the "dry-earth" system in such places will be found to be costly, involving much labour and expenditure of fuel if properly carried out.

Public latrines, generally used by natives only, are also worked on the dry-earth system.

Where funds permit, a much better method in connection with a pail system is the addition of cresol solution in place of dry earth. It is often spoken of as the "moist" method, and has had an extended trial in India.

A solution of cresol (Liq. Cresoli Sap. fort.) of a strength of 1 ounce to a gallon of water (1 in 160), is made up, and a half gallon of this is put into each bucket before placing the latter into position under the seat. The amount mentioned is that used in camps, where 5-gallon buckets are in use, and the contents are removed twice daily. For a native community the amount required per bucket would be governed by the size of buckets in use, number of users, and frequency of removal. The absence of flies, from latrines worked on this system, is most marked.

In connection with any pail system, especially in public latrines under an Inspector's supervision, attention must be paid to the following points:—(1) The fitting of the pails to the seats. This should be so arranged that there is little or no gap between them. (2) The number of pails provided, to ensure that a duplicate can be inserted when one is removed to be emptied and cleansed. (3) The cleanliness of the latrine; the floor should be impervious and properly graded, the walls lime-washed, and the seats hinged to admit of scrubbing both sides. (4) Access for removal of pails, and avoidance of spilling of contents. (5) System of removal and final disposal. Conservancy squads should be organised and allotted to districts for removal of pails from the latrines daily. In many districts this work is done by prisoners. It should always be carried out in daylight. The use of a cart into which the pail contents are transferred and then taken to the place of final disposal is not to be commended. The dangers of spillage, difficulty of cleaning the cart, etc., are great. It is much better to keep the excreta in the receptacle in which it is passed by man, until finally disposed of.

Usually a certain area of ground is allotted for the reception of the pail contents; this should be outside the inhabited area, and not near a water supply.

Trenches are dug, some 3 ft. wide, 6 ft. deep, and 20 ft. long, in which the contents of pails are buried. A man should be told off for this duty, to ensure the application of earth to the excreta. When the trenches are filled to within 1 ft. of the ground-level, they are filled in with the remaining earth, and new ones dug.

One squad should be detailed for the cleansing of the buckets before replacement.

If the work of removal and supply of dry earth (where used) is done by contract, care should be taken to see that the earth is not obtained from the site of an old trench, as is not infrequently done.

Unless strict supervision is carried out, the pail contents will be dumped in any out-of-the-way corner, especially if containing only urine. Confetti or pieces of coloured paper can be used to ascertain if this is going on ; these are put into a few of the buckets, and if they are emptied in the neighbourhood, though the urine soaks away, the paper will be in evidence and noticed during routine inspection.

The disposal of dejecta by incineration, though the ideal method, is not yet practicable for large communities; but for small numbers it can be done successfully (with care) in the refuse destructors.

Biological installations for the disposal of pail contents have been tried in India, but have not been considered an unqualified success. The question of their suitability in a particular district is one for the Sanitary Engineer and the Medical Officer of Health, and does not intimately affect the Sanitary Inspector.

At coast towns the used pails are taken in boats well out to sea, and the contents 'dumped.'

In temporary camps, with expeditions or exploration parties, the short trench method is the best. Short trenches are dug, 3 ft. long, 1 ft. wide, and 2 ft. deep, and 2½ ft. between each trench. The earth from the trenches should be placed behind them, and applied by each occupier to cover his own dejecta. Before vacation, or when within 9 ins. of the top of the trenches, they should be filled in with the remaining earth.

Refuse.

The collection, removal, and disposal of refuse, as in the case of excreta, also require organisation and constant supervision.

House refuse may consist of ashes, dust, food, paper, tins, bottles, etc. Collections of these very soon give rise to a nuisance from putrefactive changes, which occur in the presence of warmth and moisture.

The basis of any system of collection and removal should be the allotment of scavenging squads to sub-districts, each section being supervised by a Sanitary Constable, or 'head-man.'

Collection and removal methods vary. They are largely matters of finance. Under no consideration should heaps of refuse be allowed to accumulate in compounds. Existing rubbish pits should be filled in, and the modern type of ash-bin (Fig. 103) substituted. A convenient size is 18 ins. in diameter, and 3 ft. deep. They should be made of galvanised iron, circular in shape, and provided with a tight-fitting conical lipped cover and suitable handles. They are usually provided by the householder; but in some places by the Sanitary Authority and allotted to compounds, streets, markets, etc., according to local requirements. In many districts there are provided separate cages for tins and bottles; these are thoroughly broken up before being disposed of.

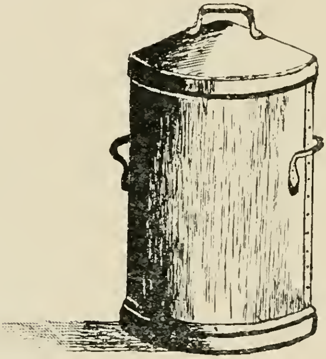


FIG. 103.—Sanitary Refuse Bin.

Removal is done daily, or, better still, twice daily; the occupiers of houses, etc., are instructed to place the bins and cages in the street at definite times. The contents are emptied into the scavenging cart, wagon, or hammock, according to the local methods of transport available, and may be disposed of in any of the following ways:—

1. *In the Sea.*—This method, where carried out at coast towns, often gives rise to a nuisance along the sea front. Parts of the beach are allotted as dumping grounds, from which the refuse is dragged to the water's edge to be carried out by the tide. A preferable method is that of loading up a boat kept for the purpose, and taking the refuse well out to sea, there to be dumped.

2. *Filling in Excavations, Ponds, and Pools.*—This is

a useful way of disposing of refuse, providing incinerators are not available and the place of disposal is outside the inhabited area. Unless care is taken, nuisances will arise from the blowing about of waste paper and dust. The foregoing also applies to disposal by burying rubbish in trenches.

3. *Destruction by Fire*, i.e. *Incineration.*—This is by far the best method of dealing with refuse. In practice it will be found the least expensive, and the risk of nuisances occurring is reduced to a minimum. The heat evolved may, in some pattern of incinerators, be utilised for raising steam to induce a draught by steam jet, and work a small plant, *e.g.* to break up and dry, earth required for a dry-earth system of excreta disposal.

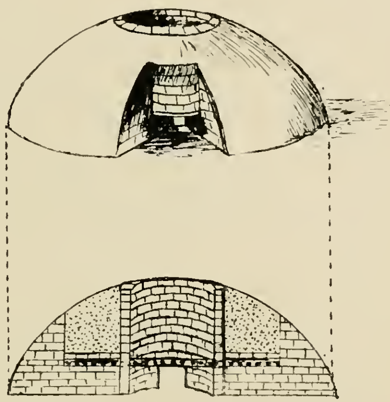


FIG. 104.—View and Section of Improvised Incinerator.

Where money is not available, incinerators may be improvised, and, if constructed with care, will be found to work well. The principles embodied in any type of improvised incinerator are: (1) a central chimney, near the base of which combustion takes place; (2) air inlets; (3) protection from rain. Figs. 104 and 105 are examples of improvised types.

Fig. 106 shows a "Horsfall" destructor, suitable for small populations. It is designed to serve a population of from 2000 to 6000. The furnace chamber consists of a steel-plate casing lined with firebrick, and having a grate area sufficient for burning about ¼ ton per hour. It is attached to a multitubular steam boiler, which supplies steam for the steam-blowers which provide forced draught for the furnace. Fittings are provided, consisting of steam-gauge, water-gauge, injector, safety valve, and feed check valve, and a junction valve can be fitted if required, to give a steam supply for external use.

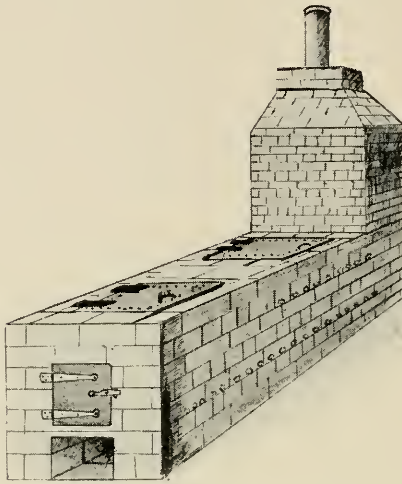


FIG 105.—Improvised Incinerator.

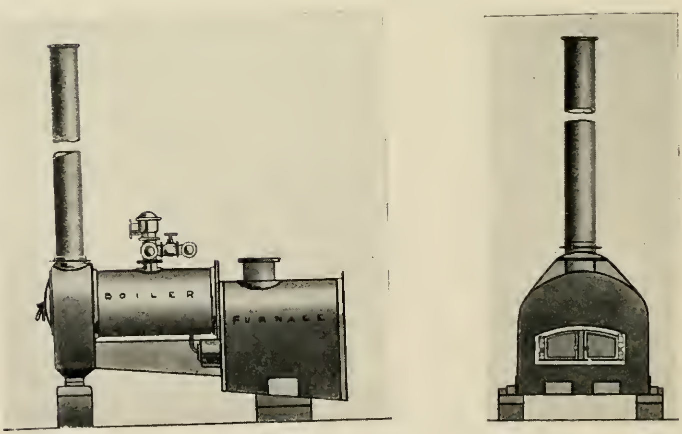


FIG. 106.—"Horsfall" Destructor, suitable for small towns.

The gases after passing the boiler are conducted to a chimney, and a by-pass is also provided direct from the furnace to the chimney, with suitable dampers for use when the boiler is producing more steam than can be made use of. The plant is intended to stand in a house of corrugated steel plate, on steel framing, and provided with a suitable storage bin into which the refuse can be tipped.

Fig. 107 represents a small pattern "Horsfall" incinerator, very suitable for slaughterhouses and markets, with a capacity of about $\frac{1}{2}$ ton per day of ten

FIG. 107.—Small Type Destructor.

hours. It has an outer casing of cast iron, with a lining of fireclay blocks dividing the feeding chamber from the combustion chamber and the outlet to the chimney, so that the draught is downwards from the feed-hole, thus preventing the escape of smoke during charging and feeding, and assisting to burn the smoke by passing it through the hottest portion of the fire before it can escape.

Whichever pattern incinerator is decided on, provision should be made for draught, drying of damp rubbish, and protection against rain. Haphazard stoking by scavenging labourers emptying bins direct into the furnace should not be allowed. A fixed and covered receptacle should be provided at the incinerating station to receive the bin contents. Stoking from this receptacle is done by the man in charge, who by experience will know best how to do it.

The site for refuse destructors should be as near as possible to the perimeter of the inhabited area. They should be erected so as to meet the wants of the subdistricts, and avoid long journeys of the scavenging carts through the central parts of a town.

In large municipalities the question of refuse destruction is one for the Sanitary Engineer rather than the Sanitary Inspector.

CHAPTER XI

HABITATIONS

Except in primitive districts, the problems connected with house construction, width of streets, and town planning are dealt with by the Sanitary Engineer, Architect, and Surveyor of the Public Works Department.

In practically every tropical place of sufficient size to be called a town, plans of suggested buildings have now to be submitted, considered, and approved by a sub-committee of the local authority, before operations may be commenced.

As an Inspector's duties are intimately connected with habitations, a knowledge of the conditions which ensure health becomes a necessity. These are:—

1. A site which is dry and not malarious.
2. A sufficient initial air space and proper system of ventilation.
3. A pure water supply.
4. A system of immediate removal and proper disposal of refuse and sewage.
5. Proper house construction, which ensures among other things, dryness of the foundations, walls, and roof.

(1) As dryness of a site is an essential condition, rising ground is chosen where possible, to facilitate drainage. The ground should not be "made" ground. It should be clean, free from sewage or refuse, and have a porous subsoil. The ground water should not be nearer the surface than 8 ft.

There should be facilities for drainage and water supply.

In malarious districts, European quarters should not be built in the vicinity of the native population.

A European 'colony' is usually formed on a suitable site a mile or so away from native towns.

(2) (3) and (4) have already been dealt with.

(5) A knowledge of drawing, building construction, and material used will be found advantageous.

In addition to being able to "read a drawing," an Inspector should be able to make simple plans, elevations, sections, etc., to scale; to illustrate reports, and recommendations. The elementary principles of drawing may be learnt from any of the numerous cheap text-books on the subject.

A draughtsman in a drawing endeavours to convey to one 'reading' it, not only a mental picture of the object depicted, but also, by distinctive shadings, a key to the chief materials illustrated. "New work" on a drawing is usually shown in red.

The types of buildings met with in the tropics vary enormously—from palatial residences to wooden bungalows and mud huts. A detailed description of these would be out of place in this manual; suffice it to say, that in addition to a general knowledge of sanitary construction in buildings at home, opportunity should be taken by the newly arrived Inspector in the tropics to find out the variations from standard types, the different details and reasons for same, by inspecting completed buildings and buildings in course of construction.

Building Materials in Common Use.

Bricks are made from sandy or loamy clay with a small proportion of lime, magnesia, soda, and iron salts. They vary a little in size in different districts; the length should equal twice the width plus thickness of one mortar joint. The average is 9 ins. × 4 ins. × $2\frac{1}{2}$ ins., and each weighs about 9 lbs. Finished brickwork usually measures four courses to the foot. A large variety are obtainable, and are used for different purposes.

Bricks may be (1) moulded by hand before being burnt, or (2) machine made, and then burnt. The former have a 'frog' for bonding; the latter have no frog, and are wire cut, *i.e.* the mixed clay is forced by a machine through an aperture 9 ins. × 4 ins., and cut by wires at intervals of $2\frac{1}{2}$ ins.

Glazed bricks, commonly used in many sanitary works, are usually made from fireclay; the white glazed surface is obtained by a thin coating of china clay over the face; this becomes vitrified in burning. The colour is varied by adding colouring matter to the wash. Before being laid, bricks are usually dipped in water, to counteract dryness and dust.

Good bricks should have a clear ring when struck—the bricklayer tests them with his trowel. They should be free from lumps of lime and pebbles, and should resist the knife.

A good brick will not break when thrown to the ground.

Wood enters largely into the construction of buildings. Different kinds are used for different work; the important point about all timber used is that it should be well-seasoned.

Limes are obtained by the calcination of chalk, limestone, and certain other minerals; carbonic acid and moisture are driven off, leaving 'quick' lime. This is done in lime-kilns.

Slaked lime is lime to which water has been added.

Hydraulic lime is so called from its power of setting under water.

Sand is used a great deal in building works. Sharp sand is free from clay or loam. It is said to be clean, and feels hard and rough when rolled in the hand.

Gravel is simply large sand.

Mortar is usually composed of 1 part of stone lime and 2 parts of sharp sand. For work in wet ground, hydraulic lime is used. Cement mortar is used for special work.

Cement is an artificial mixture of lime and clay, burnt and ground together ; the exception being Roman cement, which is a natural product, having a rich brown colour. Portland cement is so called from its resemblance to Portland stone in colour ; usually a bluish grey. It contains $\frac{2}{3}$ lime and $\frac{1}{3}$ clay.

Other cements in use are Parian and Keene's. These are used for internal surfaces. The former is plaster of Paris and borax, and the latter plaster of Paris and alum. Selenitic cement consists of plaster of Paris and hydraulic lime.

Rendering in cement, is a term used for the process of applying cement to the naked surface of walls. It may be done internally to present a smooth surface, or externally to improve the appearance or to prevent damp reaching walls in exposed positions.

Concrete consists usually of 1 part by measure of Portland cement, 1 part of clean sharp sand, and 4 parts of stone, clinker, or brick, broken to pass through a 1-in. ring. The materials are mixed dry, and turned over twice while being watered.

Its use for building purposes in the tropics is becoming more and more common, and it is taking the place, to a large extent, of bricks and stone. Concrete walls are 'run' up in moulds of wood, and are sometimes reinforced with iron or steel rods and bands.

Sanitary Aspect of Building Construction.

Foundations.—This term applies to the soil supporting a structure, and to the footings beneath the wall. Damp sites are made impervious by a 6-in. layer of cement concrete over the whole.

Walls.—Damp-proof courses of slate, tiles, or other impervious material are a necessity. They are inserted, during building operations, at a point above the ground-level yet below the lowest floor.

Roof.—This may be of thatch (Fig. 108), wood, corrugated iron lined with felt, or asbestos or other tiles. The latter are preferable, as they are bad conductors of heat. Ventilated double roofs to keep off the sun's rays are a feature of most government buildings.

Floors.—Wood is the general material used, and, if well seasoned, is quite satisfactory.

Dry rot in floor-boards, although usually associated with unseasoned timber and damp stagnant air under the floors, is caused by a fungus (*Merulius lachrymans*) which grows in the wood as a network of threads.

FIG. 108.—Illustrating Native Thatched Roof.

When the fungi have obtained a good hold, there is no cure. The parts affected should be cut out and renewed, and the remainder painted with a strong solution of copper sulphate.

The usual preventative is to provide ventilation, by placing air-bricks in the walls on opposite sides below floor-level. If on a damp site, it may be necessary to put down a 6-in. layer of cement concrete.

Wood which is underground is preserved in a number of ways, the best method being that of creosoting the wood. Other methods are: (1) charring the end to be put into the ground and quenching with water when the wood is charred ¼ in. deep; this method is applicable only to well-seasoned wood. (2) Embedding the posts in cement concrete.

The general rule in houses in the tropics is to use the first floor for living and sleeping rooms, the ground floor being used as a store.

'Frame' structures are raised from the ground on piers to a height of 4 or 5 ft., and the site concreted and graded to a proper outfall, to avoid puddles and other collections of water and their associated mosquitoes.

Wooden structures, though useful as temporary measures, being easily obtained and quickly erected, are not suitable as permanent buildings. The wood rapidly deteriorates, and the rooms become infested with insects and vermin. An additional objection is the risk of fire.

All houses should be of a brown or dark red colour, have wide verandahs all round, and, as stated previously (under Ventilation), the window-frames should be provided with jalousies or venetian blinds, as aids in controlling the light.

In native houses the floor should be impervious, and raised some 2 ft. above the ground-level.

All yards should be paved and graded to surface gutters leading to the street drains or sewers.

In West Africa house records are tabulated on the following form :—

SANITARY DEPARTMENT.

(Name of Town)

.... House Records. 191....

Section ——— Street ....

Street Number	Name of Occupier	Name and address of Owner	Cesspits	Well	Tank	Barrel.	Iron Roof	Grass Roof	Animals Kept

In making an inspection of a building with a view to furnishing a written report upon it, the following points should be enquired into :—

(*Date.*)

Name of building, No., and street (address).

(*Inspector's name.*)

Reason for inspection.

1. Purpose of the building.
2. Number of occupants.
3. Accommodation available according to byelaws
4. Outline description—

   (*a*) Nature of the site.
   (*b*) Nature of foundation.
   (*c*) Walls.
   (*d*) Roof covering.
   (*e*) Floors.
   (*f*) Ceilings.
   (*g*) Doors.
   (*h*) Windows.
   (*i*) Any other important item.

5. Water supply available: (*a*) source; (*b*) system; (*c*) general remarks.
6. Disposal of waste matters—

   (*a*) Drainage and sewage disposal—
   (*i*) General description; (*ii*) method of removal; (*iii*) disposal.
   (*b*) Method of refuse disposal.

7. Ventilation.
8. Lighting.
9. External observations—

   (*a*) Roof gutters and connections.
   (*b*) Roads and paths, surface drainage.
   (*c*) Vegetation.
   (*d*) General state of compound.
   (*e*) Whether mosquito larvæ found.

10. Health of occupants.

A rough plan of buildings and compound should always be furnished, similar to that shown in Fig. 109.

As a fitting end to this chapter, the following words of a distinguished sanitarian are very much to the point, and should constantly be borne in mind :—

"Sanitary environment is mainly the product of the man, and individuals without hygienic habits are but little benefited by sanitarily constructed premises."

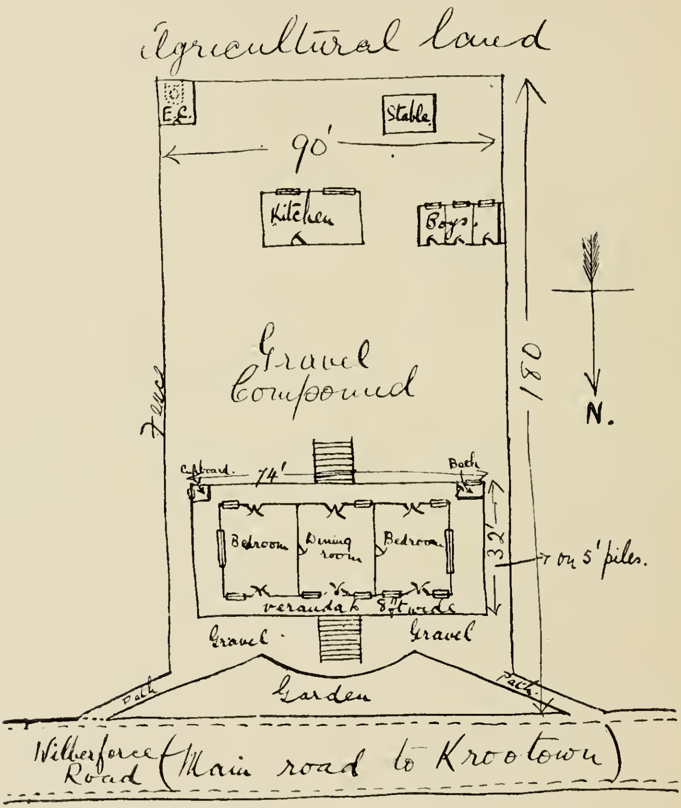


FIG. 109.—Sketch Plan to accompany Reports.

CHAPTER XII

SANITARY LAW AND PRACTICE

The term "Sanitary Law" includes all laws, ordinances, byelaws, regulations, and orders affecting the public health.

Each colony has its own laws on this subject; details of these cannot be given in a limited work of this kind, they would fill another volume. Indeed, such is not necessary, for an Inspector, in addition to being well grounded in British sanitary law, on which the majority of the colonial laws are based, only requires a knowledge of the particular legislation affecting the district to which he has been appointed. This he can best learn, together with the topography of, and duties to be performed in, his district, on the spot.

In the previous chapters, where considered necessary, brief notes on British sanitary law have been given in connection with various subjects. Strictly speaking, laws mean statute laws passed by, or made under powers granted by Acts of Parliament.

Orders in Council are orders made by the King in Council, on the instigation of the executive officers of the Crown. They are issued for various reasons, among others for the purpose of regulating colonial government.

Public Health Ordinances in force in a colony are made under Orders in Council, and are confirmed by the governor of the colony, acting as the representative of the Colonial Office.

Byelaws are made under conditions expressly stated in Public Health legislation. They have the force of law, *i.e.*, non-compliance entails action by the Sanitary Authority, followed, on conviction, by a penalty. They are intended to supplement, but not to vary or supersede the law.

All byelaws made by Local Authorities must be approved and sealed by them and confirmed by the Governor or other representative of the Central Authority. Public notice of intention to apply for confirmation of byelaws is necessary.

Model byelaws are those issued by the Central Authority to Local Authorities, as guides for framing byelaws.

Regulations differ from byelaws in that confirmation by the Central Authority is not usually required.

Nuisances in sanitary law mean statutory nuisances scheduled in one or other of the various Ordinances in force.

Apart from common law nuisances, a nuisance has been defined as "something which injures or is likely to injure the public health, and admits of a remedy." It should be noted that this definition embraces future as well as present consequences.

The scheduled nuisances include those connected with refuse, drainage, cesspits, collection of water, keeping of animals, overcrowding, and also a general clause covering "Any premises, etc., in such a state as to be a nuisance, or injurious to health."

For the purposes of administration there is what one might term a chain of sanitary responsibility throughout the various departments and the associated officials charged with administrating Public Health legislation.

The Central Authority—the Colonial Office—is represented in a colony by the Governor. He is entrusted with the general supervision of the various sanitary boards of districts, who in turn supervise the Local Authorities within their districts, charged with the direct administration of the existing sanitary laws.

The "Health Committee" of the Municipal Council is, in practice, the Sanitary Authority.

In some districts, the Sanitary Officers or Medical Officers of Health and the Sanitary Inspector and other officials act under the direction of the "Health Committee"; in others, they act for the committee, but are under the supervision of the Principal Medical Officer of the colony, or his representative, the Chief Sanitary Officer. The practice varies in different colonies.

The sanitary staff consists of native clerks, native inspectors, assistant inspectors, sanitary constables, and labourers. With the exception of the latter, all usually write and speak good English, but have no technical qualifications.

In some colonies female Sanitary Inspectors are now being employed, on lines similar to those at work in British towns. They find a useful sphere of work and influence in their routine duties in connection with house-to-house visitation, untouched by male Inspectors.

As an example of the work done by a female Sanitary Inspector during the first ten months of her appointment, the following extract from the Annual Report of the Health Officer for Calcutta, 1909, is of note:—

"During ten months (March to December 1909) she visited 2162 houses, comprising 6579 homes, made 101 detailed inspections of schools as to their sanitary condition, and reported on them; advised 491 women about to be or recently delivered, as to their cases, and also 418 mothers as to the health of their children; discovered and reported on 186 defective privies; 48 insanitary wells and 486 other insanitary conditions; investigated 137 cases of epidemic dropsy and 76 cases of other infective diseases; vaccinated 234 children (during the epidemic), and reported 217 unprotected children over one year of age; and inspected and reported on the sanitary arrangements in five large European shops where female assistants are employed."

As already indicated in previous chapters, districts are divided into sections or sub-districts, each being under the charge of an assistant Inspector or Sanitary Constable.

The following shows the organisation which may be in force and the chain of responsibility.

- COLONIAL OFFICE.
  - GOVERNOR OF COLONY.
    - Principal Medical Officer.
      - Chief Sanitary Officer.
    - Sanitary Boards of Districts.
      - Health Committee of Municipal Council.
        - Medical Officer of Health.
          - District Health Officers.
            - Sanitary Inspectors.
              - Assistant Sanitary Inspectors.
                - Sanitary Constables.
                  - Labourers.
                  - Mosquito Brigades.
          - Plague Department Staff.
            - Medical Inspectors.
              - Plague Inspectors.
                - Disinfecting Inspectors.
                  - Labourers.
          - Veterinary Service.
            - Veterinary Officers.
              - Slaughterhouse and Markets Inspectors.
                - Food Inspectors.
                  - Labourers.
    - Chief Engineer.
      - Public Works Department.
        - Sanitary Engineer.
          - Building Inspectors.
          - Labourers.

The Sanitary Inspector should remember that he is really the servant of the Health Committee, and zeal for sanitary progress should be tempered with discretion.

Tropical sanitation is largely influenced by the habits and customs of the native population in the district concerned, and a knowledge of these is not to be got from books. Without such knowledge the Inspector would soon find himself in deep water. Progress along the lines of least resistance, the policy usually adopted by Local Authorities, is not enough, especially in primitive districts. Inspectors should endeavour, where such a policy exists, to have full executive powers granted them if real progress is to be made. There must be some definite plan backed by suitable legislation. Lectures and pamphlets, though excellent in intent, will not cause the people themselves to co-operate, unless such legislation is in force.

Yet there exists a proper limit to the province of law. This was splendidly set by Lord Haldane recently. Law, he declared, "Provides only what is necessary for mutual protection and liberty of just action." It will not instantly bring about a change of habits and mode of life amongst a community, unless it is ready for the change. At the root of all lies education.

Practical Application of Principles.

This is largely a matter of initiative, organisation, and discipline, all preventive measures being based on a knowledge of the causes of disease.

The following notes apply chiefly to Inspectors appointed to primitive districts. Those appointed to municipalities in civilised districts may work on similar lines, having in addition the assistance of other Inspectors with local experience.

After reporting to his immediate superior, and receiving instructions as to the extent and scope of his work, the Inspector is usually taken round the district, section by section, by an assistant. The first month or so will be spent obtaining an intimate knowledge of the district, the organisation under his control, insanitary conditions prevailing, sanitary legislation in force, police court procedure, etc.

Every part of the district should be visited systematically, and the time required to inspect the whole noted. Routine inspections should be so planned that the whole district is covered in a fixed period.

Minor insanitary conditions noted can often be remedied by tactful suggestions to the persons responsible, others may entail service of notices for abatement. On such notices should be specified the Act, etc., under which action is taken, the work required to remedy the conditions, and a time limit.

It is well to remember that the money factor and native customs often operate against a keen Inspector's modern ideals. The co-operation of the police, if obtained, will be found most useful in assisting to carry out regulations, etc., in force.

Although the greater part of an Inspector's work will be outdoor, a certain time each day should be set apart for office work, interviewing complainants, native Inspectors, and others. If no office exists, one should be established temporarily at the Inspector's house.

The following books should be obtained and kept up to date: (1) office diary; (2) letter book; (3) register of letters; (4) book of notices; (5) register of sub-district Inspectors and work done; (6) register of food purveyors, slaughterhouses, etc.; (7) house-to-house inspection record book; (8) nuisance record book; (9) food inspections and analysis report book.

The assistant inspectors should be interviewed each morning at the office to report progress. They should be provided with note-books, and at the end of each day furnish to the office a report of work done, notices served, and action taken. These reports (which should be kept filed under Inspector's name), checked from time to time by personal observation, help to compile the register (5) mentioned.

The object of keeping a diary and books is to show a continuous record of the work done by the department, and for this reason should be properly planned and always up to date. If an annual grant is allotted to the department, a record book showing items of expenditure should be kept. The memory should never be trusted to retain information required for the department. Entries should be made in a pocket book at the time of the inspection, etc.

The report to the Sanitary Officer (usually monthly) requires careful compilation, and in suggesting improve-

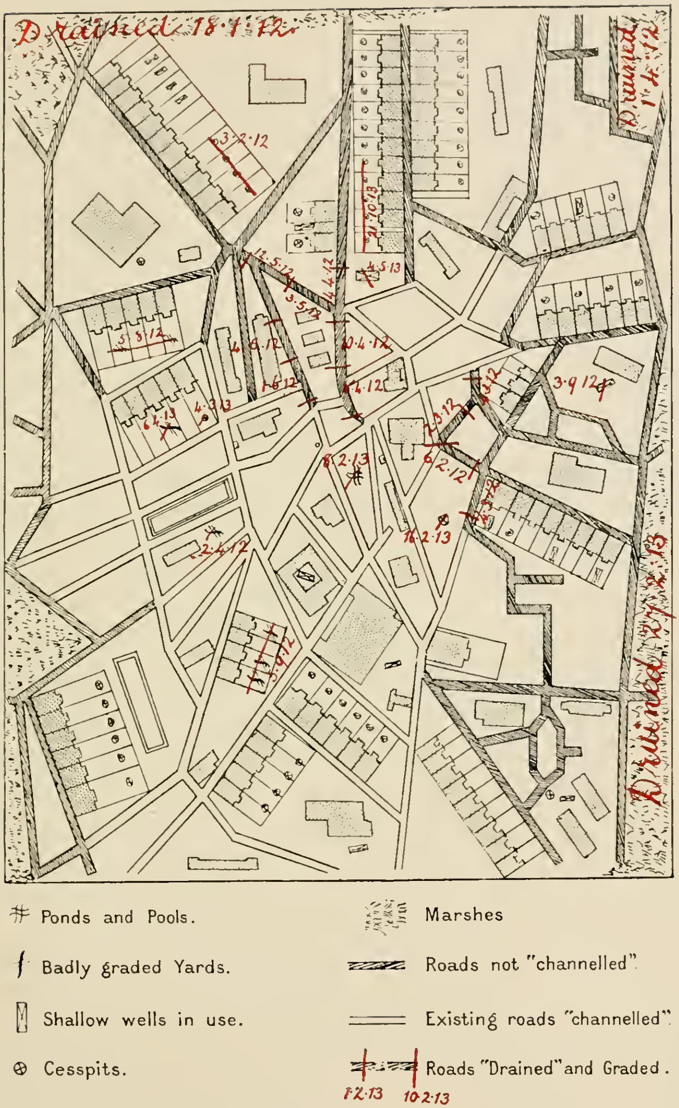


FIG. 110.—'Spot' Map of a Sub-District.

[*Face p.* 234

ments entailing exceptional expenditure, estimates of the cost of the work should be obtained, as they may be called for at any time.

Fairly large maps of sub-districts should be obtained and used as 'spot' maps, conventional signs being used to indicate various conditions met with at the spot indicated. In fact, any insanitary condition may thus be noted, and as such are remedied the signs should be crossed out in different coloured ink, and dated. (Fig. 110.) The maps should be kept up to date by observations during routine inspections, and reports of assistant inspectors noted, to see improvements carried out.

The following is a fair example of a day's work :—

5.30 *a.m.* Inspect the slaughtering of cattle and examine the carcasses afterwards.

6 *a.m.* Attend the office, parade the entire staff; apportion head men and labourers to each section or sub-district; see tools, etc., issued.

(7 *a.m.* Breakfast.)

8 *a.m.* Go out with a Sanitary Constable round his section; inspect compounds for larvæ, noting insanitary conditions; visit the dumping grounds and incinerators, where the refuse is disposed of. Examine cesspits, cook-houses, and wells.

10 *a.m.* Superintending office work.

11 *a.m.* Parade Sanitary Constables. The Sanitary Officer may want to mention particular items to them. Important work on hand is discussed, and routine duties arranged.

11 *to* 12 *noon.* Attendance at the office of the Medical Officer of Health. Appointments made regarding inspections, etc. Attend police court, if necessary. (In some districts a native Inspector of experience does this work.)

(12 *noon* to 2 *p.m.* Lunch.)

2 *to* 4 *p.m.* Continue compound inspection, varying it with visits to the principal parts of the town that may call for special attention.

Complaints received regarding nuisances are investigated and reported on by a Sanitary Constable on the following form, on which also is eventually stated the action taken :—

Complaint as to Nuisance.

SANITARY DEPARTMENT. (*Name of Town.*)

Matter complained of

Address

Date of Receipt of Complaint

Date of Inspection

How received

Name and Address of Owner or Agent

Inspected by

Report

Sanitary Constable.

Action taken

Sanitary Inspector.

Notices are served for various nuisances; the following are examples of some used in West Africa :—

SANITARY DEPARTMENT.

No.

To Mr

I HEREBY GIVE YOU NOTICE to clean, or cause to be cleansed and emptied, the cesspit owned by you, or in your care, and situated in ; the contents of the cesspit to be removed and thrown into the sea, and the place white-washed and disinfected.

If this Order is not complied with within days from the date hereof, legal proceedings will be taken against you according to the Ordinance in such case made and provided.

Sanitary Inspector.

SANITARY OFFICE OF 191

SANITARY DEPARTMENT. (*Name of Town.*)

No.

To Mr

I HEREBY GIVE YOU NOTICE that you are not, in future, to throw or deposit, or cause to be thrown or deposited, in or upon the

any corpse, dead animal, night soil, filth, dung, or other unwholesome matter, or any dust, ashes, rubbish, refuse, loose dirt, high weeds, grass, or other encumbrance, or commit any other nuisance or indecency not expressly mentioned herein in or upon the above

Any contravention of this notice on your part shall make you liable under the Public Health Ordinance, No. of , to a fine not exceeding

Sanitary Inspector.

SANITARY OFFICE OF 191

The following is a specimen of the daily reports furnished :—

DAILY REPORT.

Date 9th Sept 1913   Section 18

Street and Number. Princess Street.	No. of House	Larvæ and what in	Cesspits In Order	Cesspits Out of Order	Wells	Water Containers Barrel	Water Containers Tanks	Nature of Nuisances, if any Instructions given or action taken
Mammy Sarah	6	none	yes	no	none	none	none	yard clean
Bukari	15	"	"	"	"	"	"	" "
McClusky	4	"	"	"	"	"	"	" "
Suri	32	"	"	"	"	1 Proof	"	" "
Varnish	12	"	"	"	"	1 "	"	" "
Johnn	7	"	"	"	"	none	"	" "
Tarbrush	9	"	"	"	"	"	"	Weeds, warned to be clean
Johannes	40	"	"	"	"	1 not proof	"	warned.
Juah	11	"	"	"	"	none	"	yard clean
Rose Johnston	16	"	"	"	"	"	"	" "
Bobo	30	yes, in a cistern	"	"	"	"	"	" "
Boy Fathead	33	none	"	"	"	"	"	" "
Christie	42	"	"	"	"	"	"	Weeds, warned to be clean
Jewah	10	"	"	"	"	"	"	" " " "
Wartan	17	"	"	"	"	1 Proof	"	yard clean
Vrodah	19	"	"	"	"	none	"	" "
Banur	18	"	"	"	"	"	"	" "
Isfan	14	"	"	"	"	"	"	" "
Mammy Rewah	8	"	"	"	"	"	"	" "
John Martin	2	"	"	"	"	"	"	" "
	20	Houses						

I certify that I visited Labourers Weeding and removing rubbishes, in my section, Labourers emptying dust-bins at the incinerating station. I inspected compounds at Princess Street. Larvae was found at Bobo's No 30 Princess Street, in a cistern; I also examined Public Latrines, and found the seats properly scrubbed, clean, and buckets arranged. I examined meats in the City Market, and found all satisfactory.

(Sd) John Thomas
Assistant Sanitary Inspector.

Countersigned ____________ Sanitary Inspector

Application to the magistrate for summonses are made on the following form :—

SANITARY DEPARTMENT.

Summonses are required for the undermentioned Cases under the...

Ordinance No.... of 19...

No.	Name and Address.	Nature of Offence and Date.	Remarks.

The following are the returns requiring compilation regarding cases dealt with :—

SANITARY DEPARTMENT.

Return of Cases dealt with in the .... Police Court

on 191

No.	Name and Address.	Offence.	Result.

Total Number Tried... Total Number Convicted...

Total amount of Fines £.

RETURN showing number of prosecutions made in the Sanitary Department at ____________

during the month of ____________ 190

Date.	Number of Prosecutions.	Number of Convictions.	Fines Collected. £ s. d.	Number Imprisoned.	Remarks.

The Principal Medical Officer.

Signature ____________

Rank ____________

Station and date ____________

Annual Return of Prosecutions made in the Sanitary Department for the year 19

Station.	Nature of Offence	Number of Prosecutions.	Number of Convictions	Number Fined.	Total Amount of Fines.	Number Imprisoned.

The following detailed returns of sanitary work are forwarded to the Medical Officer of Health :—

SANITARY DEPARTMENT.

DETAILS OF SANITARY WORK, (Rendered Weekly)

Name of Town 19

Sections	Removal of Refuse.				Removal of Tins and Bottles.				Record of Oiling.				Latrines.		Remarks.
	Cartloads.	Hammock-loads.	Headloads.	Number of men employed.	Cartloads.	Hammock-loads.	Headloads.	Number of men employed.	Cesspools.	Wells.	Drains and Pools.	Number of men employed.	Number of pails removed.	Number of men employed.	
1															
2															
3															
14															
Totals.															

Sanitary Return No.

To be rendered monthly.

(*Name of Town.*)

1. Number of pails of night soil removed
2. Number of soiled pails removed and clean pails substituted
3. Number of night-soil men employed to clean latrines and excreta
4. Number of cesspools cleansed
5. Number of new cesspools constructed
6. Number of cesspools abolished
7. Number of cesspools oiled regularly by Department
8. Amount of refuse removed daily from the street. This should be given as the number of cart-loads or head-loads removed
9. Amount of refuse removed daily from yards or premises, rendered as above
10. Number of men employed moving refuse

11. Average daily number of cart-loads of empty tins, cans, bottles, broken crockery, and other incombustible material removed from houses, huts, and compounds

11a.	Daily average number of pails of excreta.	Daily average number of cart-loads or head-loads of refuse.	Daily average number of cart-loads or head-loads of slaughterhouse and market offal.
Buried or trenched .			
Burnt . . .			
Thrown into sea .			
Otherwise dealt with (state mode of disposal)			

12. Number of lineal yards of masonry drains reconstructed
13. Number of lineal yards of masonry drains repaired
14. Number of linear yards of earth ditches cleansed
15. Number of linear yards of earth ditches dug and graded
16. Number of square yards of weeds, grass, and vegetation cut and removed
17. Number of excavations filled up
18. Amount of low-lying and marsh land raised and drained
19. Number of cubic yards of material used for filling up pools and excavations
20. Number of persons fined for making new excavations
21. Number of men employed in filling up pools, etc.
22. Number of drains oiled
23. Number of pools and excavations oiled
24. Number of tanks and barrels oiled
25. Number of men employed for oiling drains, pools, and water-tanks or barrels
26. Number of inspectors employed
27. Number of houses inspected
28. Number of houses where larvæ was found
29. Number of notices served to remove the conditions causing breeding of larvæ

30. Number of persons prosecuted for having vessels, used for catching and storing rain-water, unscreened
31. Number of persons fined for having vessels, used for storing or catching rain-water, unscreened
32. Number of notices served to remove insanitary conditions on premises
33. Number of persons fined for not removing insanitary conditions on premises
34. Number of buildings condemned as dangerous
35. Number of condemned buildings removed

(Signed)

Sanitary Inspector at

Date

SANITARY Progress Report for Month of 191

Recommendations.	To whom made	Date.	Action Taken.

Sanitary Inspector.

Date 191

Nominal rolls of labourers and amounts of pay received by them are sent in weekly to the pay department on the following form, through the Medical Officer of Health, who usually countersigns them :—

SANITARY DEPARTMENT.

Nominal Roll of Scavengers, &c., Employed from ________ to ________

Station ________

No.	Class.	Name.	Date.	No. of days worked	Rate per diem	Amount.	REMARKS

____

Sanitary Inspector.

In conclusion, an Inspector should be well known in his district, and ready at all times with advice and help in sanitary matters. His office should be a centre of sanitary effort; and, in primitive districts, the 'spot' maps of sections the indices of progress: each adding his quota to the fulfilment of the prediction of Colonel Gorgas, one of the greatest authorities on tropical sanitation, that, ". . . Life in the tropics for the Anglo-Saxon will be more healthful than in the temperate zones, and that gradually within the next two or three centuries, tropical countries, which offer a much greater return for a man's labour than do the temperate zones, will be peopled by the white races and become the centres of wealth, population, and civilisation, as they were in the dawn of human history."

APPENDIX

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(*m*) Useful factors for conversion 275

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(*a*) HOW TO MAKE DRIED BLOOD FILMS.

For making stained preparations, dried blood films must be used. A straight surgical needle (the eye of which has been removed with a pair of forceps) and glass slides are all the articles necessary for taking films. Cover-glasses are not required.

The finger is pricked, and a glass slide is lowered on to the drop of blood that exudes, so that it touches the drop about half an inch from one end of the slide. The slide is then held between the finger and thumb of the left hand, and the shaft of the needle (which is held by the point) is placed crosswise on the slide over the drop of blood. The blood will run along the underside of the needle, which is then drawn evenly along the slide to the end, thus making a broad thin film of blood.

Films prepared in this way should be allowed to dry in the air, and then fixed by immersion in absolute alcohol for ten minutes.

(*b*) HOW TO COLLECT BLOOD FOR EXAMINATION BY THE SERUM TEST.

This test is used in connection with the diagnosis of enteric and Malta fevers.

The following articles are required:—(1) Small glass capsules of the shape shown in Fig. 111: these can be obtained from any laboratory. (2) A spirit lamp. (3) An unused surgical needle. (4) Alcohol or ether for cleaning the skin. (5) A pair of forceps.

To collect the blood, firstly place all the required articles on a sheet of clean glass or paper on a table by the bedside of the patient, light the spirit lamp and sterilise the tips of the forceps by passing them through the flame, also sterilise in a similar way the two closed ends of the blood capsule. With the forceps break off the tips of the glass capsule so as to open both ends of it, then lay it down on the glass or paper on the table. Sterilise the tip of the patient's finger with alcohol, and dry it thoroughly with a sterilised cloth. Let the hand hang downwards so that the blood collects in

FIG. 111.—Blood Capsule.

it, and wind a corner of a handkerchief tightly round the base of the finger so that the tip becomes congested with blood; prick the finger, and a large drop of blood will immediately flow. Hold the open end of the curved limb of the capsule in the blood with the bulb at a lower level. When the capsule is half full remove it, and seal the open end of the straight limb by holding it for a few seconds in the flame. Seal the other end in the same way, then place the capsule in cotton-wool in a small box, and despatch it with particulars to the examiner.

(c) HOW TO DEAL WITH SPECIMENS OF VISCERA, ETC., REQUIRED FOR CHEMICAL EXAMINATION.

The suspected viscus or other material to be sent for examination should be enclosed in a glass bottle or jar, fitted with a stopper or sound cork.

If the material sent is liable to decomposition, it should invariably be preserved by one of the following methods:—

(1) In cases of suspected poisoning in man, other than alcoholic poisoning, the material sent should be

immersed in spirit of wine. The spirit should be sufficient in quantity to cover the material immersed, in whatever position the vessel containing it may be held; and should not bear a smaller proportion to the bulk of such material than one-third. Care should be taken that common bazaar spirit is not used.

(2) In cases of suspected alcoholic poisoning in man, the contents of the stomach and its washings in pure water should be placed in a bottle with a sufficient quantity of clean table salt to saturate the solution and leave a little salt undissolved. The stomach itself, after being washed in pure water as above, may be preserved in alcohol as in (1).

(3) In cases of suspected cattle poisoning, the viscera or other material may be preserved in spirit or in a solution of common salt. If a solution of salt is used, it should be prepared as follows:—

Common salt should be added to pure water at the temperature of the air, and stirred until no more salt dissolves, when the solution should be filtered through a plug of cotton-wool.

The bottle containing the viscus or other material should be filled up with the solution to within $\frac{1}{4}$ of an inch from the stopper. To obviate any danger from the solution of salt being tampered with, a separate sample of the solution should in every case be sent to the examiner by the officer despatching the viscus, and another sample should be retained in a sealed bottle in his office.

Great care should be taken that the stopper or cork of the bottle fits tightly. This precaution is especially necessary when alcohol is used as a preservative; in such cases a ring of beeswax or candle-wax should be placed round the lip of the bottle so as to cover the shoulder of the stopper. The stopper should be carefully tied down with bladder or leather, and sealed.

The glass bottle or jar should then be placed in a strong wooden or tin box, which should be large enough to allow of a layer of raw cotton, at least $\frac{3}{4}$ of an inch thick, being put between the vessel and the box.

The box should be sealed with a distinctive seal, preferably the office seal of the officer despatching it.

(*d*) HOW TO DESPATCH MATERIAL FOR BACTERIOLOGICAL EXAMINATION.

Pus, sputa, urine, fæces, etc., should be sent in a small bottle, previously placed in boiling water for a few minutes. Portions of solid organs may be dealt with in the same way, if the temperature is not high and the time required for transit short. Otherwise these should be put in glycerine and water, 1 in 4. The bottles must be securely stopped or corked, and very carefully packed.

Dead rats and other small animals suspected of plague should be first immersed in a liquid insecticide solution to kill any fleas or other insects they may harbour. Carbolic acid, cresol, or paraffin are examples of suitable solutions. The animal should then be packed in a tin or jar, and this placed in a large wooden box packed with straw or sawdust.

Great care must be used in packing these things to avoid risk of infection in transit. It must also be ascertained that postal or other carrying agencies' regulations are not infringed in sending them. Most postal authorities allow of such material being sent under certain safeguarding regulations.

(*e*) NOTES REGARDING COLLECTION, ETC., OF MOSQUITOES AND OTHER FLIES.

[*From the pamphlet on "How to Collect Mosquitoes," issued by the British Museum (Natural History). By permission of the Trustees.*]

List of Articles Used for Collecting and Preparing Mosquitoes.

One entomologist's collecting-net of book-muslin (one or two spare net-bags may be taken, in case the one in use gets torn).

A number of glass-*bottomed* pill-boxes (1½ to 2 ins. in diameter is about the best size).

A cyanide killing-jar, or materials for making same, as follows:—

> ¼ lb. of cyanide of potassium (in lumps).
> 1 lb. of plaster of paris.
> A glass jar with wide mouth and closely fitting lid.

Entomological forceps, with curved ends for holding pins, are very useful.

One ounce No. 20 entomological pins (D. F. Tayler & Co., New Hall Works, Birmingham. These pins are sold in boxes at 7s. 6d. per ounce; and as the pins are exceedingly fine, an ounce will go a very long way).

Common pins (three or four packets).

Gun-wad punch, No. 20 bore.

Cards (4-sheet Bristol board) from which to punch discs; a supply of the latter should be prepared ready for use.

Needles (two or three) mounted in handles, for arranging legs and wings.

A good pocket-lens.

Cork carpet, one or two sheets, about 6 ins. square, on which to perform the operations of pinning, etc.

Medicated cotton-wool for packing mosquitoes in pill-boxes when time does not allow of pinning.

A strongly made wooden box (a cigar-box will do), in the bottom of which is fixed a layer of cork carpet.

A number of glass tubes for collecting larvæ and pupæ.

It should be borne in mind that, for the purpose of the scientific determination of species, *mosquitoes cannot be collected with too great care.* As important specific characters are furnished by the *scales*, *wings*, and *legs*, it is of the utmost consequence that the scales should not be rubbed off, or the wings and legs injured. *Unless attention is paid to this point, the specimens will probably be quite worthless for determination or description.*

Specimens for determination may also be sent in spirit. Each species should be sent in a separate tube, and the tube numbered to correspond with the number of a dried specimen of the same species. They are best preserved in 70 per cent. alcohol.

Mosquitoes are best pinned as soon as possible after death. Specimens should be pinned in three positions—(1) to show the dorsal view; (2) the ventral, and (3) the lateral aspects. When travelling in haste, specimens may be kept in pill-boxes partly filled with medicated cotton-wool.

In collecting specimens of a species of mosquito for determination, some *half-dozen* examples of *each sex* should, if possible, always be obtained and pinned or preserved dry, and the same number in spirit.

Method of Collecting and Killing.

Mosquitoes may be captured in the open; an entomologist's collecting-net is then necessary, from which the insects can be transferred to glass-bottomed pill-boxes. In doing this, great care must be taken not to pull off the legs. Inside buildings mosquitoes can easily be captured on walls and windows in the pill-boxes themselves. Specimens are, however, best obtained in good condition by *breeding* them; this can readily be done by keeping the larvæ or pupæ in a basin or jar of water covered over with book-muslin. In any case mosquitoes are best collected alive in the glass-bottomed pill-boxes (obtained from any dealer in natural history apparatus). Not more than a single specimen should be put alive in each box. To kill the mosquitoes, the box is opened a fraction of an inch on one side, and placed for a few minutes in a cyanide killing-jar, which must, of course, be closed. They may also be killed by tobacco smoke or chloroform. If cyanide or tobacco smoke is used, they should not be left in the fumes more than ten minutes. As soon as the insects are quite dead, they should be turned out on to a sheet of cork carpet; they should be touched as little as possible, the manipulations necessary to arranging the wings and legs being performed with a needle.

When travelling, and time and space are of importance, mosquitoes need not be pinned, but may be collected in pill-boxes and kept firm by *medicated* cotton-wool. Glass-top boxes of metal are best for tropical climates. The gnats should be placed, when killed, on the glass, and then a loose plug of medicated cotton-wool placed on them so as to prevent them from shaking about.

To pin a mosquito, take a card disc and write on its *underside* the data connected with the specimen to be pinned, such as: (1) name of *locality*, including *altitude*, if necessary; (2) *date*—day, month, year—thus, 9.11.98; (3) *collector's name*; (4) any *remark of interest*, e.g. "Most troublesome species in district," or attach these remarks to the label. Place the disc on a sheet of cork carpet, and make a fine puncture with a stout pin; then pick up one of the fine No. 20 pins and thrust about one-third of an inch of it through the puncture made in the disc. Lay the specimen *on its back* (turning it over with the aid of a needle), and thrust the pin, which now carries the disc, through the centre of the thorax, between the bases of the legs, until the tip of the pin projects a little beyond the dorsal surface of the thorax; invert the disc, and thrust an ordinary pin through the disc, near the margin for the purpose of carrying both disc and specimen. The next and last thing to be done is to arrange the legs and wings as far apart as possible—*i.e.*, the wings must be made to project at an angle from the body, and not allowed to remain closed; and the legs must be disposed symmetrically on the card disc. These operations must be performed as gently as possible with the help of a needle mounted in a handle, and care must be taken that hairs and scales are not rubbed off in the process. Proceed in much the same way in pinning specimens to show the ventral and lateral surfaces.

The insect should be mounted with its head *away* from the pin (see Fig. 41).

Preservation of Larvæ and Pupæ.

Specimens of larvæ and pupæ should always be preserved, especially when it is possible to breed some of them out, or otherwise to determine the species to which they belong. They should be killed and kept in alcohol or formol. If in alcohol, it should be about 60 per cent. strength.

Of formol a 4 per cent. solution (*i.e.* 1 part of ordinary commercial 40 per cent. solution to 9 parts of water) is quite strong enough for killing and preserving.

Larvæ and pupæ (whether preserved in formol or alcohol) should be put in small glass tubes, and then corked; the corks may be coated with paraffin wax, though this is not absolutely necessary. Each tube should contain a scrap of paper, on which the necessary data (locality, date, whether from fresh or salt water, collector's name, etc., with, if possible, a reference to pinned specimens of the perfect insect, so that these may be identified) should be written in pencil.

The tubes should be packed in cotton-wool in a small tin box for transmission to England.

It is scarcely necessary to add that each species should be kept distinct, in a separate tube.

Transmission of Specimens to England.

Pinned specimens of mosquitoes, like those of other insects, rapidly develop mould during the rainy season in tropical countries; and since mouldy specimens are practically worthless for purposes of scientific determination, the insects should be sent home as soon as possible after collection. To contain the specimens, if a proper entomological store-box is not available, any small strongly made box (such as a cigar-box) will serve, in the bottom of which a layer of cork carpet is firmly fixed. The greatest care must be taken to prevent specimens getting loose and rolling about in transit, since in this way a single loose disc might easily destroy or hopelessly damage all the other specimens in the box. To prevent this, the pins supporting the cards should be inserted as tightly as possible into the cork carpet, and they should all be driven in to the same level. Other pins may be inserted between the discs to stop them turning round and so rubbing against the next insect. A piece of naphthaline should be firmly fixed in each box to keep off mites, which often destroy collections during transit. The box containing the specimens should be well wrapped in cotton-wool or similar material, and firmly packed in an outer box for transmission (by parcel-post) to England, addressed to the Director, British Museum (Natural History), Cromwell Road, London, S.W.

The above instructions, though drawn up with special reference to mosquitoes, are equally applicable to the collecting of diptera in general and other blood-sucking insects, except that in the case of the large forms, such as horse-flies (*Tabanidæ*), robber-flies (*Asilidæ*), etc., it is not necessary to use so fine a pin as a No. 20 (D. F. Tayler & Co's entomological pin No. 5—price 1s. 6d. per ounce—would do instead). Fleas (*Pulicidæ*) are best sent in spirit; so also are the parasitic bugs (*Hemiptera*), unless they are large species.

N.B.—NOT ONLY MOSQUITOES BUT ALL BLOOD-SUCKING INSECTS SHOULD BE COLLECTED AND SENT HOME.

HOW TO MAKE A LARGE-SIZED KILLING-JAR.

Take any fairly large glass jar (such as a pickle bottle), with a wide mouth and closely fitting lid, and cover the bottom with a layer of dry plaster of paris to the depth of half an inch; pour in above this a layer, equal in depth, consisting of *powdered* cyanide of potassium, mixed with rather more than its bulk of dry plaster of paris; cover this mixture with a layer of dry plaster of paris to the depth of a quarter of an inch or so, and pour in above the whole a layer, half an inch in depth, consisting of plaster of paris mixed with water to the consistency of cream. As soon as the top layer of plaster is dry, the jar is ready for use. To obviate the risk of cracking the jar owing to the heat evolved when plaster of paris is mixed with water, it may be advisable to stand the jar in warm water before adding the final layer. The exact amount of cyanide of potassium to be used is of no great consequence, but in the case of a properly prepared jar, the odour should be readily perceptible on removing the lid; if it is not, the reason may be that the mixture is too dry, when a little water poured on to the top layer will probably set matters right. After some months' use the cyanide loses its efficacy (to obviate this as far as possible, the jar should never be allowed to remain open), and the mixture must then be renewed.

(*f*) HOW TO COLLECT SAMPLES OF WATER FOR ANALYSIS.

1. The samples of water for chemical and for bacteriological examination should be taken from the same source and at the same time.

2. The sample intended for chemical analysis should measure at least 1 gall., and should be forwarded in "Winchester quart" bottles. The sample for bacteriological examination should be sent in a bottle specially sterilised for the purpose. In the event of the "Winchester quarts" not being available, water for chemical analysis may be forwarded in other similar stoppered bottles. Corks should not be employed, except on emergency. If used, they should be quite new, well tied down and sealed. Luting of any kind (such as linseed meal) should not be used. Each bottle should be labelled so as to correspond with the official letter or invoice.

3. Great care must be taken that a fair sample of the water is collected; and at all times, before being charged with water, the "Winchester quart" bottles should be rinsed out with some of the same kind of water as that which is to be analysed. In taking water from a stream or lake, the bottle ought to be plunged 1 ft. below the surface before it is filled. In drawing from a pipe, a portion ought to be allowed to run away first to get rid of any impurity in the pipe. In judging a town supply, samples should be obtained direct from the mains as well as from houses.

4. Should there be any doubt as to the absolute cleanliness of the "Winchester quart" bottles, a little strong sulphuric acid should be allowed to flow over the inner surface of the bottle, which should then be thoroughly washed out with the water to be examined, until the rinsings are no longer acid to litmus paper. Great care should be exercised in the collection and forwarding of that portion of the sample intended for bacteriological examination. The special bottle and the stopper must be sterilised at 100° C. for three hours; if this is impossible, the bottle and stopper should be cleansed with pure sulphuric acid, and all traces

of the acid removed by washing with water from the source to be examined. In taking a sample, the following details should be observed :—

(*a*) Before opening the sterilised bottle, sterilise the stopper and neck by passing over and around them the flame of a spirit lamp for half a minute. Then remove the stopper by means of a pair of metal forceps, which have been sterilised previously in the flame. Hold the forceps and stopper in the hand, and then fill the bottle at once with the water. When the bottle is full, pass the stopper through the flame for a few seconds and quickly replace into the neck of the bottle.

(*b*) When the water is collected from a tap or delivery pipe, the mouth of such tap or pipe should be flamed for a minute, and the conduit flushed by allowing the water to run for three minutes.

(*c*) Place the bottle in a suitable container, and pack with ice and sawdust. If ice is not procurable, the container should be filled with sawdust only.

5. Samples should be forwarded always by the most expeditious route, and it should be borne in mind that the samples for bacteriological examination should arrive at the laboratory to which they are being sent, not later than forty-eight hours after collection.

6. The collection of all samples of water to be submitted for analysis must be made either by or under the direct personal supervision of the Sanitary Inspector, who should ensure that these directions are carried out, and that a report embodying the following information is furnished with each sample :—

(*a*) Source of water, viz., from tanks or cisterns, main or house-pipe, spring, river, stream, lake, or well.

(*b*) Position of source, strata, so far as they are known.

(*c*) If a well, depth, diameter, strata through which sunk; whether imperviously steined in the upper part, and how far down. Total depth of well and depth of water to be both given. If the well be open, whether furnished with a cover or with a pump.

(*d*) Possibilities of impurities reaching the water; distance of well or source from cesspools, drains, middens, manure heaps, stables, etc., if drains or sewers discharge into streams or lakes; proximity of cultivated land.

(*e*) If a surface water or rain-water. Nature of collecting surface and conditions of storage.

(*f*) Meteorological conditions, with reference to recent drought or excessive rainfall.

(*g*) A statement of the existence of any disease supposed to be connected with the water supply, or any other reason for requiring examination.

(*h*) Date, place, and name of official who took the sample.

(*g*) COPY OF "SANITARY INSTRUCTIONS FOR THE TROPICS." By SIR RONALD ROSS, K.C.B., M.D., D.P.H., F.R.S.

Issued by the Incorporated Liverpool School of Tropical Medicine.

1. ALL FOOD, including raw meats, cold meats, bread, butter, milk, vegetables, fruits, sweets, opened tins, soup and gravy stock, must be kept in a fly-proof safe in a draughty, shaded place. This safe should, if possible, be hung from the roof, or, if stood on the floor, be secure from ants. The servants should be instructed to use it properly, and without fail. The kitchen, pantry, vessels, and dishes must be kept scrupulously clean.

2. All DRINKING WATER must be boiled in suitable closed vessels every evening without fail. The vessels containing the boiling water should then be put, steaming, in the dining-room or other place in sight of the master of the house; and should be kept there to cool until morning, when the water may be poured into special coolers or other vessels for the day's use. If the water requires filtration, it should be filtered *before* boiling. Tongs should be used for breaking ice. Aerated waters are generally safe.

3. Unless fresh MILK can be obtained from a reliable source, it must be pasteurised or boiled (for one minute

only) *just* before being taken, even in tea and coffee. As a rule, tinned or powdered milk is to be preferred. Milk for children, even tinned milk, must be most scrupulously protected from flies.

4. MOSQUITO NETS must be invariably used during sleep, even if few mosquitoes are to be seen. The net should be white and entirely free from holes; should be arranged so as not to leave any apertures; should be lowered before night; and should be tightly stretched in order to allow the air to enter freely. If sand-flies are present, special muslin nets must be employed. It is good to protect the windows with wire screens, or, at least, to screen a portion of the verandah to be used as a sitting-room. Every house should possess a small white butterfly net, with which mosquitoes can be easily destroyed.

5. Europeans should use PUNKAS, or hand-fans, or fans driven by hot-air engines or electricity. These keep off insects, add to comfort, and prevent much of the debility produced by long-continued heat.

6. Much VEGETATION, especially undergrowth, should not be allowed close to houses, as it exhales moisture, increases dampness, and encourages mosquitoes. Several species of garden plants contain water which breeds mosquitoes; and flowers in the verandah give these insects shelter.

7. All WATER-BUTTS, wells, and cisterns should be protected against mosquitoes. All garden cisterns, fire buckets, and vessels of water should be completely emptied, if possible, once a week.

8. All RUBBISH and REFUSE, including broken bottles, crockery, and flower-pots, tins, kitchen waste, and manure must be kept in a special rubbish-bin, and removed at least once a week.

9. LATRINES, drains from kitchens, bathrooms and stables, ground gutters and roof gutters, must be kept in good repair, scrupulously clean, disinfected, and free from stagnant water. Night-soil must be removed daily.

10. The master or mistress of the house should carefully INSPECT the whole of his premises at least once a week.

11. Intelligent persons will learn from experience the quality and quantity of DIET which suits them best. Too

frequent meals, too much hot meat, and greasy food are generally to be avoided.

12. ALCOHOL should be taken very sparingly, if at all. It should never be touched before sunset or just before bedtime. Light wines are better than beer or spirits.

13. CLOTHING should be porous, and may be very light in hot weather if a flannel band is worn round the waist. Europeans must always wear sun-hats.

14. EXERCISE should be taken morning and evening. Cold BATHS may be indulged in only if found to agree.

15. It is usually very DANGEROUS, and often deadly, for Europeans to live or sleep in houses occupied, or recently occupied, by natives.

16. For further information, apply to the nearest Health Officer or Physician.

(*h*) NOTES ON OIL AND PETROL ENGINES USED WITH THE CLAYTON DISINFECTING APPARATUS.

Oil engines using paraffin, when working with hot-tube ignition, will only run well when the tube is kept at a clear cherry red heat, and the cylinder head itself, which forms the vapouriser, is also kept fairly hot, but not red.

Paraffin engines with electric ignition have a separate vapouriser, which must be heated before starting, but is kept hot during running by the exhaust from the engine cylinder. The lamps used in both of these types of engine are of the Aetna pattern, and should be kept clean (a strainer should be used for the paraffin when filling the reservoir), and the nipples of the lamps cleared when necessary with the small pricker provided.

Petrol engines must *not*, of course, be heated by any form of lamp, and great care must be taken to avoid water getting mixed with the petrol.

Either type of engine will run best when the supply of oil is cut down to a minimum. If the supply is too great, the engine will not run faster, but rather slower.

(*i*) A NOTE ON VITAL STATISTICS.

Vital statistics are so called because they are associated with problems relating to health and the chances of life. Such statistics if accurately compiled enable one to determine causes and limits of mortality, and to apply them as tests of the health of the communities which they embrace.

The chief statistics refer to population, age, and sex distribution, births, marriages, occupations, diseases, and deaths.

Statistics of sickness apart from mortality and infective disease rates are impracticable. They are difficult to collect accurately, which is fatal to their value as vital statistics.

All calculations being in ratio to the population, it follows that the accuracy of the figures for the latter is of first importance. This is ensured by obtaining them from the decennial census returns.

Age and sex distribution are also obtained from the census returns.

Birth, Marriage, and Death-rates are calculated to show the number per 1000, so that statistics of different communities may easily be compared. The figures are obtained from the Registrars.

Death-rates are dealt with in the following ways:—

1. Annual death-rate per 1000.
2. Annual death-rate per 1000 living at each age period; 0-5, 5-10, 10-15, 15-20, and so on.
3. Annual death-rate by districts.
4. Annual death-rate, showing causes of death.
5. Annual death-rate, showing occupation.

The mean age at death is obtained by adding up the ages of the deceased, and dividing by the number of deaths.

The case mortality is the proportion of deaths to the number of cases occurring of any disease. It is usually shown as a percentage.

In judging the health of a community by statistics, the following rates are of most importance:—

1. Annual death-rate.
2. Infective disease death-rate.
3. Infantile morality.

(*j*) NOTES ON METEOROLOGY.

(*Based on information contained in the Publications of the Royal Meteorological Society.*)

METEOROLOGY is that branch of science which deals with climate and weather.

CLIMATE may be defined as the average condition of meteorological phenomena at a given place. The four main operating factors are: (1) distance from the equator; (2) height above sea-level; (3) distance from the sea; and (4) direction of prevailing winds.

A climate may be tropical, sub-tropical, temperate, cold, mountain, or marine.

WEATHER is a term used to include the condition of the atmosphere at any moment with regard to wind, pressure, temperature, cloud, moisture, and electricity.

The instruments for observing meteorological conditions at a climatological station are: standard barometer, maximum thermometer, minimum thermometer, dry- and wet-bulb thermometers, a suitable shelter, and rain-gauge.

At some stations there are also provided an anemometer, a minimum thermometer (graduated on the stem, without attached scale) for terrestrial radiation, an earth thermometer, and a sunshine recorder.

All instruments are standardised, and the corrections known.

The thermometers have the scales etched on the tubes.

A barometer is an instrument for measuring the pressure of the atmosphere.

It should be hung vertically, and at such a height that the observer can read the scale comfortably when standing upright.

The following is the mode of taking a reading :—

First note the reading of the attached thermometer to the nearest degree ; then (if the barometer is a Fortin) adjust the mercury in the cistern by turning the screw at the bottom of the cistern, so that the ivory point is *just* brought into contact with the surface of the mercury, but does not depress it ; the ivory point and its reflected image in the mercury should appear to just touch each other and form a double cone. Then gently tap the tube with the finger, to prevent the mercury from adhering to the glass. Next, adjust the vernier so that its two lower edges shall form a tangent to the *convex* surface of the mercury—in fact, the front and back edges of the vernier, the *top* of the mercury, and the eye of the observer must be in the same plane (Fig. 112). Move the head up and down to make sure that this is so.

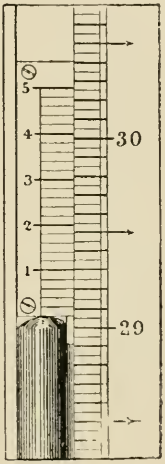

FIG. 112.—Vernier Scale.

The scale on the instrument is usually divided into inches, tenths, and half-tenths, and the vernier, being made equal in length to twenty-four divisions of the scale, is divided into twenty-five equal parts. Each division of the vernier is, therefore, shorter than each division of the scale, by the twenty-fifth part of ·05, which is ·002 in. First read off the division next below the lower edge of the vernier. Suppose it be between 29·05 ins. and 9·201 ins., the reading is 29·05 ins. *plus* the vernier indication. Next look along the vernier until one of its lines is found to agree with a line on the scale. Suppose this is at the fourth division on the vernier ; as each of the figures marked on the vernier counts as a hundredth, and each intermediate division as two thousandths, the reading of the vernier will be ·008 in. The reading of the barometer is, therefore, 29·05 + ·008 = 29·058 ins. Should two lines on the vernier be in equally near agreement with two on the scale, the intermediate value should be adopted. For instance, suppose that the third and fourth divisions above the figure were one as much below as the other is above the lines on the scale, the vernier value would then be ·047 in. The barometer reading would consequently be 29·05 + ·047 = 29·097 ins. When it is difficult to say which division of the scale is that immediately *below* the lower edge of the vernier, the vernier reading will itself indicate which principal division should be taken.

After the reading has been taken, if the barometer is a Fortin, the mercury in the cistern should be lowered by turning the screw at the bottom until the surface is well below the ivory point, otherwise dirt will collect and the mercury will oxidise immediately underneath the ivory point, and its reflected image will become indistinct. If the barometer is of the Kew pattern, no adjustment of the cistern has to be made, and the vernier is read exactly as with the Fortin.

The actual reading requires correction for (1) index error, (2) temperature, and (3) height above sea-level.

The first is given on the certificate of verification, the second by means of tables which reduce the observations to 32° F., and the third by means of tables which reduce the reading to sea-level; roughly, ·1 in. for every 100 ft. above sea-level.

The following example will show the method of applying the corrections. Suppose the readings to be:—

Attached thermometer	55°
Barometer	29·526 ins.
Dry-bulb	53°
Correction for index error	+ ·005 in.

then—

	ins.
Barometer reading	29·526
(1) Correction for index error . . .	+ ·005
	29·531
(2) Correction for temperature 55° (Table 1) .	− ·070
	29·461
(3) Correction for altitude 190 ft., 53° (Table 3)	+ ·206
Barometric pressure at sea-level . . .	29·667

The maximum and minimum thermometers should be firmly fixed in a horizontal position. They register the highest and lowest temperatures respectively attained since the time they were last set.

From the readings of the dry-bulb and wet-bulb thermometers, the dew point and relative humidity are ascertained by means of tables. The former is the temperature at which dew begins to be deposited, and the latter is the ratio or percentage of the actual vapour pressure to that of

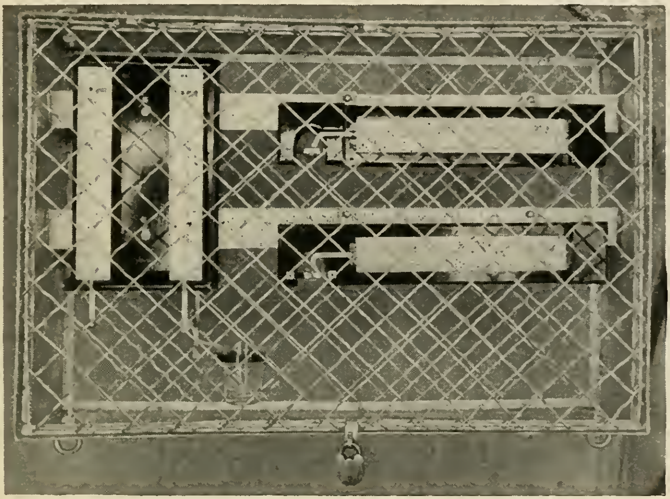

FIG. 113.—Tropical Thermometer Screen *(Negretti and Zambra)*.

saturated water vapour at the temperature of the air; in other words, it expresses the percentage of saturation of the air with aqueous vapour.

The thermometers used for temperature observations should be mounted in a suitable shelter.

The following arrangements are recommended for use in tropical countries by the Committee of the British Association on the Climate of Tropical Africa:—The thermometers should be placed within an iron cage, which should at all times be kept locked, so as to prevent interference with the instruments. (Fig. 113.) This cage should be suspended under a thatched shelter, which should be situated in an open spot at some distance from buildings, must be well ventilated, and guard the instruments from being exposed to sunshine and rain. A simple hut, made of materials available on the spot, would answer this purpose. A gabled roof with broad eaves, the ridge of which runs from north to south, is fixed upon four posts, standing 4 ft. apart. Two additional posts may be introduced to support the ends of the ridge beam. The roof, at each end, projects about 18 ins. In it are two ventilating holes. The tops of the posts are connected by bars or rails, and on a crossbar is suspended the iron cage with the thermometers. These will then be at a height of 6 ft. above the ground. The gable ends may be permanently covered in with mats or louvre-work, not interfering with the free circulation of the air; or the hut may be circular. The roof may be covered with palm-fronds, grass, or any other material locally used by the natives as building material. Care must be taken to fix the cage firmly, so that the maximum and minimum thermometers may not be disturbed by vibration.

The observations are made as follows:—Having let down the door of the screen, the dry-bulb and wet-bulb thermometers are to be read first, so that they may not be affected by the nearness of the observer. The maximum thermometer is to be read next, by noting the point at which the end of the column of mercury is lying. The minimum thermometer is read last, by noting the position of the end of the index farthest from the bulb. (The end of the column of spirit shows the temperature at the time of observation.) When this has been done, and the figures written in the observation book, the instruments should be looked at again to see that no mistake has been made in entering the readings. The maximum and minimum should then be set. When set, the end of the mercury in the maximum, and the end of the index farthest from the bulb in the minimum, should indicate nearly the same temperature as the dry-bulb. The muslin and cotton on the wet-bulb should be examined, and the glass cup filled with water, after which the door of the screen should be closed.

All the thermometers should be read to tenths of degrees. This can readily be done by mentally dividing the space between each degree into ten parts, and estimating at what tenth the end of the column or index stands.

A rain-gauge is necessary to measure the rainfall (Fig. 114). It is best made of copper, and should have a circular funnel of either 5 or 8 ins. diameter, with a can and a bottle (roughly marked with half-inches) inside to collect the water. It is very desirable that it should be of the Snowdon pattern —that is, with a 6-in. cylinder on top of the funnel and a sharp brass rim. It should be set in an open situation, away from trees, walls, and buildings—at the very least, as many feet from their base as they are in height —and it should be so firmly fixed that it cannot be blown over. The gauge should be planted in the earth and fixed by stakes, or placed, in a hole which exactly fits it, in a block of cement. The top of the rim should be 1 ft. above the ground, and must be kept quite level.

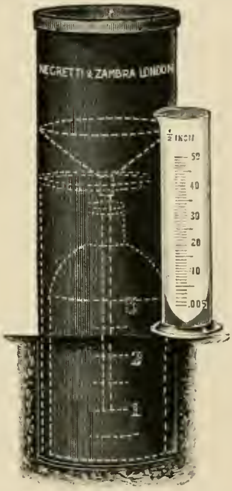

Fig. 114.—Rain-gauge.

The measurement of the rain is effected by pouring out the contents of the bottle into the glass measure, which must be placed quite vertically, and reading off the division to which the water rises; the reading is to be taken midway between the two apparent surfaces of the water. The glass measure is usually graduated to represent tenths, five one-hundredths, and hundredths of an inch; the long divisions, tenths of an inch, have figures attached. If there be more than half an inch of rain, two or more measurements must be made, and the amounts added together. The complete amount should always be written down before the water is thrown away. The gauge must be examined daily at 9 A.M., and the rainfall, if any, entered to the previous day; if none be found, a line of dots should be inserted in the register, instead of leaving the space blank or putting noughts. It is desirable to measure very heavy falls of rain immediately after their occurrence, entering the particulars in the remarks, but taking care that the amount be included in the next ordinary registration. A fall recorded as 0·01 in. or above is held to constitute a "rainy day," or, to put it more accurately, a "day of precipitation." If the gauge contains less than one-hundredth (·01) of an inch, but more than half that amount, it should be entered as ·01, while if there is less than half that amount the few drops may be thrown away, and the day entered as if no rain had fallen. The measurements of rainfall should be entered in the register in hundredths of an inch—that is, there should always be two figures to the right of the decimal point. If the amount is less than ·10 in. the decimal point and the figure 0 must always be inserted in order to avoid uncertainty—thus, ·01, etc.

Small amounts of water are at times deposited in the rain-gauge by dew, hoar frost, or fog. Whenever this occurs, the amount must be treated as rainfall, and entered accordingly.

When self-recording rain-gauges are used, care must be taken to fix them in such a position that the water, when emptied by the syphon or tipping-bucket, can run away, otherwise the instrument will not work properly, owing to the excess of water round the outflow pipe.

The wind force is measured by means of an anemometer, some patterns of which are self-recording.

Cloud formation and proportion of sky covered are also observed. The chief are :—

The Stratus.—A uniform layer of cloud resembling a fog.

The Cumulus.—Wool-pack clouds, often dome shaped (like a mountain), having the proverbial silver lining.

The Cirrus are filament-like clouds, often showing a feathery-like structure. Usually they are very high.

The Nimbus, or rain clouds.—A thick layer of dark clouds without definite shape, often having cumulus clouds beneath or at the sides.

Observations should be made daily at 9. A.M. (local time).

For further information on this subject the reader is referred to the official handbook of the Royal Meteorological Society, in which the tables referred to on p. 266 will be found.

(*k*) COMPARATIVE TABLE OF THERMOMETER SCALES. CENTIGRADE AND FAHRENHEIT.

C.	F.	C.	F.	C.	F.	C.	F.
0	32·0	26	78·8	51	123·8	76	168·8
1	33·8	27	80·6	52	125·6	77	170·6
2	35·6	28	82·4	53	127·4	78	172·4
3	37·4	29	84·2	54	129·2	79	174·2
4	39·2	30	86·0	55	131·0	80	176·0
5	41·0	31	87·8	56	132·8	81	177·8
6	42·8	32	89·6	57	134·6	82	179·6
7	44·6	33	91·4	58	136·4	83	181·4
8	46·4	34	93·2	59	138·2	84	183·2
9	48·2	35	95·0	60	140·0	85	185·0
10	50·0	36	96·8	61	141·8	86	186·8
11	51·8	37	98·6	62	143·6	87	188·6
12	53·4	38	100·4	63	145·4	88	170·4
13	55·4	39	102·2	64	147·2	89	192·2
14	57·2	40	104·0	65	149·0	90	194·0
15	59·0	41	105·8	66	150·8	91	195·8
16	60·8	42	107·6	67	152·6	92	197·6
17	62·6	43	109·4	68	154·4	93	199·4
18	64·4	44	111·2	69	156·2	94	201·2
19	66·2	45	113·0	70	158·0	95	203·0
20	68·0	46	114·8	71	159·8	96	204·8
21	69·8	47	116·6	72	161·6	97	206·6
22	71·6	48	118·4	73	163·4	98	208·4
23	73·4	49	120·2	74	165·2	99	210·2
24	75·2	50	122·0	75	167·0	100	212·0
25	77·0						

(*l*) USEFUL TABLES OF WEIGHTS AND MEASURES.

British.

Avoirdupois Weight.

16 drachms . .	1 ounce	28 pounds . .	1 quarter
16 ounces . . .	1 pound	4 qrs. or 112 pounds	1 cwt.
14 pounds . .	1 stone	20 cwts. . . .	1 ton

Dry Measure.

2 pints . . .	1 quart	2 bushels . . .	1 strike
2 quarts . . .	1 pottle	4 bushels . . .	1 coomb
4 quarts . . .	1 gallon	8 bushels . . .	1 quarter
2 gallons . . .	1 peck	5 quarters . .	1 load
4 pecks . . .	1 bushel	10 quarters . .	1 last

Useful Tables—British—*continued.*

Measures of Length.

12 inches	1 foot
3 feet	1 yard
2 yards	1 fathom
$5\frac{1}{2}$ yards	1 pole
22 yards	1 run
220 yards	1 furlong
8 furlongs / 1760 yards / 5280 feet	1 statute mile
6082.66 feet	1 nautical mile or knot
7.92 inches	1 link
100 links / 66 feet / 22 yards	1 chain

Square Measure.

144 square inches	1 square foot
9 square feet	1 square yard
$272\frac{1}{4}$ square feet / $30\frac{1}{4}$ square yards	1 square rod or pole
40 square rods	1 square rood
4 square roods / 160 square rods / 4840 square yards / 10 square chains	1 acre
640 acres	1 square mile
30 acres	1 yard of land
100 acres	1 hide of land
40 hides	1 barony

Cubic Measure.

1728 cubic inches	1 cubic foot	27 cubic feet	1 cubic yard

Angular Measure.

60 seconds (″)	1 minute	90 degrees	1 quadrant
60 minutes (′)	1 degree	360 degrees	1 circle
30 degrees (°)	1 sign		

Useful Tables—British—*continued.*

MISCELLANEOUS.

1 stone	14 pounds
1 score	20 pounds
1 gross	12 dozen
1 quire	24 sheets
1 ream	20 quires
1 cord of wood	128 cube feet
1 ton of coal	10 sacks
1 ton of Portland cement	10 sacks or 6 casks
1 barrel of tar	25 gallons
1 ton	2240 pounds
1 pound (avoirdupois)	7000 grains
1 ounce (avoirdupois)	437.5 grains
1 gallon	70,000 grains

Metric.

WEIGHTS.

The gramme (the weight of 1 cubic centimetre of water at 4° C.) is the unit.

10 milligrammes	1 centigramme
10 centigrammes	1 decigramme
10 decigrammes	1 gramme
10 grammes	1 decagramme
10 decagrammes	1 hectogramme
10 hectogrammes	1 kilogramme
10 kilogrammes	1 myriagramme
10 myriagrammes	1 quintal
10 quintals	1 millier or bar

MEASURES OF LENGTH.

The metre (approximately one ten-millionth part of the distance from one of the earth's poles to the equator at the meridian of Paris) is the measure of length.

10 millimetres	1 centimetre	10 decametres	1 heotometre
10 centimetres	1 decimetre	10 hectometres	1 kilometre
10 decimetres	1 metre	10 kilometres	1 myriametre
10 metres	1 decametre		

Useful Tables—Metric—*continued.*

Measures of Capacity.

The litre (the volume of a kilogramme of pure water at its temperature of maximum density, 4° C., and under an atmospheric pressure of 760 millimetres of mercury) is the unit.

10 millilitres . . .	1 centilitre
10 centilitres . . .	1 decilitre
10 decilitres . . .	1 litre or cubic decimetre
10 litres	1 decalitre
10 decalitres . . .	1 hectolitre
10 hectolitres . . .	1 kilolitre or cubic metre
10 kilolitres . . .	1 myrialitre

British and Metric Equivalents.

1 millimetre . . .	0.03937 inches
1 metre . . .	39.37079 inches
1 decimetre . . .	3.94 inches
1 cubic metre . .	35.31628 cubic feet
1 square metre . .	10.7642 square feet
1 centimetre . . .	0.39 inches
1 cubic centimetre .	0.06103 cubic inches
1 kilometre . . .	1093.6331 yards
1 litre of water . .	61.02705 cubic inches 35.27 ounces (avoirdupois) 1.76 pints 0.22 gallons
1 milligramme . .	0.01543 grains
1 gramme . . .	15.43235 grains
1 kilogramme . .	2.2 pounds (avoirdupois)
1 ton	1015.649 kilogrammes
1 pound (avoirdupois) .	453.415 grammes
1 ounce (avoirdupois) .	28.35 grammes
1 ounce (fluid) . .	28.4 cubic centimetres
1 inch	2.54 centimetres
1 foot	3.05 decimetres
1 yard	0.91 metres
1 mile	1.61 kilometres
1 pint	0.57 litres
1 gallon . . .	4.54 litres

(*m*) USEFUL FACTORS FOR CONVERSION.

To convert—	*Multiply by*
Inches to metres	0.02540
Feet to miles	0.00019
Yards to miles	0.00057
Inches to centimetres	2.539
Millimetres to inches	0.03937
Inches to millimetres	2.5399
Centimetres to inches	0.3937
Metres to feet	3.28
Feet to metres	0.3047
Grammes to pounds (avoirdupois)	0.0022
Pounds to grammes	453.715
Kilogrammes to pounds	2.204
Tons to kilogrammes	1018.2
Kilogrammes to tons	0.00098
Pounds to kilogrammes	0.4537
Grammes to grains	15.432
Grains to grammes	0.0648
Ounces to grammes	28.35
Grammes to ounces (avoirdupois)	0.0353
Litres to gallons	0.22
Gallons to litres	4.537
Litres to pints	1.76
Pints to litres	0.568
Cubic centimetres to fluid ounces	0.0352
Fluid ounces to cubic centimetres	28.57
Cubic feet to gallons	6.2355
Cubic inches to gallons	0.003607
Cubic inches to pints	0.0288
Cubic inches to fluid ounces	0.577
Cubic inches to cubic centimetres	16.386
Cubic centimetres to cubic inches	0.061
Cubic feet to cubic metres	0.0283
Cubic metres to cubic feet	35.32
Cubic feet to litres	28.31
Litres to cubic feet	0.0354
Pints to cubic centimetres	568.182

Useful Factors for Conversion—continued.

To convert—	*Multiply by*
Square feet to square metres . . .	0.0929
Square metres to square feet . . .	10.764
Square feet to square yards . . .	0.111
Parts per 100,000 into grains per gallon .	0.7

To convert—

Grains per gallon into parts per 100,000, *divide by* 0.7
Degrees C. into degress F., *multiply by* $\frac{9}{5}$ *and add* 32
Degrees F. into degrees C., *subtract* 32, *then multiply by* $\frac{5}{9}$

(*n*) FORMULÆ FOR CALCULATING SUPERFICIAL AND CUBIC SPACE.

Superficial Space.

(1) *Area of Rectangle and Square.*—The length multiplied by the breadth.

(2) *Area of Rhombus or Rhomboid* (*in which the opposite sides are parallel*).—The base multiplied by the perpendicular height.

(3) *Area of Trapezoid.*—Half the sum of the two parallel sides, multiplied by the width.

(4) *Area of Triangle.*—Half the product of base and height.

(5) *Area of Regular Polygon.*—The sum of the sides (perimeter) multiplied by half the perpendicular (drawn from the centre to the middle point of any side).

(6) *Area of Parabola.*—The base multiplied by two-thirds of the height.

(7) *Area of Circle.*—Square of diameter multiplied by ·7854, or square of radius multiplied by 3·1416.

(8) *Area of Ellipse.*—The product of the long and short diameters multiplied by ·7854.

(9) *Area of Segment of a Circle.*—The cube of the height divided by twice the length of the chord added to two-thirds of the product of chord and height.

Note.—When the segment is greater than a semicircle, find the area of the circle and deduct the area of the smaller segment.

(10) *Area of Sector of a Circle.*—Half the product of the arc multiplied by the radius.

(11) *Area of Sphere.*—Diameter squared, multiplied by 3·1416.

Cubic Space.

(1) *Volume of Cube or Rectangular Room.*—The length multiplied by the breadth multiplied by the height.

(2) *Volume of Prism.*—Area of base multiplied by height.

(3) *Volume of Cylinder.*—Area of base multiplied by height.

(4) *Volume of Cone or Pyramid.*—The area of the base multiplied by one-third of the perpendicular height.

(5) *Volume of Dome (Segment of a Sphere).*—Area of base multiplied by two-thirds of the height.

(6) *Volume of Sphere.*—Cube of diameter multiplied by ·5236.

(7) *Volume of Wedge.*—$\frac{B\,H\,(2\,L + E)}{6}$

B = width of base.
H = height of wedge.
L = length of the base.
E = length of the wedge.

(8) *Volume of Frustum of Cone or Pyramid.*—The sum of the areas of the two ends of the frustum and the square root of their product, multiplied by one-third of the height of the frustum.

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