Suggestions in regard to sanitary works required for improving Indian stations prepared by the Barrack and Hospital Improvement Commission. In accordance with letters from the Secretary of State for India in Council, dated 8th December 1863 and 20th May 1864.

SUGGESTIONS

IN REGARD TO

SANITARY WORKS REQUIRED FOR IMPROVING INDIAN STATIONS

PREPARED BY THE

BARRACK AND HOSPITAL IMPROVEMENT COMMISSION,

IN ACCORDANCE WITH

Letters from the Secretary of State for India in Council, dated 8th December 1863 and 20th May 1864.

LONDON:
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CONTENTS.

INDEX

TO

SUGGESTIONS IN REGARD TO SANITARY WORKS REQUIRED FOR IMPROVING INDIAN STATIONS.

INTRODUCTION.

SECTION I.—DRAINAGE OF STATIONS.

SECTION II.—WATER SUPPLY.

SECTION III.—PRINCIPLES OF BARRACK CONSTRUCTION.

SECTION IV.—PRINCIPLES OF HOSPITAL CONSTRUCTION.

SECTION V.—SANITARY POLICE OF BARRACKS, HOSPITALS, AND STATIONS.

SECTION VI.—REGISTRATION OF DEATHS, &c.

REGISTRATION FORMS.

APPENDIX.

LIST OF PLANS.

SUGGESTIONS

IN REGARD TO

SANITARY WORKS REQUIRED FOR IMPROVING INDIAN STATIONS.

Introduction.

The following suggestions are intended to embody in a practical form those points of home experience in sanitary works and measures which appear to be more or less applicable to conditions brought out in evidence and described in the Report of the Royal Commission on the Sanitary State of the Indian Army. They are in no sense intended to fetter the judgment of local authorities, either military or civil, in India. It would indeed be impossible, without careful local examination, to lay down precise measures and works required for abatement of causes of disease at any given station. Such an examination can be conducted only by persons on the spot; and suitable works can best be designed for India by engineers of Indian experience. The sole advantage which this paper seeks to attain is to bring under the notice of local authorities in India and elsewhere those general principles and forms of procedure which have been found useful at home, and which, it is hoped, with the required modifications, may be useful in India and in tropical stations generally.

The Reports transmitted to the Royal Commission from Indian stations show that improvement of those stations includes the following elements:—

(1.) A thorough drainage of ground occupied by stations.
(2.) An abundant supply of pure water distributed over stations.
(3.) The adoption of healthy principles of construction in barracks, including suitable provision of means of employment and recreation in the way of gymnasia, workshops, games, soldiers' gardens, reading and day-rooms.
(4.) Improved principles of hospital construction.
(5.) Improving the sanitary police of stations, bazaars, and adjacent native towns.

All these improvements require to be carried out more or less before it can be said of any station that every removable local cause of disease has been removed.

It would be a grave error to trust to any one of them for improving the health of the troops. Each has its uses, but all are necessary. No improvement in barrack or hospital accommodation will compensate for a malarious subsoil or for bad water; and on the other hand, no improvements in drainage and water supply will neutralize the influence of an ill-ventilated, badly constructed, overcrowded barrack or hospital. And even if these works were carried out, much removable sickness would still exist, unless the men's leisure were profitably occupied, and the sanitary police of bazaars and towns efficiently attended to.

When it is contemplated to erect barracks at any station, the question of improved construction should be considered as one only of the elements affecting the health of a station. All the points enumerated above should be carefully provided for at the same time, and a consistent scheme drawn up for making the station habitable and healthy.

In not a few cases this may possibly involve the question of whether a better site for a station than the one proposed to build upon may not be found within the strategic limits of the position. This point also should receive attention.

The next question of importance in the improvement of stations is the extent to which sanitary methods and appliances suitable for barracks in Europe would answer for barracks in India and in tropical stations generally.

It is possible, *e.g.* to subsoil drain any extent of ground in England. And this process is attended not only with increased productiveness but with improved health. Wherever subsoil water comes within a certain distance of the surface of the ground,

it interferes with healthy vegetation, and generates damp, fogs, and malaria, which have been found to diminish or disappear when the water level has been lowered by drainage.

The universal prevalence of malarial disease at Indian stations indicates a malaria-generating condition of the earth. And one of the first improvements required is to diminish or remove this condition. But in order to do so there must be the necessary materials and skill for subsoil draining and an outlet for subsoil water.*

The question, therefore, occurs whether proper drain tiles can be obtained or manufactured in India; or whether the same result could not be obtained by some equally efficient local expedient. The mere fact of difficulty should not be allowed to overbalance other considerations. Great difficulties were at first experienced in introducing land drainage in England, but they gradually disappeared as improvement advanced.

A similar remark applies to the question of town and barrack drainage. Not many years ago these improvements were as little known in many parts of England as they are at present in India, and much controversy and opposition preceded their introduction. Yet populous districts have been drained in the face of great difficulties, even where they not only had no fall, but were considerably below the level of the drainage outlet.

The introduction of this class of drainage works would of course necessitate the use of closed drain pipes or built drains, with a sufficient fall obtained either naturally or by mechanical methods, such as pumping.

A sufficiency of water would be required for flushing these drains, but this could be readily afforded by waste water from baths and ablution rooms, or water might be carried by hand to a small flushing tank, if there be no pipe service.

The ablution apparatus, latrines, &c., now extensively used in England, are new to India and other tropical countries, but they could be obtained either from England or manufactured in India.

It is understood that excellent earthenware is made in India.

There would be some difficulty at first about fittings on account of the want of skilled labour, but this might be in time overcome by attaching trained workmen to each station. Or, what would be much better, by selecting from among the soldiers men who had formerly worked at the required trades, or who might be trained to such work in the regimental workshops. There is reason to believe that almost every regiment would afford the requisite amount and kinds of skilled labour.

The accompanying barrack and hospital plans have been prepared on the supposition that works of drainage and water supply are to be carried out at stations, and that improved sanitary appliances are to be introduced in both classes of buildings.

We next proceed to give a few general principles, based on experience both in warm climates and in England, on each of the heads of improvement laid down above.

Section 1.—Drainage of Stations.†

1. *Surface Drainage and Paving.*

Roof gutters. All rain water from roofs within the limits of stations should be collected by eaves-gutters, and either conducted to tanks for use after being filtered, or passed directly into the drains of the station.

The immediate surface surrounding buildings should be flagged or paved with closely jointed non-absorbent paving stones, with a sufficient slope to the surface channel to conduct water away from the building by carefully laid surface drains.

In large stations, in cases where the surface becomes soft and sloppy, flagged or paved foot-paths between the different buildings, properly raised and drained, should be provided for use in wet weather.

The whole surface of the station, and also that of its vicinity, should be carefully levelled; all inequalities, pits and holes, should be filled up, and collections of surface water carefully drained away.

Trenching. Deep open trenches dug in the ground, although an excellent means of drainage for temporary camps, are not adapted for surface drainage of permanent stations. They are apt to become irregular, and to retain water. They act partly as filters through which water passes into the subsoil, leaving its impurities to ferment in the drain, and they are liable to be more or less filled up. Wherever open surface drains are required they

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* At stations over which malaria is carried by winds from a distance, a screen of trees or of bamboos or other quickly growing vegetation will be useful in shielding the station from malaria. But this expedient should be considered as temporary only until the malaria is removed by drainage.

† *Recommendation of the Royal Commission respecting Drainage and Water Supply.*

8. "That works of drainage and water-supply be carried out at all stations."

should be formed of impervious material; they should be smooth and carefully laid so as to convey away water as speedily as possible.

Paving. Paving of towns is one of the first sanitary improvements that will tell on health. The material available for this purpose in India will vary in every district. In Europe almost every geological rock is used for paving. As much of the excellence of the surface depends on the manner of laying the material as on the material itself; hence great care should be bestowed on the workmanship.

There is nothing better than flagged foot-ways, and roadways paved with close fitting square setts or well-laid macadam. Rubble and boulder paving of every kind should be avoided; these make a bad surface, difficult to cleanse. Small close courts and passages should all be flagged or paved.

A smooth surface, from which water readily runs off, is best suited for purposes of health. There should be carefully formed side drains, for receiving and conveying away water. All roof water, if not tanked for use, should be collected by eaves-gutters, and turned away from the foundations of houses. All gully-grates should be carefully trapped; and all water-traps kept supplied with water.

Paved streets and roads are costly in their first formation, and require skilled labour to prepare the stone and to lay it; but they are cheaper in maintenance than other roads when properly made. Paved streets are more easily cleansed than any other; they do not absorb organic matter, and the air over them is less impure than over macadamized roads.

The most recent and best paving in England is formed with the hardest granite or whinstone, not exceeding nine inches by three inches, and nine or 12 inches in length, set on edge; that is, in courses three inches wide and nine inches deep. The preparation for pavement will be in every respect as for road making. The foundation should be carefully prepared, firm, and well drained. A dry bed of evenly sorted gravel, or of broken stone, as for road making, not less than three inches in thickness, should be spread over the prepared subsoil, upon which the paving stones will be set in sand, and then beaten down with a 9 lbs. beater.

2. *Sewerage and Drainage.*

Surveys, and levels. As the question of drainage is intimately connected with the question of levels and of outlets, the first step to be taken before beginning the drainage of any station, town, or district is to make a detailed survey, on a suitable working scale, of the whole area to be drained, in order to settle the levels, with a view of ascertaining the fall and where the outlet should be placed.

Subsoil drainage. The great amount of miasmatic disease already mentioned shows that subsoil drainage is necessary as a means of prevention. Miasmatic diseases appear to be most severe at times when surface water, proceeding from heavy rain-fall, water-logs the subsoil. It is not at all improbable that the generation of malaria, under such circumstances, is in its effects local rather than general, and that, by removing subsoil water to a sufficient depth from the surface, the generation of local malaria may be to a large extent prevented. At many stations it would be in vain to attempt to remove the whole of the rain-fall in this way. Well-formed impervious bottomed surface drains would afford the only possible outlet for heavy rains.

But heavy rains are less injurious to health than a wet or damp soil surcharged with organic matter under high temperature. Even in the cooler climate of England it has been found necessary for health to afford a ready means of exit for subsoil water from barrack and hospital grounds. This kind of work is usually carried out, like ordinary agricultural drainage, by means of drain-tiles laid in lines four or five feet below the surface and 15 or 16 feet apart. We would strongly recommend that this improvement be tried at a few of the larger Indian stations; and the effects of it upon the soil and upon the health of the men carefully noted.

The chief difficulty in low flat stations, where subsoil drainage is most required, is to find an outlet for water. The question of drainage outfall is, indeed, as important to a station as the question of water sources. In all new stations the outfall for drainage should be a special subject for inquiry, and sites which are found to be defective in this respect should be rejected, just as they would be if there were no water. As regards existing stations, absence of outfall should be taken into account in determining whether a station is to be retained. But where a station must be held, an outfall must in some way be provided.

General suggestions. The following general suggestions respecting works of sewerage and drainage for stations, towns, and districts are intended to embody the chief points of experience obtained in England, and may be adopted in India so far as they may be found appli-

cable under local and special peculiarities of surface, of contours, subsoil, rain-fall, and drought.

Drainage sanitary works should aim at producing a dry and wholesome subsoil, a clean surface, and a pure atmosphere around and within houses, barracks, and hospitals.

Defective surface contours may be improved by surface trenching, and by providing safe and ready means of escape for surface water, by deepening, straightening, and improving natural valley lines and watercourses or nullahs, as also by forming new surface conduits.

Land drains.

Wet water-logged subsoils, where an available fall can be obtained, may be improved most cheaply by land drains. The depth to which such subsoil can safely be drained will depend on local peculiarities. Not less than six feet vertical depth ought to be attained for main land drains if practicable.

Land drainage is applicable to the suburbs of towns and stations, to barrack yards and enclosed lands adjoining, to hospital sites, and to lands surrounding hospitals or in their immediate vicinity.

Tubular earthenware tiles from one inch to six inches internal diameter make the cheapest and best land drains.

All drain trenches must be set out perfectly true in line, and must be bottomed true in gradient. The several lines should be parallel, and all the junctions should be carefully made.

The tiles should be laid in the trenches truly and evenly, with the joints sound, true, and close. Filling in over the tiles should be most carefully performed, so as not to disturb the line or grade, nor break nor injure any tile or tile joint.

Manholes should be brought up to the surface at all main junctions of land drains, so that the working of the drains at these points may be inspected from time to time.

The mouth of the outlet drain should be protected with a fine wire grate, or by some other efficient means, to prevent the drains being choked from without.

If drains are injured during the hot and dry season, on account of drying and cracking in the ground, such drains should be repaired and made good before the rains commence.

Land drains should not be used to convey away surface water other than filters through the soil. There must not be any direct communication from the surface, such as a grate or gully. Sewers and drains must be provided separately for surface and refuse water.

Land drains should not be laid near tree roots nor amongst rank vegetation, but should be adopted for cleared and open spaces, where a dry subsoil is essential to health.

Every district, not an absolute swamp or area embanked in from tides or land floods, will have surface fall and natural valley lines. The removal of surface water, in dry and in wet seasons, should be provided for at the surface. Surface water should not be passed into sewers.

Valley lines, natural streams, and surface contours should in all cases be improved so as to diminish any inconvenience or injury caused by excess of water during wet seasons.

Natural streams should not be arched over to form sewers, as a natural stream may drain an area many times greater than the area to be sewered, and the volume of water to be passed will constantly be varying from a minimum in drought to a maximum in excessive wet. This variation in England is at times from 300 up to 500 to one. Sewers and drains should be made to serve a special purpose, and as much as is practicable should be confined to such purpose, namely, to remove all slop and refuse water immediately to some common outlet.

Sewers.

Main sewers may be constructed with bricks, tiles, or stone. In each case hydraulic lime should be used for mortar.

All main sewers should be egg-shaped on cross section, the small end down. The invert in all cases ought to be struck with a short radius, and the crown should be a semicircle.

Bricks or tiles moulded to the radii will make the cheapest and strongest sewers. Stone may be worked to the radii, or if the mortar is good and the stone suitable, rubble masonry may be used.

Plan I. gives the forms, sizes, number of bricks, the cost of each section per lineal yard and the prices of the various materials in sewers of different dimensions. The prices are those at which the work was actually executed at Berwick-on-Tweed, Carlisle, Chorley, Lancaster, and other places. It will be seen that, in every instance, double courses of bonding bricks were put in at or near the springing, to ensure the rings being tied together.

Side junctions for branch drains should be provided and fixed in the main sewer as the work proceeds. All such junctions should be properly closed for after use, and an

accurate record should be kept of their depth, diameter, and true position, so that the point of junction can be found when required.

Main sewers should be absolutely true in line and in gradient from point to point.

At each change of line or gradient in a main sewer a manhole should be provided, so that the entire system of sewers may be perfectly under command and may be inspected.

At each manhole there should be means for flushing and for permanent ventilation. In providing for ventilation there should be a fixed screen or filter of charcoal, through which the sewer air must pass before escaping into the atmosphere.

The radius of no curve on a main sewer should be less than ten times the cross sectional diameter of such sewer, excepting that, when a change of line is not greater than 22½ degrees, the curve may be formed in the manhole, an extra fall of three inches being provided.

Sewers of unequal diameters should not join with level inverts; but in all cases tributary sewers should have their inverts at or above the level of the ordinary flow of sewage in the main. The junction should curve in the direction of the main flow, and have extra fall, so as to deliver freely from the tributary sewer to the main sewer.

All main sewers should have full means for permanent ventilation at the upper or higher ends through charcoal air filters; and means for flushing at such points should be provided.

Flushing of sewers and drains.

Flushing arrangements may be made by a manhole, or a surface tank may be adapted to this purpose. A large volume of water is not required so much as a volume of water let off quickly, to act with a cleansing effect. In one instance sewers of rude workmanship were effectually cleansed by flushing from an ordinary wine cask filled by hand with sea water and discharged suddenly into the sewers.

Sewers should not enter buildings nor pass beneath buildings, but should terminate outside, and have full means for permanent ventilation. A side drain or side drains may be laid from the head of any main or tributary sewer so as to remove the point of outlet for ventilation to any safe distance.

Duplicate systems of sewers are not required, that is, sewers for storm flood waters and sewers for sewage. As previously stated, surface contours and natural valley lines may be improved, and main sewers may have overflow communications with such valley lines and natural water courses, so as to relieve the sewers at all available points during heavy rains. At such times any sewage will be in extreme dilution and the whole district will be in flood, so that any sewage will be washed away without causing injury.

Causes of obstruction of sewers.

Sewers are liable to choke from several causes:—

1. Irregular lines and uneven invert gradients.
2. Defective workmanship and a porous subsoil, allowing fluids to filter away and leaving the solids to accumulate.
3. Sewers too large and having wide, flat, and uneven inverts, which the ordinary volume of fluid sewage can neither cover nor scour.
4. Sewers liable to be water-logged, either by tides or by rain or river floods.

Where sewers have to be formed on open gravel, sand, or rock, a lining of puddle should be placed, so as to render the sewer water-tight to half its vertical sectional depth. Great care must also be taken to form the invert of any sewer over such subsoil true, sound, and water-tight.

Trapping.

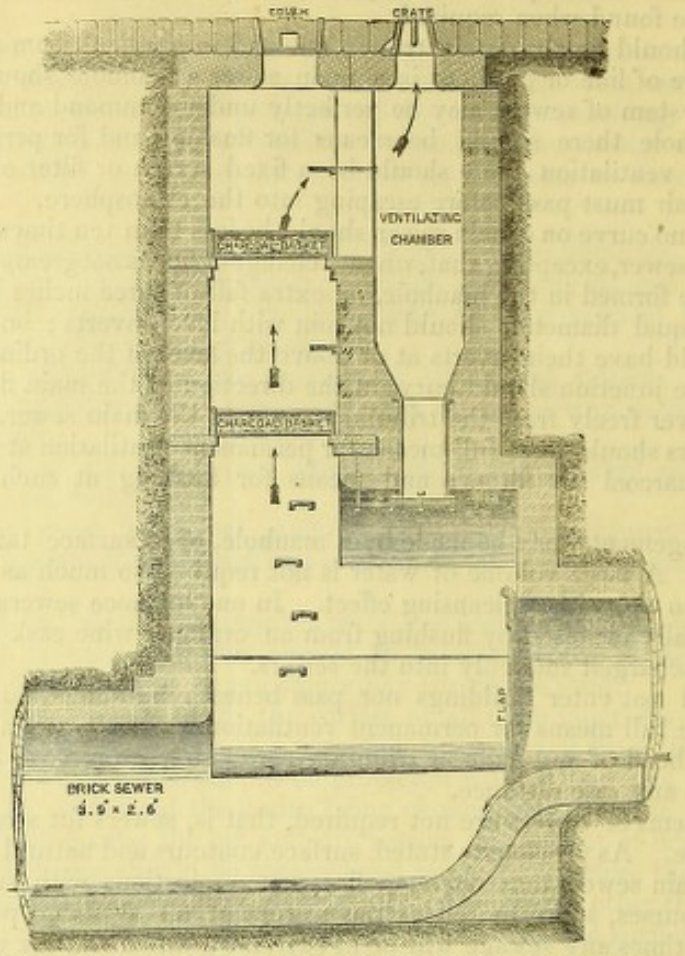
All sewer mouths must be protected, so as to prevent the wind blowing in and driving sewage gases back. A single flap for small sewers, or a compound flap for larger sewers, or a fall of canvas, weighted, may be applied. Means must be adopted to protect the mouths of all sewers and drains.

Ventilation of sewers.

Manholes should have moveable covers at the surface. There should be a side chamber for ventilation, "step-irons" to give access to the invert, and a groove to allow of a flushing board being inserted at will for flushing purposes. The side chamber may have a charcoal screen or filter.

Fig. 1 shows a system of ventilation of sewers which has been successfully brought into use in England. The figure shows the usual manhole and shaft with moveable iron cover, made to fit tight and prevent the passage of sewer air. Across the shaft are laid two or more moveable charcoal filtering screens, through which the sewer gas, deprived of its noxious matter by the charcoal, passes into a side ventilating chamber and thence through an open grating into the street. The chamber is intended to receive any solid matter falling in from the street, which can be removed when necessary by a slide at the lower end of the chamber. In a hilly town the system of sewerage should not be so connected as to permit the accumulation of sewer gases in the higher parts of the district. In such cases, the sewer should be divided by steps or falls with a flap valve at the discharging end of the sewer, as shown in fig. 1, to compel the gases to pass through the ventilating shaft.

Fig. 1.



Manhole, Tumbling Bay, and Double Ventilating Arrangement.

The details of other ventilating arrangements at present in use for brick sewers at their junctions and along their course are shown on Plans II. and III.

Pipe drains.

Earthenware pipes make the best drains up to their sectional capacity, say 15 inches.

Half-socket pipes, laid with the half-socket down, make the best drain, as any pipe can be removed without breaking a pipe.

Common circular vitreous earthenware pipes, with ordinary junctions, are the best.

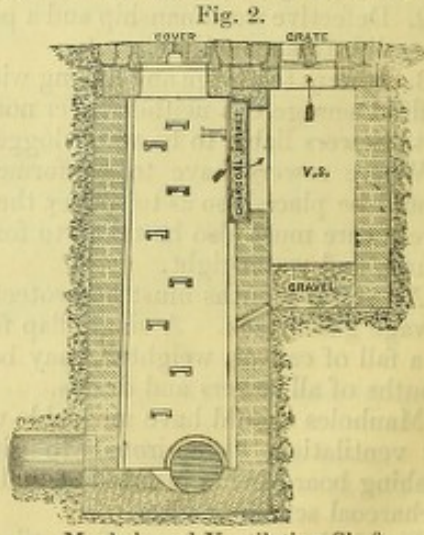
Drain pipe joints may be made with well-tempered clay in sound ground, but should be made with cement or with hydraulic mortar in open or in sandy ground.

Plan IV. gives the usual construction, junctions, and water-traps adopted in laying down earthenware pipe sewers.

Manholes, as for sewers, should be provided on all drains, with means of flushing and ventilation.

On Plan V. are shown sections and plans of different forms of manhole and lamphole for examining pipe drains.

Fig. 2.



Manhole and Ventilating Shaft.

The usual method of ventilating pipe drains is shown in fig. 2, where the charcoal screen is placed vertically between the manhole and the ventilating shaft.

Earthenware pipes of four inches in diameter are sufficient for waterclosets and sinks; these may join drains of six inches, the six inches joining nine inches, 12 inches, and 15 inches, and these forming a tributary main, or passing to a main sewer.*

* The town of Alnwick, in Northumberland, stands on part of a natural drainage area of 2,000 statute acres, with steep gradients. The population is about 7,000. There is a water supply of 150,000 gallons per day, and some 1,400 waterclosets regularly in use. Common privies have been abolished. The outlet sewer is 18 inches in diameter, upwards of 2,000 yards in length, having a fall of one (1) in 400. There are sewers of 15 inches, 12 inches, nine inches, and six inches; all house drains are four inches. These sewers are entirely of earthenware pipes, and have acted perfectly during 10 years. There have been falls of rain, tropical in character, causing great destruction at the surface, but the sewers were not injured, nor did any one complain

Large cities and towns are exceptional, and will require large constructions where natural streams, such as the Fleet ditch in London, are arched over. But in this instance the Fleet ought not to have been used as a sewer; intercepting sewers should have been formed on both sides, with flood or storm water overflows from the intercepting sewers to the Fleet river.

In India, and at all tropical stations where there are heavy rains, any attempt at proportioning main sewers to area and rain-fall must break down. Sewers cannot be formed, at any reasonable cost, to remove all the surface water during heavy rains; and if they could be so formed, such sewers would be enormously too large for the ordinary dry weather flow of sewage, and so far as a sewer is larger in sectional diameter than is requisite to remove the ordinary refuse, soil, roof, yard, and waste water, such sewer becomes a cause of nuisance in dry and hot weather. Sewers of small sectional area will answer best even in India.

Leading principles of drainage and construction of sewers and drains.

The leading principles to be kept in view are,—

1. To provide by carefully formed surface drains for the removal of all the rain-fall except what sinks into the ground.
2. To provide for the rapid removal of this subsoil water by land or subsoil drainage.
3. To drain away the refuse fluids of all houses, barracks, hospitals, stations, and towns by close sewers and drains.

"Sight-rails" should be put up at all convenient points to mark the proposed line and level of the sewer or drain before the ground is opened. The longest lengths of trenching that the ground will allow should be opened, trimmed, and bottomed truly before commencing to lay in drain pipes or to construct sewers. To construct drains or sewers in short lengths is to increase the risks of defective workmanship.

Sewer and drain trenching requires skilled labour. Deep trenching may require staying, propping, and "polling." Quicksand will require special means, "close timbering" and working in short lengths. Stable litter mixed with ashes placed in the joints of close timbers arrests quicksand better than any other means of filling in. But no general instructions can be given for dealing with quicksand; the engineer must use his practical knowledge. Where quicksand occurs in narrow streets or near buildings, the proposed line of sewer or drain may have to be abandoned for a line at a safer distance.

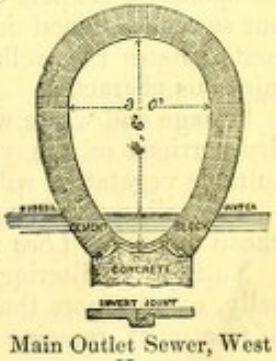
Heavy clay ground should not be allowed to fall in large masses on the finished sewer or drain. Bricks may be displaced and earthenware pipes may be crushed by allowing large masses of the sides of trenches to fall. If there is danger in removal of timber stays and props from trenches, when filling in over a finished sewer or drain, it will be better and cheaper to leave such timber undisturbed and fill in the trench, burying the timber.

Sewers formed of a single brick in thickness require more care in filling in than where two bricks in thickness are used. The sides and "spandrils" may, in some cases, be filled in with concrete up to the level of the crown of the arch. Ordinary gravel mixed with one-seventh by measure of lime will make concrete sufficient for such purpose.

"Fall" or "grade" in any sewer or drain is not absolutely necessary. A proper arrangement of manholes and flushing will preserve sewers clean and sweet having no fall. There must, however, be a free outlet.

As a proof that sewers laid without gradient can keep themselves clear, it may be stated that the main sewer at West Ham, a section of which is shown at fig. 3, is laid level for half a mile at low water of spring tides, and then for 2½ miles with a fall of three feet in a mile. This sewer is four feet six inches high and three feet wide. The surface of the ground under which it is laid is from 10 to 12 feet below high water in the Thames. The subsoil was so porous that the water could not be kept, by pumping, below the line shown in the figure. The iron invert had to be so planned that it could be laid under water by feeling only. Upon this cast-iron invert cement blocks were laid, and the sewer built on them in the ordinary manner. About three miles of this sewer have been in use for four years. And although the outlet has been obtained by pumping, the sewer has been kept clean. Means of flushing were provided, but the only fall was the surface gradient or water head in the sewer.

Fig. 3.



Main Outlet Sewer, West Ham.

that they were not larger. It would have required a sewer 10 feet in diameter to have removed the flood water; this passed over the surface as such floods had done in all former periods.

Alnwick Castle, standing on several acres of ground, is sewered with earthenware pipes of 12 in. to 4 in. diameter. They answer perfectly.

It is not advisable to construct sewers and drains without fall, nor will it be necessary to do so excepting on rare and special occasions. A comparatively steep fall will not in all cases serve to preserve sewers and drains clean and sweet in very dry weather and with a limited supply of water passed down in driblets. There must be flushing at regular and short intervals; once a day at least.

Sewers, drains, sinks, waterclosets, latrines, lavatories, baths, and urinals cannot be so constructed as to act without constant care. The superintendence of these arrangements must be intelligent and unceasingly regular.

In a system of sewers and drains, a full provision of manholes, ventilating chambers, described above, and flushing arrangements will enable the engineer to be absolute master of the situation. Inspection can be made of the sewer or drain at any and at every manhole; flushing can be brought into use at all the upper ends of sewers and drains, as also at all intermediate manholes; whilst the ventilating chambers secure an unceasing distribution and dilution of sewage gases at numerous points, settled by the engineer.

No system of sanitary works should be considered satisfactory if the engineer is not absolutely master at every point, without the necessity of excavating one cubic foot of earth, or removing one brick or drain pipe.

Sewers "sufficiently large for a man to enter" ought never to be considered necessary for cleansing. Men need not be required to enter any sewer. Flushing, or mechanical means, such as a rope or chain passed from manhole to manhole, will serve to remove even heavy road grit sediment, if the invert of every sewer is true, smooth, and struck to a radius not greater than nine inches. No egg-shaped sewer, however large, need have an invert of greater radius than nine inches.

A velocity of one foot per second may be easily obtained through a sewer of the flattest gradient by flushing, and such velocity will remove silt and coarse sand.

Gullies. All sewers and drains should have gullies and other inlet connexions with the surface and subsoil or other water, so formed as to prevent solids larger than grains of coarse sand being admitted, *see* Plan IV. Silt and sediment of all sorts should, however, be prevented as much as possible from having access to sewers and drains.

Gullies should be small and numerous, rather than large and open. Each gully should have a sediment box which may be easily removed and emptied.

For all purposes of drainage of barrack and hospital buildings, for latrines, closets, urinals, lavatories, sinks, and baths, glazed earthenware pipe drains, of nine or 12 inches in diameter, will be found sufficient for 1,000 men. Pipes require to be carefully laid on a well-formed and hard rammed bed. The joints should be tight, so that no sewage can escape from the drain into the subsoil. It is a cardinal principle in barrack and town drainage, that, after sewage has once entered the drain, it shall not escape from it except at the outlet.

The water from latrines, urinals, lavatories, and baths may be so used and discharged down the drains and sewers as to have a flushing effect. This should be provided for, and should also be regularly attended to.

The purpose of drainage sanitary works and regulations should be to remove all refuse mixed in water, all surplus, dirty, and waste water, immediately or before fermentation and decomposition commences.

Disposal of sewage. Tanks should never be used in India to store sewage and foul water, but the produce of each day should be expended, so as to prevent the commencement of putrefaction, either by discharging it from the outlet, or by applying it to the surface of the ground for manuring soldiers' gardens, or for similar purposes. Fresh sewage is not injurious, but sewage retained in cesspools, in imperfect drains and sewers, fouls the subsoil and contaminates the wells, and its decomposition produces gases of a most noxious and injurious character.

Sewage and waste water ought, if possible, to be used for purposes of irrigation during dry portions of the year. Fresh sewage properly applied for promoting the growth of suitable vegetation will be found a profitable undertaking.

The solids and flocculent matter may be strained out of sewage in any simple and cheap manner. (*See* Appendix No. I.)

No form of filtering, precipitating, or treating sewage, either mechanically or chemically, can do more than separate the grosser solids. The effluent water, after any form of treatment, remains essentially sewage water, and should only be used for irrigation purposes.

Fresh sewage passed at once over light soils need not have the coarser particles removed, but for many plants it may be advisable to remove the sediment and flocculent matter so as to use the effluent water alone. The solids removed from sewage may be used as ordinary manure.

Sewage outlets.

Sewage outlet works should ever be simple in design and inexpensive in construction. Brick tanks are not needed. Canal-like tanks, with earth sides, through which there shall be an unceasing flow not greater than three inches per second, answer best. There should be two or more such tanks so arranged that either one or both combined may be used, and one may be cleansed whilst the other is in use.

It is frequently necessary to carry the outlet of a sewer to a river having a low summer level and a high or flood level. To prevent nuisance arising from the sewage running over the surface at low water, a plan such as that adopted at Windsor Castle and shown in figs. 4 and 5, has been found to answer. An iron pipe was fixed at the bottom of the

Fig. 4.

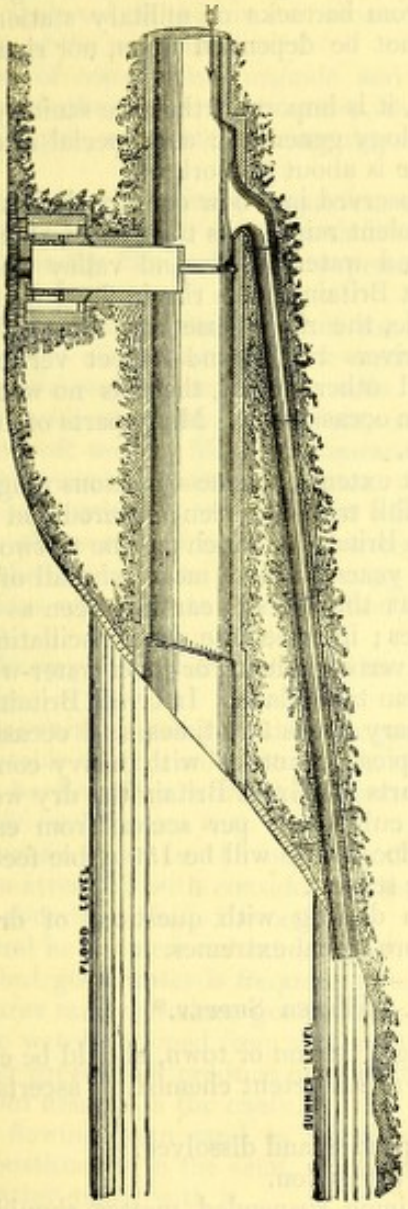
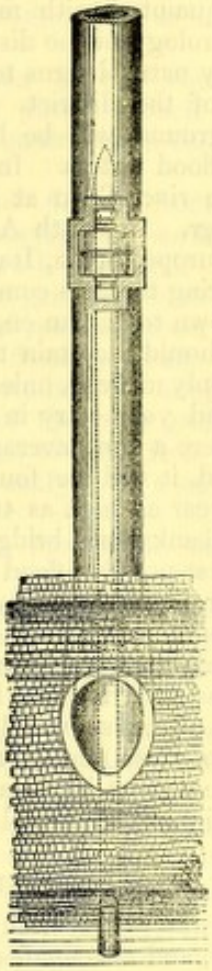


Fig. 5.



Dry Weather River Outlet at Windsor Castle.

sewer with a slight dam in front of the junction. This simple arrangement ensured the discharge of all the ordinary sewage below the summer low water level, while the brick sewer above gave free passage to the storm water. In England a sewer, four feet high and three feet wide, might be required for the removal of storm water; while an iron pipe, 12 inches in diameter, would remove all the ordinary sewage.

Land below high-water level of the sea may be embanked, as in Holland, the fens of England, and other places. Such land may be sewered and drained as at West Ham, on the Thames, near London, and as is intended on the low lands at Bombay. Sewers may be laid at the depth of low water, the outlet being protected with self-acting tidal valves; fixed permanent valves being also provided to use at will, and as occasion may require.

Where sewers communicate with rivers liable to rise in flood, the area used must be embanked, and such sewers must have self-closing valves, as also duplicate valves to be closed by hand. The river floods must be banked out. At the city of Carlisle, in England, river floods rise at times 23 feet vertical above the invert of the sewer, and some

15 feet vertical above the land through which the outlet sewer is laid. All manholes are carried above the highest level of floods.

Where lands desirable to be used for building purposes are water-logged by artficial constructions, it will be a question of removing the cause of obstruction or of artificially draining the site proposed to be used.

Pumping is resorted to for drainage purposes in many places, and will pay for purely agricultural uses. Sewage is pumped at West Ham, near London, and at Worthing, in England. The low levels of London will be pumped, as also the low levels at Bombay.

The sewage pumps at West Ham are so arranged as only to lift to the actual head or level of the tide as each tide rises and falls, and not to a fixed extreme high-water head.

Steam is the cheapest pumping power for large volumes of sewage of towns. For small volumes of sewage, proceeding from barracks or military stations, animal power may be made available; windmills cannot be depended upon, nor river currents, where weather and rain-fall are variable.

Importance of meteorology to drainage.

In dealing with questions of drainage, it is important that the sanitary engineer should make himself acquainted with meteorology generally; and special attention should be paid to the meteorology of the district he is about to work in.

There are many natural signs to be observed in a new country, indicating the meteorological character of the district. If violent rain floods take place, steep ground will be furrowed, rocky ground will be bare, and watercourses and valley lines will show the violent effects of flood waters. In Great Britain, rivers rise in flood from low-water level some 20 feet; the river Eden at Carlisle, the river Ouse at York, and other rivers of a similar character. In South Africa, rivers rise 60 and 70 feet vertical in floods. In many parts of Europe, Spain, Italy, and other places, there is no water visible in dry seasons where roaring torrents come down occasionally. Many parts of India are similarly affected, as is known to Indian engineers.

The engineer should ascertain to what extent extreme variations range. "Mediums" and "averages" only mislead, unless the full truth has been mastered and is comprehended.

The seasons and years vary in Great Britain as much as one to two; that is, at any point or place where a long average of years shows a mean rain-fall of 30 inches, then, during such period, it will be found that the driest year has been as low as 20 inches and the wettest year as high as 40 inches; intermediate years oscillating between these extremes. All embankments, bridges, culverts, viaducts, or other water-ways must be sufficient for the largest possible flood that can take place. In Great Britain the dry weather volume in a river is increased by ordinary floods 300 times, and occasionally up to 500 times the dry weather volume. In tropical countries with heavy continued rains the excess will be much greater. In most parts of Great Britain the dry weather flow from land down streams and rivers is half a cubic foot per second from each 1,000 statute acres of land, and of course in ordinary floods this will be 150 cubic feet per second, and during extreme floods 250 cubic feet per second.

It will be of the utmost importance, in dealing with questions of drainage and water supply, to ascertain and record all meteorological extremes.

Section II.—Water Supply.*

Examination and selection of water sources.

Every existing water-source, supplying a station or town, should be examined as to its available quantity, and also analysed by a competent chemist, to ascertain,—

a. Its hardness, by Clarke's test.

b. Nature of its constituents, suspended and dissolved.

c. Quantities of each constituent per gallon.

It is a first principle that water, containing suspended matter, should never be distributed in that state for the use of troops.

The most important soluble ingredient in water is its organic matter. The amount of this should be very carefully estimated and its nature ascertained whether it be of animal or of vegetable origin.

Any appreciable quantity of animal matter subject to putrescence is objectionable in tropical climates and in such climates as those of India. Water containing it should either be purified from its presence, or, if this cannot be done, it should be rejected altogether.

A grain or two of vegetable matter per gallon is not so objectionable.

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* *Recommendation of the Royal Commission respecting Water supply.*

"8. That all existing water sources be subjected to analysis, and those rejected which contain matters injurious to health. That the present method of drawing and distributing water be discontinued wherever practicable. That all water used for drinking purposes be filtered, or otherwise purified."

Waters containing a large amount of dissolved saline matter, especially of chlorides or sulphates, are not suitable for use, on account of their action on the mucous membrane of the bowels.

If at any station there be a water source containing two or three grains of saline constituents not of injurious character, no appreciable quantity of animalized matter, and only a grain or two of dissolved vegetable matter per gallon, such water may be retained for use.

If any existing water source can be made to afford water, after filtration through sand and charcoal, with or without artificial magnetic oxide of iron, of a degree of purity similar to that stated above, it may be used for the supply of troops.

Every proposed new water source for supplying troops or for extending the existing supply should be analyzed in the manner recommended, and only those sources selected which afford water of the requisite purity.

As the amount of constituents, organic and inorganic, per gallon will vary according to the season, whether it be rainy or dry, the purity of any water source should be judged of from analysis, conducted during the dry season, as well as during the season of the rains.

In addition to these preliminary inquiries, all water sources should be examined chemically from time to time to ascertain their state of purity. Such inquiries are just as necessary in a country like India as are periodical inquiries into the amount of water supplied from the source.

The purest water is that obtained from the rain-fall flowing from primitive rocks. The most impure is in all probability tank water, receiving the surface drainage of a populous district; and water from shallow wells, dug in a foul subsoil.

Granite, gneiss, mica slate, and clay slate, millstone grit, and some other analogous formations produce soft water. Mountain limestone, new red sandstone, the oolites, chalk, and some of the tertiaries produce hard water. Water from the chalk is generally from 14 to 16 degrees of hardness. A geologist who has studied the subject will tell with tolerable accuracy the sort and quality of water any of the great geological formations will give; and a chemist who has analysed many samples of water from the several great geological formations will indicate the formation by an analysis of a sample of the water proceeding from it.

As a rule, bright sparkling water is hard water. The lime in the water throws down any vegetable tinge.

A brown or brownish water tinged by vegetable matter will most probably be soft water, as the vegetable tinge would not remain if lime were also present in the water.

Water may be hardened by containing in solution iron, sulphur, and other substances besides lime, and in combination with lime.

Iron and sulphur are found in the oolites and lias shales, so that deep well sinking in these formations is attended with considerable risks. Hard water fit for use is, however, to be obtained in abundance from the oolites.

Salt rock is found in the new red sandstone formation. There is risk in deep sinking from this cause; but good water is frequently found in the new red sandstone.

The coal-measures rarely produce good water. Lime, iron, and sulphur are generally combined with the water obtained from this formation.

Chalk and upper green sand produce hard water. Water from the chalk formation is mainly derived from fissures in the chalk.

Water springs flowing from sand or débris will be pure or the reverse, according to the chemical constituents in the sand, whether, *e.g.*, there be soluble saline matter, or soluble organic matter mixed with it.

Water from marshes or marshy ground should always be rejected.

The most common source of organic impurity in mountain districts is superabundance of decaying vegetable matter from trees and jungle. Waters of this class are unfit for use unless they are purified by filtration.

The most common source of animal organic matter in Indian tanks is surface filth.

Well water will vary in purity according to the nature and the soluble matters contained in the ground from which the well derives its supply.

Shallow wells are always liable to pollution from vegetable matter or even from animal matter in the surface soil. Deep wells only, *i.e.*, wells of a sufficient depth to afford water of the requisite purity, should be sunk; and the surface-soil water should be cut off from the deep water by casing the well above.

Rain water from roofs and other impervious surfaces would afford an important source of supply at many Indian stations.

Probably nearly every station in India might obtain sufficient rain water from roofs

for all drinking and culinary purposes, reserving all the other water merely for drainage and for cleanliness.

In some instances, flagged or cemented surfaces of ground might be used for collecting the rain-fall.

In hilly districts it may be practicable in some cases to construct storage reservoirs for collecting and keeping water for use during the dry season. Such reservoirs, if above the level of stations, would enable water to be laid on by gravitation.

In every case, except there be positive chemical proof that filtration is not required, water for supplying the troops should all be passed through filters of gravel, sand, and charcoal, with or without artificial magnetic oxide of iron, to free the water not only from suspended matter but from dissolved organic matter, when water of this character only is obtainable.

Means of distribution.

The means employed for distributing water should be such as to fulfil the two-fold condition of having the water always laid on by pipes for use, and delivering the water for use as pure as it is at its source. This principle necessitates the abandonment, at least for stations and towns, of the present system of water drawing and water carrying.

In every instance, except where the water source is at a sufficient elevation above the station, water would have to be pumped up for distribution.

Almost every form of water distribution is in use for towns and barracks in Great Britain. In some cases, water is laid on at head-pressure from a public reservoir, at a higher elevation than the barrack. In other instances, the pressure is obtained by steam-power employed to throw the water to a sufficient elevation in a stand pipe, from which water is conducted for town use and supplied to the barracks. In some towns, water is raised by steam power from deep wells to an iron tank, supported on a water tower of sufficient elevation to distribute water by gravitation. There is one fort in England having a water tower and tank supplied by horse labour. In other instances, raised tanks are filled from deep wells by force pumps, worked by hand. Improved windmills have also been recently introduced for the same purpose.

So far as can be judged of from the Indian Stational Reports, there is hardly a station that could not be supplied with water all over it, and at all times, and in any requisite quantity, by one or other of these methods.

The chief difficulty in India will be the question of fuel for steam power, but fuel can be dispensed with wherever animal power can be obtained. The power of running water, where there are rivers, might also be employed; or windmill power, but this, as already stated, is very inconstant, and therefore requires great storage capacity.

At most stations probably the best arrangement would be to raise a water tower to a sufficient elevation to distribute water as high as the roof of the barracks. An iron tank should be placed at the top of the tower, and protected from the sun's rays. This tank might be supplied either from a deep well, river, or surface tank; and it should be large enough to hold a day or two's supply.

The general principles of water supply may be stated briefly as follows:—

1. To select the purest available source after careful analysis.
2. To filter the water, in order to free it from suspended matter and from dissolved organic matter.
3. To store it in covered tanks, and to raise it a sufficient height for distribution by gravitation.

Applying these principles water may be obtained—

From rivers and streams.
„ natural springs.
„ wells artificially formed.
„ impounding reservoirs.
„ tanks and cisterns.
„ a combination of two or more of the sources named.

And may be conveyed for distribution,—

By means of open conduits (before filtration).
By „ „ covered conduits, always *after filtration*.
By „ „ pipes under pressure.

Aqueducts of masonry or brick-work are not named, as cast and wrought iron will, even in India, be probably cheaper than such constructions.

Water may be brought in by gravity, that is, water obtained at a distance may be found at such an elevation above the station, barrack, or hospital requiring to be supplied as to allow of its flowing through conduits or pipes to the tanks or cisterns from which it is to be distributed.

Water may be obtained from springs and wells at so low an elevation as to require to be pumped. The mode of pumping, as regards power to be used, will have to be regulated by the volume of water to be raised, the height to which it must be lifted, and the most efficient form of power at command.

A gallon of water weighs ten (10) lbs. One horse-power is equivalent to the work of raising 3,300 gallons or 33,000 lbs. weight of water one foot high per minute.

Steam is the cheapest form of power for lifting large volumes of water continuously, such as for the supply of a city, large town, or large station.

Animal power (bullocks) may be used for supplies for barracks or stations where steam engine power cannot easily be obtained.

A pump for water supply, if the lift is more than 30 feet vertical, must of course be double action—lift and force. Such pumps do not need to be described, as they can be obtained ready made of the best character from many makers.

Storage of water.

A spring is the lowest point or lip of an underground reservoir of water in the stratification. A well sunk in such strata will most probably furnish an additional supply of water.

In Appendix No. II. are given improved principles of construction of large storage reservoirs in England, together with an improved method of drawing off the water.

India contains so many excellent examples of impounding reservoirs that it is hardly necessary to state that amateur engineering should never be admitted in devising and constructing such works. No general rules indeed can be laid down on the subject. Nothing short of competent practical knowledge and experience can obviate the numerous chances of failure.

Natural springs may be utilized by storing the water in a reservoir which will contain the flow of one entire day.

Such reservoirs should be walled with masonry, and may be covered in to protect the water from contamination.

Water pipes.

Springs of water at a distance may be conducted in channels contouring the intervening distance.

The fall for a conduit may vary according to circumstances. The fall should not be less than one in 1,000 nor greater than one in 300, unless cast-iron pipe conduits are used.

In forming an earthenware pipe conduit great care must be taken to make the trench water-tight, and then to lay and joint the pipes so as to secure that the conduit shall be sound and water-tight through its whole length, to prevent leakage into the subsoil, and to obviate the risk of impure water from the subsoil entering the pipe.

In forming a conduit the pipes should be laid in straight lines from point to point. There should be means of inspection and of ventilation at all curves. The radius of all curves should be ten times the diameter of the conduit. There should be means of ventilation and of inspection in each quarter mile. There should be means of washing out at all convenient points.

Valley lines may be crossed by means of cast-iron syphon pipes, that is, a pipe may be laid across a valley to conduct the water under pressure.

All valley or syphon lines should have double the fall in their length of the ordinary contour conduit.

There should be means provided to wash out and cleanse such syphon pipe or pipes.

For town and station service cast iron should be used for all pipes above two inches in diameter.

Cast-iron pipes should be coated inside and out with black varnish.

Turned and bored joints are cheapest.

Wrought-iron pipes with screw joints may be used up to $1\frac{1}{2}$ inch diameter.

Lead for pipes and cisterns should not be used under any circumstances. Wrought-iron pipes from $\frac{3}{8}$ up to $1\frac{1}{2}$ inch may be used for services in houses and buildings, and cast-iron pipes from three inches up to three feet diameter for mains in towns.

Rain water tanks.

Cast and wrought iron alone should be used for tanks and cisterns, not lead.

Tanks to store rain water may be of masonry. They should either be arched over or be roofed so as to protect the water from the direct action of the sun and from fouling.

The ground excavated for the formation of a tank should be made perfectly water-tight. The bottom may be covered with clay puddle and the side walls be backed or lined with clay puddle. The thickness of the puddle should not be less than 12 inches.

If the site selected for a tank is sand, gravel, or open jointed rock, great care must be taken to give the puddle a full and even bearing over the whole surface area; open joints in rock must be cleaned out and then be filled up with concrete. In gravel large stones must be removed and the entire surface brought to a level, smooth, and even plain. Clay puddle will only resist the pressure of water when it rests solidly on an even bed,

so as to prevent the water forcing holes through it, which will be the case if there is a rough uneven surface and open spaces beneath.

Tanks require to have an inlet pipe, an outlet or supply pipe, a wash out or cleansing and an overflow pipe. These latter, the cleansing and overflow, may be joined.

The main tank or tanks should have valve wells so arranged as to enable the system of supply to be carried on independently of the main tank.

On Plan VI. is shown a plan and section of an underground storage tank with valve wells, as at present used in England.

By this arrangement the supply of water is passed direct to the inlet-well, and may be passed on through this well direct to the main tank; the supply may be obtained from the outlet-well by opening the valve in the main tank and the valve in the supply well. By closing the valves communicating with the main tank in both wells, and opening the valve on the end of the connecting pipe in the inlet-well and the valve on the supply pipe in the outlet-well, the supply of water may go on independently of the main tank. The overflow must be formed at the inlet-well to be connected with the wash-out. There must be manhole openings in the covering arches, and end windows in each bay, as shown in Plan VI. This is, of course, merely a sketch to show the general arrangements.

Elevated tanks for immediate or daily supply of water should be of cast iron or of wrought iron. Cast iron requires more care and practical skill in construction, but will last longer than wrought iron.

In arranging cast-iron tanks of large dimensions care must be taken to support the bottom and stay the sides by wrought-iron tie-rods in the best manner.

Cast-iron or wrought-iron tanks should be arranged so that the supply of water may be carried on in a small corner compartment, (as shown in the sketch of a cast-iron tank, with a separate supply cistern, Plan VI.) to allow of the main tank being repaired, cleaned, and occasionally painted or varnished.

At the junctions of cast and wrought iron, wrought iron will waste more rapidly than cast iron; and junctions of bolts and tie-rods may give way if not repaired in time. Cleaning and painting should be regularly done once a year.

The sketch is not complicated by showing the details of tank-plates or tie-rods; but is intended only to show the proposed mode of arranging a small inner tank, within which all the operations of supply may be carried on independently of the larger tank. This will be found to be of the utmost importance in use. The small tank will be connected with the larger tank by means of a pipe having a valve on it.

In arranging a main pipe from pumps, the pipes should have sectional capacity sufficient to allow of the velocity in such main pipe not exceeding two feet per second, as friction increases in proportion to the velocity, as is shown by the law governing the delivery of water from pipes under pressure.

Water presses equally in all directions, and the pressure is due to the vertical head and not to the volume of water in a long horizontal main.

Where water is to be collected from rain-fall, great care is requisite to preserve the surfaces on which it falls perfectly clean, as also the conduits to the reservoirs and tanks.

When rain water is collected from roofs, the first washings of the roofs should not be collected.

Where wells are sunk or used, the lining of the well should be made water-tight, so as to exclude surface water. The possibility of contamination by sewage should be prevented.

Watering troughs.

Watering troughs for cavalry horses should be so arranged that each trough may have an independent supply of water. One trough should not be supplied out of any other trough, as the water is rendered unpalateable when breathed in by other horses or cattle. It does not require more water to supply 20 watering troughs independently than it does to arrange them in line, so that the overflow of one trough shall pass into the next below, and so on through the whole line. A pipe or trough conveyed the length of the whole may be made to supply each trough independently.

Waterfilters.

All water before being stored in tanks from which it is to be pumped direct for use should be passed through filters. Every rain-water storage tank should have its filter.

The cheapest and best form of filter may be readily made with gravel, sand, and charcoal, to which may be advantageously added artificial magnetic oxide of iron in cases in which the water contains much organic matter.

The addition of artificial magnetic oxide of iron increases the oxidizing power of all filters, and renders them more effective for destroying organic matter.

The followings figs. 6 and 7 show plans and sections of filters, single or double, for stations or barracks; either of which will be found useful, according to the quantity or degree of impurity of the water to be filtered.

When considerable bodies of water have to be filtered, the arrangement of filtering material shown on Plan VII., is the one usually adopted in England. But in using such filters in India, it would be necessary to place a layer of charcoal between the layers of gravel, to destroy as much as possible any organic matters which may exist.

All possible and practicable means should be taken to collect, store, and utilize pure soft water. Springs, wells, conduits, service reservoirs, and tanks should be covered or otherwise protected from contamination.

The laws of hydraulics were known in the East ages before civilization sprang up in the West ; but the uses of cast and wrought iron for conduits, pipes, reservoirs, and tanks have materially simplified the arrangements for waterworks. Masonry aqueducts to span valleys of vast extent are not now required. A syphon pipe of cast iron will convey water across a valley cheaper and better. Elevated tanks of cast or of wrought iron may also be constructed much more cheaply than of brickwork or of masonry.

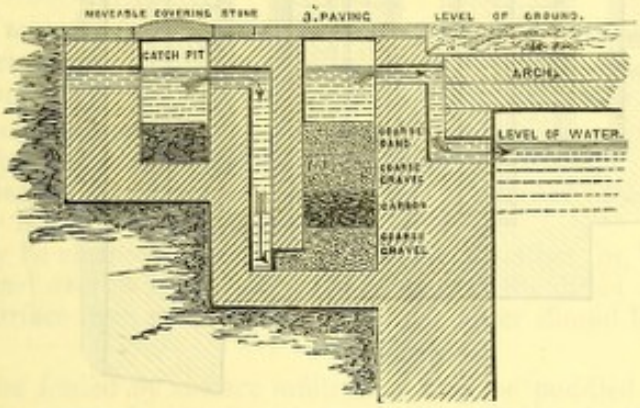
As a rule, if water can be obtained near a station at a low elevation, it will be cheaper to pump than it will be to bring in water by gravity from long distances.

A supply of soft and pure water may cost considerably more to obtain than a supply of harder and more impure water. The soft and pure water may nevertheless be the cheapest to use, though works to bring it in may cost double the sum required to furnish the harder and worse water.

Where a river flows through a valley over porous substrata, sinking a well or wells in the strata within the influence of the river filtration is a cheap and ready method of obtaining river water naturally filtered. The water supplied to Windsor Castle is

FIG. 6.—DETAIL OF SINGLE FILTER FOR RAIN-WATER TANK.

Section on Line A.B.



Plan.

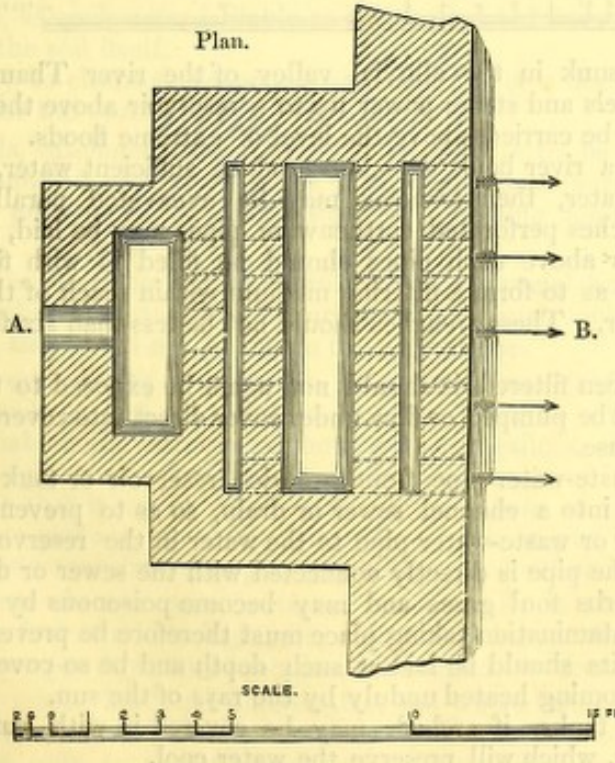
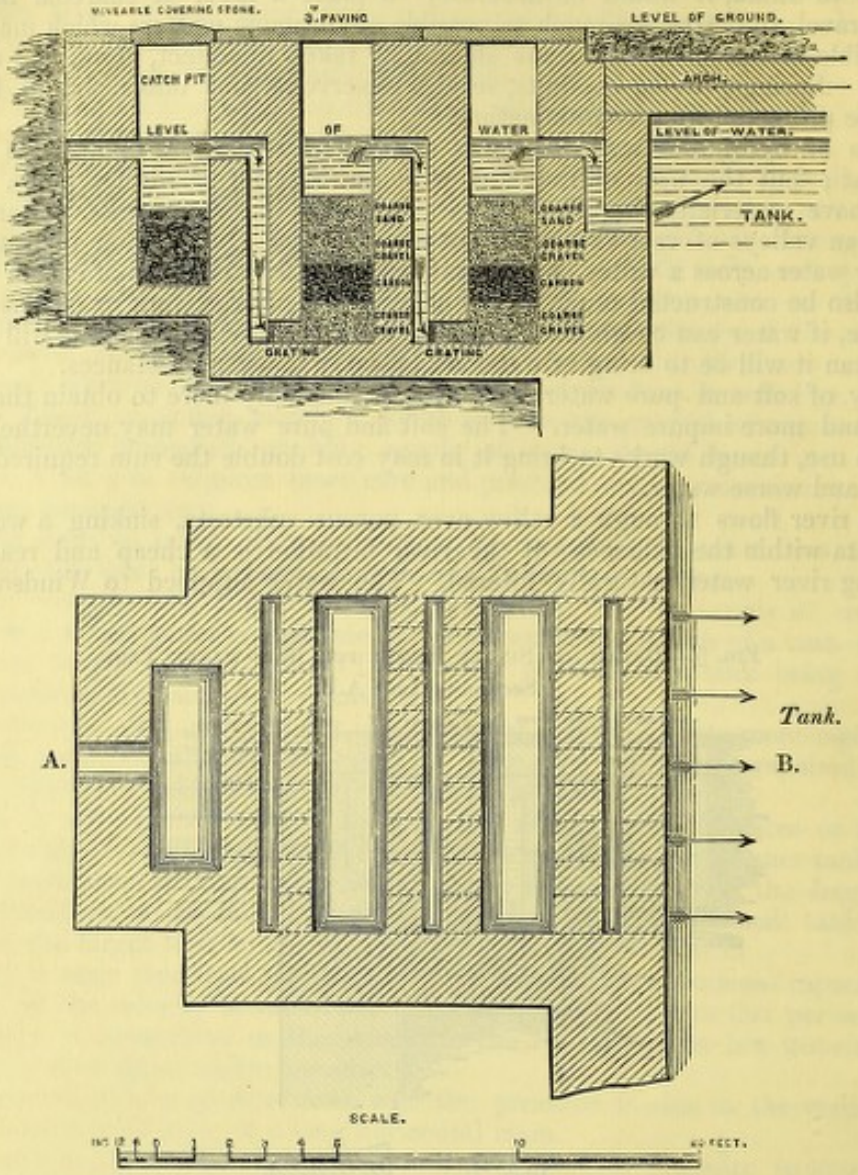


FIG. 7.—DETAIL OF DOUBLE FILTER FOR RAIN-WATER TANK.

Section on Line A.B.



obtained from wells sunk in the alluvial valley of the river Thames (gravel), and is pumped by water-wheels and steam-power up to a reservoir above the level of the castle. Wells so situate must be carried above the level of extreme floods.

If a single well on a river bank does not produce sufficient water, or if the subsoil is clay impervious to water, then trenches may be excavated parallel to the river or stream, in which trenches perforated earthenware pipes may be laid, leading to a well or wells. The trenches above such pipes should be filled in with fine assorted gravel, charcoal, and sand, so as to form a filtering medium within reach of the dry weather flow of such stream or river. These trenches should not be less than six feet deep to the top of the pipes.

After water has been filtered it should not again be exposed to the chances of contamination, but should be pumped or flow under cover direct into covered service reservoirs or elevated tanks for use.

Any overflow or waste-water pipe from a service reservoir or tank should deliver the water at an open end into a channel sewer or drain, so as to prevent gases rising back through such overflow or waste-water pipe to the water in the reservoir or tank, a result very apt to follow if the pipe is directly connected with the sewer or drain.

Water readily absorbs foul gases and may become poisonous by such means. The possibility of such contamination taking place must therefore be prevented.

Earthenware conduits should be laid at such depth and be so covered with earth as to prevent the water becoming heated unduly by the rays of the sun.

Brick and masonry tanks, if arched, may be covered in with sand or fine earth to the depth of 18 inches, which will preserve the water cool.

All covered reservoirs and tanks should be ventilated.

Service pipes and cisterns.

All service pipes may be of wrought iron from $1\frac{1}{2}$ inches diameter to $\frac{3}{8}$ of an inch diameter for single services.

All the joints must be screwed. The taps should screw on to the service pipes. A lead or soldered joint should not be required. An ordinary fitter may then fit up and maintain any water service.

All supply pipes should be arranged in such manner as to allow of easy inspection and subsequent repairs. Stop-taps should be placed betwixt the main and the building in all cases, so as to allow of isolation of any line of service pipe for repairs.

All service tanks and service pipes should be fixed in such manner that the rooms shall not be flooded in case of leakage or overflow.

Ready means of access to all tanks and cisterns should be provided to allow of inspection, cleansing, or repairs.

Up bends should not be formed on lines of main pipes or on service pipes. If up bends are inevitable, air valves should be provided to let out the air at such bends.

Bends should not be formed at right angles on pipes, but the pipe should be brought round in a curve.

If a tie-rod supports weight at both ends, the strain at either end must not exceed three tons for each square inch of cross sectional area of the rods.

Iron tanks should not be exposed to the direct action of the sun, but must be enclosed or clothed. An enclosure of boards with felt beneath will form a good protection. Water, especially for drinking, must be kept cool.

Waterworks.

All mortar used in waterworks should be capable of setting under water.

Cement similar to Portland or Roman cement may be used for jointing earthenware conduit pipes.

Before deciding to commence waterworks, a most careful examination should be made for several miles around the site to be supplied, so as not to leave any reasonable doubt about the best source of supply and the best position for the works having been chosen.

Existing means of water supply may be improved by combining with them such portion of the new works proposed as is requisite.

If a supply of water is now pumped direct from a river or stream, filtering wells or filter trenches may be formed as suggested.

Open tanks may be cleansed, improved, and covered, either by being arched in or by having a roof placed over so as to prevent fouling and the direct action of the heat of the sun, and the surface from which they derive their water should be kept clean and free from filth.

Wells liable to be fouled by surface infiltration may be puddled or lined with brickwork set in cement, or may be cased with iron to a sufficient depth to cut off the water from the alluvial soil, as such water is liable to become tainted from organic matter either on the surface or in the soil itself.

Open conduits may be cleansed, deepened, and covered, or a line of earthenware pipes may be substituted for the open and exposed channel.

Gathering grounds, catchment areas from which rain is to be impounded, may be formed, cleansed, channeled, and paved, so as to present a clean surface; and great care should be taken to prevent all gathering surfaces becoming fouled or covered with vegetation.

Deep well sinking or deep boring necessarily involves special knowledge and appropriate and special tools. A description of such work and such tools is not needed by a practical well-sinker, and would not be of use to any one else.

A steam engine, working with coals at 20*s.* per ton, will raise 90,000 gallons of water, 900,000 lbs., or upwards of 400 tons weight, 100 feet high, at a working cost of one shilling. One man making six journeys per hour with two gallons, or 20 lbs. weight, and, working at this rate eight hours, would carry up to an elevation of 100 feet 96 gallons of water, or 960 lbs.; so that it would require the united labour of upwards of 900 men working eight hours to perform one shilling's-worth of steam-engine work, such as is daily performed at the large waterworks pumping establishments for London.

Small steam engines do not raise water so economically as large engines, but the smallest engine, with fuel at a very high rate, will be far cheaper than manual labour, if 10,000 gallons of water per day should require to be raised 100 feet.

Private filters of various kinds are purchasable, and where water cannot be filtered at the works, service filters will be useful. A company is about being formed in London to supply filters, not only to remove mechanically suspended impurities, but also to

soften and otherwise purify water. Such filters or filtering media may probably in due time be made available for India.

Where waterworks are in use, care will be necessary to preserve the works in effective order.

Storage reservoirs must be fenced in. Conduits, open or covered, must be regularly looked to, so as to prevent fouling of any kind.

A report as to the state of any local water supply may with advantage be required monthly from each principal medical officer and engineer officer.

The engineer officer should give the volume used, the volume in store, and the loss or waste, if any.

The medical officer should give the quality and an analysis each month. If any men are peculiarly affected by drinking water, the facts should be recorded, and the causes should be explained, so that a suitable remedy may be provided.

Leaking reservoirs, conduits, tanks, cisterns, pipes, or taps should be repaired at once. Every possible means should be used to preserve the water for use in bulk and in the greatest possible purity.

Amount of water required.

The amount of water required for consumption at home, including washing, is about seven gallons per head per day of the whole population. In hospitals it is 25 gallons per day per head for the whole hospital population (sick, attendants, and officers), including baths but *not* washing. At Indian stations where there is a large preponderance of adults, and where the circumstances of the climate and country require so much greater attention to cleanliness, it is probable that about 12 gallons per head per day for healthy people, and 30 to 35 gallons per head for sick in hospitals, would be required for every purpose, including baths, but *not* including laundry work; and allowance must be made for waste. In England waste amounts to about two-thirds of the supply to the civil population. In barracks this can be to a great extent avoided.

At stations where the supply of pure water is limited, as, *e.g.*, where the rain-fall on the buildings affords the only pure water for cooking and drinking, this part of the supply would require to be filtered, tanked, and distributed by itself.

Underground tanks for drinking and cooking water, possess the advantages of coolness and freedom from vegetation. But wherever such tanks are made, they should be very carefully constructed and lined, so as to prevent leakage, either from the tank into the subsoil, or from the subsoil into the tank.

They should be constructed at some distance from the barrack buildings. And they should be carefully arched and covered to prevent the entrance of surface impurities.

Water distribution for buildings.

As regards barrack water supply, water should be laid on to all barracks and out-buildings for every required purpose. It should always be available by day and night, for drinking purposes, ablution rooms, baths, cookhouses, latrines, urinals. Also for stables.

Every barrack room should have a pure cool water supply for drinking, to be drawn from a tap.

Every day room and reading room should have drinking water at hand, laid on in a similar manner. And there should be drinking fountains at convenient points throughout the cantonments, especially in connexion with guard rooms, gymnasia, workshops, &c.

Although it is desirable that the whole supply should be laid on from one centre, it is expedient, with a view of watching, and, if necessary, of checking waste, in certain cases to provide each separate block or building with its own tank. When this is done, care should be taken not to place any water tank under the same roof as the barrack room. The water tank should be kept separate, closed, and ventilated.

It is a fundamental principle in the water supply of stations that every drop of water brought into them for use, should be conveyed away again by drains; otherwise it will remain, more or less, in the subsoil and become an added source of unhealthiness.

In laying on water for bazaars and towns, the same general principles should be kept in view. All water brought in should be removed by drains. Each house should have its own water supply, wherever practicable; otherwise the supply should be from fountains or hydrants.

Section III.—Principles of Barrack Construction.*

The accompanying plans are intended to illustrate the construction of barracks for accommodating British troops in India and in tropical climates generally. They embody

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* *Recommendations of the Royal Commission respecting Barrack Construction.*

"5. That the means of instruction and recreation be extended to meet the requirements of each station. That covered sheds for exercise and gymnastics be provided. * * * That workshops be established, and also soldiers' gardens in connexion with the station wherever practicable."

the principles contained in the evidence of witnesses examined before the Royal Commission on the Sanitary State of the Army in India, and in reports sent from stations in India and Ceylon.

1. *Barrack Rooms to be raised on Basements.*

The first improvement suggested by the evidence is that all future barracks and hospitals should be erected on raised basements.

In high airy positions, these basements may be three or four feet in height; they should be arched, and the floor of the barrack room should be laid on the top of the arches; means should be taken to prevent water running under the basement; the outer openings should be grated to prevent animals obtaining access, or nuisance being deposited under the arches; the basement should be sufficiently lofty to admit of the entrance of workpeople to keep it clean, and its floor should be formed of concrete. Height of basements.

One use to which the basement might be devoted would be as a place of exercise for playing bowls, walking, &c. To answer such purposes the floor of the basement would have to be raised above the ground and paved; and the height of the basement should be sufficient to enable it to be used in the proposed manner.

A damp-proof course should be carried round the entire basement a little above the ground; and also in all the piers of the arches to prevent damp rising.

If the basement were used for exercise and were of a sufficient height, say ten or twelve feet, barrack rooms constructed over basements of this height, would be raised sufficiently above the ground to be occupied in most districts, with comparative safety to health.

But in low situations, the higher men sleep above the ground, the better. And under unfavourable local circumstances, it would be advisable to interpose between the barrack room and the ground, not only an arched basement but an additional floor of rooms. A barrack block so constructed would consist of a basement of, say, three or four feet high, a floor of rooms, fifteen feet or more high, which might be devoted to purposes of recreation, &c., and the sleeping rooms over.

There is an apparent waste of space in this form of construction; because, in each block, the same amount of floor surface, devoted to the men's sleeping accommodation in the upper floor, has on the lower floor to be occupied by other accommodation. In occupying this space sufficient area might be given for the following purposes:— Uses of lower floors.

a. Dining, day, and recreation rooms.
b. Orderly rooms.
c. Serjeants' mess.
d. Schools and lecture rooms. Theatres.
e. Guard rooms.
f. Certain kinds of workshops.
g. In cavalry barracks, saddlery rooms.
h. Stores.

"9. That all future barracks * * be erected on raised basements, with the air circulating under the floors." * *

[Report, Vol. I. fol. li.] "In low, flat, and damp districts each barrack should consist of two floors, the upper one only to be used as a sleeping room, and the lower floor to be a covered place for exercise and amusement."

"10. That all new barracks be constructed to hold no more than a quarter of a company in each building, or at most half a company in one building, in two separate rooms having no direct communication with each other." * *

"11. That barracks * * be in future constructed with single verandahs only, and for no more than two rows of beds between the opposite windows."

"12. That the cubic space per man in future barracks be from 1,000 to 1,500 feet, and the superficial area from 80 to 100 square feet, varying according to the airiness of the position." * *

"13. That the beds be so arranged with respect to windows, doors, and wall spaces, as to ensure the benefit of free ventilation without exposing the men to drafts. * * That in all future barracks, the wall space be made sufficient to keep the beds at the least three feet apart and at the same time out of the door draft.'

"14. That the ventilation of barracks * * * be sufficiently provided for independently of doors and windows."

"15. That in all cavalry barracks, saddlery rooms be provided and saddles removed out of the barrack rooms."

"16. That all barracks * * be provided with sufficient glazed window space to light them." * * *

"17. That all barracks be provided with sufficient ablution and bath accommodation with a constant water supply. That drinking fountains supplied with filtered water be provided."

"18. That barrack cook-houses be improved and better ventilated."

"19. That wherever practicable, iron or earthenware water latrines supplied with water and drained to an outlet be introduced instead of the present system; that where this is impracticable, all cesspits be abolished and metal or earthenware vessels to be removed twice a day substituted. That improved urinals supplied with a jet for lavatory purposes, as well as with a free supply of water for the cleansing and drainage of the urinals, be provided."

The canteen must be quite separate, but all other accommodation could be placed on the ground-floors without interfering with the healthiness of the sleeping rooms above.

It is necessary to state distinctly that it is unadvisable to have more than one floor of men's sleeping rooms in any tropical barrack, on account of the difficulty of ventilating lower floor sleeping-rooms sufficiently for the climate.

2. *Number of Men per Room and Block.*

Size of barracks.

The Royal Commission recommend that future barracks be built to accommodate not more than a quarter of a company per room, and that each block shall consist of one single quarter company room, or at the most of two such rooms in line, completely cut off from each other, with separate doors to the open air.

This rule precludes the construction of barrack rooms for a greater number than the quarter of a company, and also the construction of rooms divided into quarter company sections by arches.

The sanitary principle on which this construction of barracks in quarter company rooms is based is that considerable subdivision *in buildings* is absolutely necessary for health in tropical climates, and that in carrying this principle into effect, it is necessary that the air be allowed to play freely over as large a surface of the buildings as possible.

To each quarter company room there should be a non-commissioned officer's room attached.

A separate barrack block would thus contain say 24 men in one room and one serjeant, or 48 men in two rooms and two serjeants.

3. *Space and Area per Man and Proportions of Rooms.*

Space per man

The Royal Commission recommend that in future the cubic space per man in barrack sleeping-rooms should be between 1,000 and 1,500 feet, and the superficial area between 80 and 100 square feet, according to the nature of the position.

They propose the smaller space to be given in elevated healthy stations, the larger in low and less healthy districts.

In disposing of this area the barrack sleeping room should be suitably proportioned in length, width, and height.

Assuming 22 feet as the minimum width of the room, the length would be 87 feet 6 inches, and the height 12 feet to the top of the wall, exclusive of the roof space, in cases where 1,000 cubic feet are given. But a foot or two of additional height of wall would make a much better room.

Where 1,500 cubic feet are given, the length would be 100 feet, the width 24 feet, and the height 15 feet to the top of the wall, exclusive of the roof space.

Barrack plans.

These are the proportions which have been used in designing the barrack block shown in Plans VIII., IX., and X. At certain very hot stations a greater height of wall is required than could be given with these allotments of space.

4. *Windows and Doors.*

Wall and window space.

There should be a window for every two beds. And the beds should be arranged, two and two, between the windows, with their heads to the wall. The wall space between the windows should be sufficiently wide to allow a space of 3 *feet at least* between the two adjoining beds, and to keep the beds free of draught from the doors.

Wall spaces of from 9 to 10½ feet, according to the cubic contents allowed, would be sufficient for these purposes.

In the majority of instances, five doors per room, two in each side, and one at the end, as shown in Plan VIII., will afford sufficient door space in a room for 24 men.

But, in unhealthy positions, it has been customary to have doors only, instead of windows, to barrack rooms. This arrangement has been considered necessary to increase the circulation of air and so to prevent the deposition of moisture within the room. It has the disadvantage of exposing the men to draughts, and causing sickness—an evil which may be diminished by introducing screens on each side of the door, as shown on Plan VIII., to shield the men from draughts while in bed. At most of the stations, the advantages of having numerous doors can be obtained by suitable independent means of ventilation.

Doors

Each door should have a window on hinges over it, carried up to within a foot or 18 inches of the ceiling. As already stated, it is necessary to shield the beds nearest

the doors from air blasts, when the doors are kept open, by thin partitions a few feet in height, and three or four feet in width.

Windows.

The window sills should not exceed two feet or two feet six inches in height. And the head of the window should be carried up to within a foot or 18 inches of the ceiling.

Every window should be glazed.

Every window should consist of two parts; the upper portion, about two feet in depth, should be hinged on its lower edge to fall inwards to form a species of large louvre for ventilation.

On each side of the hinged portion there should be a triangular cheek to prevent air currents falling upon the men. This louvred portion of the window should admit of being easily closed by a rope and pulley. To whatever extent it is opened, air currents will be directed towards the ceiling of the room.*

The lower portion of the window should be a casement opening inwards in two halves. And each window should be provided with sliding jhilmils on the outside, having the blades directed upwards and inwards. The windows should be four feet wide.

Besides the doors along the sides of the room, it will be necessary to have a door at one end of the room opening into the verandah near the entrance to the night urinal, hereafter described.

5. *Verandahs.*

Construction of verandahs.

Each barrack block should have verandahs all round. In the plans, these are shown supported on iron columns; but arches or pillars of stone or brick might be used; they should be eight or ten feet wide at the least, to correspond with the breadth of the terrace giving entrance to the rooms. As the terrace for the ground-floor rooms would rest on the arched basement, this basement would have to be longer and broader than the barrack room in proportion to the breadth of the verandah. The roof of the verandah of the upper floor should be a continuation of the slope of the roof of the barrack room. The verandah of the lower floor, where there are two floors, would be the terrace to the rooms above. But as it might hardly project far enough to shelter the lower rooms sufficiently from the sun, a series of louvres should be carried the whole way along between the pillars, sufficiently deep to afford the required amount of shade.

Roof to double.

It is important that the verandahs should be ventilated to carry off the hot air. In the upper floor verandah this can be best done by constructing the roof of the verandah double with a continuous free air-space of six inches between the outer covering and the inner lining, both of which should be continuous with the covering and lining of the roof, and the heated air should be discharged at the ridge through the air-space continued up from the verandah. The arrangement is shown in Plan XI. In the lower floor verandah, the hot air would escape by the louvres between the pillars.

An important incidental advantage derived from this construction of barrack rooms is that each half company block, if on two floors, would have about 1,200 linear feet of verandah, half on each floor, for the use of 48 men with their N.C. officers.

6. *Ventilation and Cooling of Barrack Rooms.*

Arrangement of blocks. Ventilation.

Barrack blocks should be arranged so that prevailing healthy winds should blow against their sides.

In laying down the principles on which tropical barracks should be ventilated, it is necessary to state that probably no one plan will answer for every station.

Some stations are much hotter than others. Some are in localities exposed to every breath of wind, while others are in close, sultry, damp positions, where there is little movement of the outer air. At some stations the temperature varies little between day and night. At others, cold nights succeed very hot days. At stations in India exposed to hot winds, it is sometimes necessary to close the ventilating openings to windward to prevent the rooms becoming too hot for healthy occupation, or to use artificial means of cooling the air by tatties or thermantidotes on its passage into the room. At stations where dust storms occur, there should be the means of closing all apertures while the storm lasts. It is evident that these and other local conditions require careful consideration on the spot. All we propose to do is to lay down general principles, and the mode of application which appears most suitable for the majority of cases.

Every barrack room should be ventilated separately by itself and independently of open doors and windows.

* It may be here mentioned, as a point of experience, that great care is required in warm climates, in the fitting of doors, windows, and ventilating apparatus; allowance should be made for warping and shrinking. Sometimes, from want of care in this particular, windows are broken or become fixed and immoveable; and ventilation is obstructed. Often on such small matters the entire success of improvements may depend.

The best way of supplying fresh air is to carry a ventilating course of air brick, nine inches deep, entirely round each room at the eaves; or to leave a similar open space entirely round, on all sides of the room, and close to the ceiling or eaves. This space would act as the inlet for fresh air, and should be introduced into every room in the block. At stations where it is necessary to provide for closing the fresh air inlets, a succession of louvred inlets with the louvres hinged to admit of their being closed, as shown on Plan XI. and on Plan XII., figure 2, will be found a convenient method for excluding hot winds and dust.

Where the ceiling is carried up in the line of the roof, the best outlet for foul air in the upper floor would be a continuous louvre carried along the ridge, but with flat ceilings there should be louvred shafts carried up from the ceiling to above the roof, one shaft for every six men.

The construction of a continuous louvre and the relation which it bears to the ventilation of the room and of the double roof, are shown on Plan XI. It will be seen that the louvre is so constructed as to prevent rain being blown into the room, and at the same time to admit of being closed. To obtain these advantages, the louvred outlet along the ridge is constructed in lengths in the manner shown on Plan XI. It consists of a curved shield to prevent the rain being blown into the room, and is provided with a flap valve, which can be used either for wholly or for partially closing the louvre. In certain cases at home, the means of closing and opening these valves are all connected, so that a non-commissioned officer can regulate the ventilation by simply raising or depressing a lever.

Where shafts carried through flat ceilings are used their construction should be as follows:—

a. The aggregate area of the shafts should be one square inch for from 15 to 20 cubic feet of room space.

b. Each shaft should be louvred on the four sides above the roof; the louvres should be inserted at an acute angle, to prevent rain blowing in; and for the same purpose the louvred faces of the shafts should be protected by a board placed in front of each louvre at 12 or 15 inches from its face, as shown in the plans.

c. These shafts should be louvred below within the room to prevent down-draughts. And the closed lower end should be hinged for the purpose of being opened to sweep the shaft.

d. In upper floor rooms, these shafts should be placed equi-distant from each other, along the central line of the ceiling.

e. In lower floor rooms, the shafts should be built in the walls.

f. The non-commissioned officer's room should be ventilated in the same way, *i.e.*, by a ventilating course carried round at the ceiling, and by a single shaft.

The construction and arrangement of these shafts is shown in Plan XII., fig. 2.

At stations where there are hot winds or dust storms, ventilating shafts and inlets should admit of being temporarily closed to any required extent.

Warming. At lofty hill stations in India and at certain damp stations in the tropics during the rainy season, it may be advantageous to introduce fire places for warming and drying the air in barrack rooms and hospital wards. When the fuel is wood, a fire place shown on Plan XIII., where the fuel heats a fire clay chamber through which fresh air is introduced warm into the room, may be used. When the fuel is coal the form of fire-grate, shown on Plan XII., fig. 1, will be found to answer.

Cooling. Much yet remains to be done before a satisfactory method of cooling the air admitted into barrack rooms and hospital wards has been arrived at. Various contrivances have been used and proposed, but none of them fulfil all the conditions of health, facility of application, and economy.

Of the three methods now in use, the punkah merely agitates air already more or less impure. The tattie, at present composed of vegetable material, although it cools fresh air passing through it, is apt to occasion hurtful draughts, and if the material is undergoing decomposition it may become an incidental cause of disease. If made of a non-decomposable substance, and supplied with water otherwise than by hand labour, so that no more water was used than was required for evaporation, the tattie, or at least the principle which it embodies, might admit of better application than at present. The thermantidote is correct in principle, but of all the methods of moving air, that by means of a fan wheel used in the thermantidote is the most costly, on account of waste of force. Dr. Arnott's ventilating air pump, either in the form of a light metal gasometer, or of a large light piston swinging like a punkah in a fresh air chamber, with suitable valves for ingress and egress of air and means of cooling, would be the nearest approach to an economical and effective thermantidote. The expen-

diture of force required to move large masses of air by Dr. Arnott's contrivance is very small indeed.

The cheapest source of cold for cooling air in India is evaporation. And air so cooled should be allowed to enter barrack rooms and wards, not in rapid currents, but in large slow moving masses. It should pass over no surface of decomposing or decomposable material in its passage. The cheapest mechanical method for moving large masses of air is Dr. Arnott's ventilating air pump.

We would suggest this whole subject for consideration in India, where improved methods of cooling air could be tried to an extent for which there are not facilities in this country.

7. *Ceilings.*

Flat ceilings.

Every barrack room should be ceiled. If the ceiling be carried across at the top of the wall, leaving a triangular space above it, this space should be well ventilated at the ridge and by openings in the end walls. If the ceiling be carried up in the line of the sloping roof, it would form in reality the inner layer of a double roof and should be separated from the outer roof by a sufficient depth, say, from six to nine inches, to enable a free current of air to pass upwards between the ceiling and the roof through the ridge to keep the room cool.

Double roofs.

The roof of the verandah should also be double. The outer layer should be continuous with the outer layer of the roof of the barrack; and its inner layer should be continuous with the inner layer of the roof of the room. The entire space between the two layers should be open from the edge of the verandah to the ridge of the room, so that a free current of air may pass upwards between the outer and inner layers.

Materials.

Tiles laid on felt are suggested for the outer roof, and wood for the inner. By using these materials, both the radiating and conducting of sun heat will be diminished to the utmost. The construction of this form of double roof is shown on Plan XI. It consists of an outer layer of boarding, on which the tiles are laid. Under this is a second layer of boarding at the distance of 6 inches, leaving a continuous air-space of that depth, through which the heated air from under the outer layer of the verandah and roof is allowed to escape by the ridge louvres. Under this air-space and 6 inches below it is the boarded ceiling of the room and verandah.

8. *Barrack Room Ablution Accommodation.*

Ablution and bath rooms.

In tropical climates, ablution accommodation for barracks may be provided on one of two principles; 1, the whole ablution and bath arrangements may be separate from the barrack blocks and placed in a building to be reached from the rooms by covered verandahs. Or, 2, the ablution basins may be fitted up in a small room attached to each barrack room, but placed on the outer side of the verandah. The first arrangement has the advantage of keeping every source of damp away from the barrack room. The second has the advantage of making each barrack block complete and convenient in itself, at least as regards its ablution arrangements; probably it will be found in practice that in some cases one arrangement, in some another, will be the more advantageous. As a general rule in all low, damp, hot situations, where there is little movement of the external atmosphere, it is safer to keep every additional source of damp and impure air at a distance. But, in more dry and airy positions, and at hill stations, there is no reason why ablution accommodation should not be attached to each barrack room.

Plan XIV. gives the details of a detached ablution and bath arrangement, which will be found suitable for many tropical stations, and also for Indian stations at seasons when plunge baths cannot be used. The building is lighted by windows, which, at some stations, might require jhilmils; or the windows might be protected by extending the roof so as to form a verandah. Ventilation is provided for the building at the eaves and by roof louvres.

Baths.

The slate bath shown on Plan XVI. might be found suitable [in England these baths are the cheapest, but sometimes enamelled or painted iron or zinc are used.]

Wherever a separate ablution and bath room is provided, water should be laid on; and the waste water should be conveyed away by the general sewerage of the station. The ablution building should be connected with the barrack block by a verandah.

In cases where it is considered advisable that a small ablution room should be attached to each barrack room, it should contain only a few basins and foot-pans. It would be unadvisable to introduce the ordinary ablution table and moveable iron basins, on account of the large exposed wet surface which this arrangement entails.

Ablution basins.

We would suggest for ablution rooms, whether separated from barrack rooms or connected with them, the introduction of fixed earthenware basins sunk in slate slabs, each basin having a water tap over it and a discharging plug at the bottom as in

Plan XV. These basins are found to answer perfectly in England; and with due care they would be a great improvement on the existing Indian practice.

Four basins per room of 24 men would be sufficient. And each basin should have about four feet of front to afford plenty of room for the men for washing.

Foot-pans. Three foot-pans would probably be sufficient.

Of course these arrangements are contingent on a proper water supply and drainage being provided for each barrack block.

The ablution room, when attached to the barrack room, should always be reached from the barrack room by passing out into the open air under cover of the verandah, but never direct from the barrack room.

The best form of this arrangement is that shown on the Hospital Plan XXIV., though of course without the bath, which in barracks should always be separate.

9. *Drinking Fountains.*

On each floor of the barrack block, at each end, there should be a water tap supplied with pure cool drinking water with drinking cups over a small sink. These fountains could be placed in the same compartment as the ablution room, if the ablution room is attached to the barrack. If there is no such ablution room, the fountains should be outside the barrack rooms. Drinking fountains should also be attached to all recreation rooms, gymnastic sheds, &c. throughout the station.

10. *Night urinals.*

It is proposed to provide a compartment for the night urinal attached to each barrack room to be locked during the day. Also a separate set of day urinals away from the rooms. The most efficient form of night urinal yet made is one constructed for the War Office by Mr. Jennings,* Plan XVII. It consists of a basin, valve, and syphon-trap, supplied with water, and has an overflow. It is cleansed and filled by raising the handle and dropping it, and it requires a very small quantity of water. For a urinal of this construction a constant water supply from a tank is required, and the urinal must be drained. In the absence of water and drainage, or in cases where it might be considered unadvisable to introduce a water urinal, a moveable urinal of wood lined with pitch or of enamelled iron or earthenware might be used, in some such manner as is shown on

Position. Plan XV. On Barrack Plan VIII. is shown a small compartment attached to each barrack room to contain the night urinal, which may be either a moveable vessel or a water urinal.

A small closet is also shown for containing brushes and cleansing materials for the room.

11. *Structure of Walls.*

Hollow walls. We propose that the walls should be built hollow, so as to substitute an air space instead of thickness of wall as a means of coolness.

This air space should be ventilated by air bricks, above and below, to ensure a current of air upwards, between the outer and inner walls, to carry off the sun heat.

All inner walls should be plastered.

Every barrack and outbuilding, and all covered verandahs, should be supplied with eaves-gutters and rain-water pipes to convey the rain water away from the foundations and walls of the buildings.

12. *Drainage of a Barrack Block.*

Principles. The following principles are suggested for application in barrack room drainage :—

a. Abolishing cesspits altogether.

b. Conducting all drains outside and free of the walls of the building.

c. A six-inch or nine-inch glazed earthenware pipe is sufficient for the main drain of every barrack block.

d. Into this drain should be led the water from the ablution room, if an ablution room has been attached to the block, and from the night urinal, if a specially constructed night urinal has been provided, as well as all the roof water not tanked for use.

e. The drain should be trapped outside the building, and ventilated by a rain-water pipe, or by a small pipe carried from between the trap and the wall above the roof of the barrack. Drains from all other buildings should be similarly ventilated.

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* In giving the names of manufacturers of sanitary apparatus, it is not intended to be implied that no others are capable of supplying suitable apparatus. The names given are those of persons who have voluntarily devoted time and capital to contriving sanitary appliances in conformity with the requirements of the War Office.

13. *Water Supply of Barrack Blocks.*

Unless every barrack block is supplied with water at pressure from one common centre, a closed iron tank, capable of holding two or three days' supply, should be connected with the barrack block. This cistern to be filled from the central tank of the station. Water will have to be laid on from it to the drinking taps, to the ablution basins, and foot-pans where the ablution accommodation is attached to the block, and to the urinal.

14. *Barrack Latrines and Urinals.*

Latrine buildings.

The present practice in tropical climates of having the latrines and day urinals detached from the barrack blocks and reached under cover is the most suitable arrangement for these conveniences.

The question, whether or not the construction of latrines and urinals can be improved, depends on the possibility of draining the station and providing a water supply.

Whatever form of latrine and urinal is adopted for the future should involve the abolition of cesspits or soak wells. No cesspit should be permitted within the boundary of any cantonment. Cess-pits poison the air, earth, and water.

If it is impracticable to sewer and drain a station, the best form of latrine consists of moveable metal vessels which should always be emptied twice a day at the least, and the arrangement should be such as to avoid any contamination of the surface of the latrine with filth or fluid, and no washing of the latrine should be required.

Where the surface of a station is so flat as to render it doubtful whether the discharge from the latrine would keep the drain clear, additional fall can always be obtained by raising the latrine and latrine buildings any required height above the level of the ground.

Jennings' latrine.

The most efficient form of drained water latrine for hot climates is that made for the War Department by Mr. Jennings, Plan XVIII. It requires little water, it exposes a comparatively small surface, it is discharged, cleansed, and refilled by raising a handle, it is not liable to get out of order, and it has been successfully used for a considerable time. Whether there is smell from it or not depends only on the frequency with which it is discharged and cleansed.

Macfarlane's.

Cast-iron water latrines, Plan XIX., made by Mr. Macfarlane, of Glasgow, have been successfully introduced for barracks at home. But it may be doubtful how far they would answer in warm moist climates from the larger water surface they expose.

Urinal.

Urinals should never be under the same roof as latrines. They are best placed under a simple lean-to roof, with a suitable screen. They should never be drained into the latrine, as this is found to give rise to great additional nuisance.

In the absence of drainage the best day urinal is a moveable metal or glazed earthenware vessel.

The best form of drained urinal for India is that one which exposes the smallest surface and has fewest angles. The material should be impervious and have a glazed surface, and water for cleansing it should be readily available. Mr. Jennings' white glazed earthenware urinals made by him for the War Department, Plan XVII., are apparently the best hitherto contrived for use in warm climates. They require very little water, they are self cleansing, they expose a small surface only, they can be discharged and cleansed any number of times a day by simply raising a valve, and with ordinary care they are not liable to damage; they have besides been used with entire success in barracks at home. Plan XIX. shows a form of slate urinal attached to Macfarlane's latrines. Over every urinal should be placed a water tap for purposes of cleanliness for the men.

Latrine buildings should be placed well to leeward of prevailing winds. They should be simple in construction and thoroughly ventilated at the eaves and along the ridge. There should be divisions between the seats, with partial doors to each seat, and there should be sufficient light to admit of doors being used.

It would be best to subdivide latrines so as to have one set and one building for not more than a company. In tropical climates latrines and urinals should be connected with the barracks by covered passages in the manner adopted at many Indian stations.

15. *Cook-houses.*

Construction.

The first requisite for cook-houses in warm climates is sufficient ventilation. This can only be secured by having cook-houses detached from other buildings; windows or doors on all sides, together with openings at the eaves and louvres along the roof.

Drainage and water supply.

Efficient drainage is also required. Surface drains should never be used for the discharge of cook-house water, and cesspits to receive the drainage are inadmissible. The floors should be well raised above the level of the ground outside, and well flagged or paved.

If an outlet cannot be obtained for cook-house drainage, perhaps the best way of disposing of it would be to carry a discharge pipe from the sink to a moveable vessel which could be carried away as often as necessary.

Every cook-house should have a constant water supply from a water tap placed over a sink; waste water should be drained away from the sink, either to an outlet or to a moveable vessel in the manner stated above.

Improved kitchens.

It is worthy of consideration whether the introduction of improved cooking apparatus might not lead to more wholesome cooking and to greater economy both in fuel and in food. It is found that steel boilers and steel ovens set in fire-clay lumps, Plan XX., are very economical in fuel, and it is suggested that they might be tried in warm climates. Every cook-house should be provided with suitable tables and racks. The arrangements shown on Plan XXI. will be found to be convenient.

16. *Means of Employment and Recreation.*

Considerable advances have recently been made in India in providing this class of accommodation.

We shall therefore merely suggest generally the points in the accommodation requiring attention as regards health.

Gymnasia.

The best gymnasium for tropical stations generally is a large covered shed, open on all sides, like a railway station, sufficiently high to contain the apparatus.

The floor should be raised two or three feet above the level of the ground. And roof water should be collected by gutters either into a tank or to be removed by the drains.

The same shed might very well answer for a variety of out-door games and exercises.

Ball courts, &c.

All ball courts and skittle alleys should be covered to enable them to be used in hot weather and in rains; and roof water should be carefully disposed of.

Workshops.

Workshops for lighter kinds of labour, tailoring, shoemaking, printing, harness and saddle making, watch making, certain kinds of wood working, might be placed in the ground floor of new barracks.

For other heavier trades shed buildings would be required.

Reading and day rooms.

All library, reading room, day and lecture room, and school room accommodation could very well be placed in ground floors of new barrack blocks. But where day rooms, lecture rooms, reading and game rooms, have to be provided separately, they should all be placed in a single block at a distance from the canteen, and this "institute" should have the means of supplying tea, coffee, and other non-intoxicating refreshments to the men. It is not improbable that accommodation of this nature would be required in India for two-thirds of the men. N.C. officers' rooms should be attached to day rooms and libraries for the sake of discipline. In barrack blocks of two floors, two such rooms would form part of the construction under the N.C. officers' rooms of the floor above.

The general sanitary principles as to ventilation, doors, windows, &c., already laid down, will be found applicable to this class of accommodation. It need scarcely be pointed out that reading and recreation rooms should be made comfortable and attractive, and of sufficient dimensions and height to prevent closeness and crowding. Broad verandahs should be provided on all sides, and each block should have latrine and urinal accommodation. Also a sufficient supply of pure cool drinking water laid on.

Soldiers' gardens.

If soldiers' gardens, properly laid out, were permanently attached to stations, all waste water and sewage of stations might be used for watering and manuring the ground. If this were carefully done these gardens might be placed, say, 600 or 700 yards to leeward of the nearest barrack room.

The irrigation might take place at times when the men are not employed in the gardens

17. *Quarters for Officers, Non-commissioned Officers, and married Soldiers.*

Government should provide quarters.

The most suitable arrangement of officers', non-commissioned officers', and married soldiers' quarters for tropical climates is probably that of separate bungalows at present in use in India. But it would be very advisable that all quarters should in future be constructed by Government and form part of the barrack or station establishment, an arrangement which would enable quarters to be built on some uniform plan, with due regard to health and to the execution of repairs.

All separate quarters should be erected on raised basements constructed on the principles already suggested, and with ventilation beneath. The height of the basement

should vary with the sanitary condition of the district. The higher sleeping rooms can be raised above the ground the more healthy will they be.

There should of course be a suitable allowance of rooms for officers of different ranks. We would propose for tropical climates to fix the minimum space at two rooms for a married soldier, and to add on additional rooms to suit the requirements of each rank.

Construction of quarters.

The general principles of construction for health should be similar to those already suggested for barracks, viz., windows or doors on all sides, glazed, made to open, and with sliding jhilmils; verandahs, a sufficiency of ridge and eaves ventilation; means of ablution and of bathing.

Drainage should be carefully attended to as far as it may be required for detached dwellings of this class. The roof water should be removed and collected for use, the subsoil should be drained, the surface paved and guttered. It might not be practicable in many cases to improve the present latrine arrangements in detached quarters by using water closets and drainage, but where married soldiers' quarters are grouped together, water latrines, one set for men and another for women, as shown on Plan XXII., may be introduced. Ablution water and all refuse water should be very carefully drained away from all detached quarters, and should not be allowed to sink into the ground in the immediate vicinity.

One general cookhouse provided with a sink, water laid on, with drainage and ventilation and means of cooking separately for each family, will probably be sufficient for each group of married soldiers' quarters.

18. *Wash-house and Laundry.*

Although all washing in India is performed by washermen, there are certain climates and seasons when it is very difficult to dry and get up linen, especially for hospital use. In the moist climate of England, the washing and drying arrangements shown on Plan XXIII. have been introduced with complete success. And it is possible that there may be stations at which similar apparatus might be advantageously introduced.

Section IV.—Principles of Hospital Construction.*

Proportion of sick and convalescents.

For tropical stations generally, ten per cent. hospital accommodation will be sufficient. But making allowance for epidemic seasons, hospital accommodation should be provided at Indian stations for from 10 to about 15 per cent. of the strength, according to the healthiness or otherwise of the station.

Considering the local peculiarities of the climate and the nature of the prevailing diseases, every Indian hospital, except perhaps at convalescent stations, should consist of two divisions;

a. For sick.

b. For convalescents.

The convalescent division should be sufficient to accommodate about 25 per cent. of the total hospital inmates.

Every Indian hospital, and every hospital at the more unhealthy tropical stations, should consist of detached wards in separate blocks, one ward to each block.

Each ward or block should hold no more than from 20 to 24 beds.

Space per bed.

The space per bed in the more healthy districts should be 1,500 cubic feet at the least, and the superficial area 100 square feet per bed.

In the less healthy districts, the space per bed should exceed 1,500 cubic feet up to 2,000 cubic feet, and the superficial area should be 120 to 130 square feet per bed according to the locality.

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* *Recommendations of the Royal Commission respecting Hospital Construction.*

"9. That all future * * hospitals be erected on raised basements with the air circulating under the floors." [Report, Vol. I. fol. lxviii.] The only way to prevent malaria from the ground entering the sick wards is "to construct hospitals always of two floors, placing the sick only on the upper floor."

"10. * * That hospitals be constructed in detached buildings containing no more than from 20 to 24 beds." * *

"11. That * * hospitals be in future constructed with single verandahs only, and for no more than two rows of beds between the opposite windows."

"14. That the ventilation of * * hospitals be sufficiently provided for independently of doors and windows."

"16. That all * * hospitals be provided with sufficient glazed window space to light them."

"22. That the cubic space in hospitals be fixed at 1,500 feet and upwards, and the superficial area at from 100 to 120 and 130 square feet according to the healthiness of the position; and that the wall space per bed be never less than eight feet." * *

"23. That every hospital be provided with a constant supply of pure filtered water and with drainage."

"24. That every hospital be provided with ablution accommodation, with fixed basins, and with baths, having hot and cold water laid on, conveniently accessible from the wards."

"25. That wherever practicable, water closets with drainage and water-supply be introduced for hospital wards, and privies converted into water latrines."

Sick to be always in upper floors.

Each hospital block should consist of two floors over an arched basement at least 4 feet high.

In India and at all tropical stations sick and convalescents should sleep on upper floors only.

The lower floors might be used for day rooms, dining rooms, book room, waiting room, surgery, pack store, clean linen* and bedding store, utensil store, without detriment to the sick. Accommodation might also be found, at healthy stations, on the ground floor for European regimental orderlies and serjeants. If the surgery is placed under a ward, it should be at one end of the block, on account of the large class of native patients, servants, and others who resort to it. The surgeon's room should be next the surgery.

In very unhealthy localities, the attendants should all be lodged on upper floors.

Ward doors and windows.

A ward for 24 beds should have 11 windows and doors, placed at equal distances along each of its sides. And the beds should be arranged, one bed to each pier between two windows, and one bed placed about 18 inches or 2 feet from each corner. A large door at each end of the ward would be sufficient at all healthy or comparatively healthy stations. But in very close positions it may be deemed advisable to place a door or two on each side of the ward. As these doors where introduced will open close to the beds it may be advantageous to place a thin partition a few feet high between the nearest beds and the door to shield the patients from blasts of air.

Hospital plan.

Plans XXIV., XXV., and XXVI. show a plan, section, and elevation of a hospital block for 24 sick, embodying the principles laid down by the Royal Commission. The ward is 111 feet long, 26 feet wide, and 15 feet high to the top of the wall, and 21½ feet to the ridge. These dimensions allow upwards of 120 square feet and 1,800 cubic feet per bed, counting the space to the top of the wall only.

As the upper floor of a hospital block will always be occupied by the sick through the day, it is of the greatest importance that the radiating and heat conducting power of the roof should be diminished to the greatest possible extent. This may be done either by making the roof of the verandah and ward double throughout, with a ventilated air space between as already recommended for barracks; or a transverse plastered ceiling, having a space between it and the roof well ventilated, may be carried across the ward at the top of the wall. The double roof has the advantage of giving additional height and additional cubic space to the ward. The construction of double roof we propose for hospital wards is the same as that shown on Plan XI. and already described.

Each ward block requires a hospital serjeant's room, a scullery, an ablution and bath room, waterclosets, a sink for ward slops, and an urinal.

We propose to arrange these offices in the manner shown on Plan XXIV.

A place for a slipper bath is also required, with the means of filling it with hot and cold water, and also for running the water off.

There should be for each ward a water tap supplying pure cold water for drinking.

All the ward offices must be arranged in such manner as to leave the air to play freely on each of the four sides of the block.

Among sick, after the convalescents have been removed, about 10 out of every 24 sick would be greatly benefited by being moved from the ward into a separate dining room, if under the care of a hospital serjeant.

Dining room.

Each sick block should therefore have dining and day room accommodation for this number on the ground floor, as sketched on Plan XXIV. and shown in section on Plan XXV.

Operation room.

To each general hospital for a large station there should be an operating theatre attached to one of the wards, to be used as a surgical ward. The operating theatre should be lighted from the north, and means should be provided for moderating the light, as the operating surgeon may require.

For operation cases, not less than 2,000 to 2,500 cubic feet per bed should be given, according to locality. We propose to attach the operation ward to a surgical block of such dimensions as to allow of these amounts of space being given, in the manner shown by the dotted lines on Plan XXIV.

In regimental hospitals the serjeant's room would afford all the accommodation required for operations, which are very few in number in such hospitals.

Construction of hospital.

Every hospital block should be surrounded by single open verandahs and terraces, ten or twelve feet wide, supported on pillars or arches. The upper verandah should be continuous with the roof. Its roof should be double and ventilated, as already mentioned and shown on Plan XI.; the amount of shade may be increased to suit local position by carrying louvres along between the columns.

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* In damp climates it will be necessary to provide a drying closet, possibly in the room under the ward scullery, for airing linen before issuing it to the sick.

The construction of windows should be the same as that recommended for barrack blocks, *i.e.* each window should consist of an upper part made to fall inwards, and capable of being closed by a rope and pulley, and the lower part should open in two halves like a casement. There should be a similar glass window to open inwards over each door.

Each window should have sliding jhilmils. And all windows should be glazed.

The windows and doors of the floor below the sick ward should be constructed on the same principles, but their arrangement will of course differ in different blocks, to suit the purposes to which the lower floors are devoted.

Ventilation.

The ventilating arrangements for sick wards should be generally the same and subject to the same local variations to suit circumstances, as already mentioned with regard to barracks.

The great principle to be kept in view is that the ventilating arrangements should be independent of doors and windows; continuous ridge ventilation where the ceiling is carried up in the line of the roof, with inlets for fresh air along the eaves, as shown on Plan XI., or shafts carried above the roof for removing foul air where a transverse plaster ceiling has been adopted, together with inlets for fresh air round the outer walls close to the ceiling, like those on Plan XII., figure 2, are suitable alike for hospitals and barracks.

Ablution and bath room.

Every sick and convalescent ward for 24 beds requires for lavatory purposes three sunk earthenware basins, with water laid on, as on Plan XV., and one bath also with water laid on, as on Plan XVI. Rufford and Finch's bath is best for hospitals.

Water closets.

Each sick and convalescent ward requires three syphon water-closets of the best construction, and one glazed earthenware sink for ward slops, all with water laid on.

The compartments, where these ward conveniences are situated, require thorough ventilation. They should be quite detached from the ward block, and reached under cover of the verandah, as shown on Plan XXIV.

Scullery.

Each ward scullery requires a glazed earthenware sink, with water over it for washing up, and means for warming drinks, &c., required for patients.

There should be a small glazed window from the scullery, looking into the ward.

Serjeant's room.

The hospital serjeant's room should be large enough to hold a bed and bed room furniture with coolness and airiness. It should also have a small inspection window into the ward. The hospital serjeant must be in charge of his wards by night as well as by day, as every efficient head nurse is.

Both hospital serjeant's room and scullery should be ventilated on the same principle as the ward.

Convalescent wards.

Each convalescent block should consist of the sleeping room above, with a dining and day and game room, and reading room below. This day accommodation should be overlooked by the hospital serjeant from a room at the end of the block corresponding to his sleeping room above.

Hospital drainage and watersupply.

All that has been said regarding drainage and water supply of barracks applies with even greater force to hospitals. Special care should be bestowed on the formation of the surface and on the surface and subsoil drainage of every hospital enclosure. Roof water should be carefully collected by eaves-gutters and rain-water pipes, and tanked or conveyed away from the ground. The space immediately round each hospital block should be sloped and paved or cemented to allow of the water running freely away from the building to the surface drains. Any surface drains should be smoothly laid with impervious bottoms to remove the rain water as rapidly as possible. There should be no cesspits, and the hospital drainage should be part of the general drainage system of the station.

Detached ablution rooms, baths, latrines, and urinals for hospitals in addition to those connected with wards, should be constructed on the principles already suggested for barracks, and exhibited in Plans XIV., XV., XVI., and XVII., XVIII., or XIX.

Kitchen.

Improved kitchens and cooking apparatus on general principles similar to those recommended for barracks, and shown on Plan XXI., are required for hospitals. These should also be in detached buildings.

Arrangement of buildings.

Buildings allotted to sick or convalescents should be arranged so as to receive all healthy winds on their sides. Crowding of buildings should be avoided. Care should be taken that nothing interferes with the free outer ventilation of the blocks, and all such buildings should be connected by verandahs for facility of administration in wet and hot weather. Where it is considered necessary to provide a ward for a small number of beds, in order to admit of the segregation of special cases, the ward may be placed in the position of the operating room in Plan XXIV., shown by dotted lines; or, if in a separate block, the general construction of such wards as regards doors, windows, ventilation, &c., should be the same as that described above. But for such cases, the cubic space per bed should never be less than 2,500 cubic feet.

Enclosure. Enclosures of all hospitals in tropical climates should be formed of railings on dwarf walls, never of high walls.

Section V.—Sanitary Police of Barracks, Hospitals, and Stations.

The following points relating to the prevention of disease and the current efficiency of sanitary works at stations have been raised in the Report and evidence of the Royal Commission, and require to be embodied in an improved sanitary code for India.

(1.) *Sanitary Duties of Regimental Medical Officers and of Military Sanitary Officers of Stations.*

The Royal Commission has made recommendation (No. 32) that the sanitary duties of regimental, garrison, and inspecting medical officers, described in the new Medical Regulations of Oct 7, 1859, be applied or adapted to all stations in India.*

Duties of medical officers. These regulations are to the following effect: — By Section XX. Nos. 5 to 21 the surgeon is charged with the duty of examining and reporting on the condition of barracks, hospitals, canteens, quarters, places of amusement and recreation, lavatories and baths, ventilation, lighting, lime washing, urinals, latrines, drainage, water supply.

By Regulations 22 to 25, the principal medical officer or sanitary officer, if such has been appointed, is required to do the same duties for garrisons, camps, and stations.

By Section II., Nos. 1 to 36, the Inspector-General or Deputy Inspector-General of Hospitals of the district is charged with inspectorial functions in all of these matters; and each class of officers is required to report to their commanding officers on all defects they may discover.

Duties of commanding officer. The commanding officer is bound by the regulation to take steps for remedying the defects so represented to him, unless he have sufficient reasons for not doing so, in which case he is bound to transmit his reasons to the superior military authority.

Some subjects of complaint the commanding officer could deal with himself, but for all matters beyond his own immediate jurisdiction, such as repairs of works, &c., he would have to apply to other departments.

Duties of executive authority. Any code of sanitary regulations, intended for Indian stations, should therefore lay down in a manner not admitting of mistake the relation which is to exist between the commanding officer and the executive authorities, whoever they may be, in order that the requirements for health made on the commanding officer by the medical or sanitary officer may be complied with; and that works of repair, cleansing, draining, &c., may be carried out.

It will be observed that by Section XX. Clause 23, the duty of reporting on the health of troops by the sanitary or medical officer includes not only reporting on causes of disease within a station but causes in "its vicinity," which will include all nuisance or cause of unhealthiness, beyond the boundaries of such station, likely to influence its health.

Causes of disease to be removed. Provision would therefore have to be made in the code for the immediate abatement, removal, or prevention of all causes of disease connected with stations, bazaars, native towns, on receipt of complaints or representations from commanding officers. The code should state clearly the necessary course of proceeding, the local authorities or other persons to whom representations are to be made, and the steps to be taken for abating the nuisance.

The chief causes likely to give rise to complaints to commanding officers on the part of regimental surgeons or medical sanitary officers at stations, as brought out in evidence before the Royal Commission, are as follow:—

1. Surface filth. Defects in cleansing.
2. Excavated and broken ground.
3. Marshy or wet ground. Unwholesome collections of water.
4. Dung heaps and stables.

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* *Recommendations of the Royal Commission regarding a new Sanitary Code and Sanitary Regulations for India.*

"32. That the sanitary duties of regimental, garrison, and inspecting medical officers, prescribed in the new medical regulations of October 7th, 1859, be applied or adapted to all stations in India, and that properly trained army medical officers of health be appointed to this service at the larger stations."

"37. That a code of Regulations embodying the duties and adapted to the specialities of the Indian sanitary service be drawn up and issued under authority."

[These sanitary duties, extracted from the Army Medical Regulations with alterations in italics to render them suitable for Indian service, are given in Appendix No. IV.]

5. Unwholesome latrines and urinals. Cess-pits.
6. Nuisance committed by natives.
7. Nuisance from animals and slaughtering places.
8. Impure or deficient water. Fouling of water supplies.
9. Want of drainage, or bad drainage of surface or subsoil. Foul gutters and drains.
10. Growth of jungle and underwood. Old walls or useless buildings interfering with the ventilation of the station.
11. Repairs of buildings necessary for health, including windows, doors, floors, ventilators, &c.; lighting, cleansing, limewashing of barracks and hospitals; lavatories, baths, &c.
12. Unwholesome means of disposing of dead.
13. Other removeable causes of unhealthiness.

It will be seen that among the matters which the medical officer will have to represent are certain causes of disease for the removal of which permanent works will be required. It is necessary, therefore, to provide for the execution of these works.

When all the stations are properly regulated and their sanitary defects removed, representations on such points would probably be unnecessary; but until this is done provision would have to be made for attending to any such representations as speedily as possible.

Army sanitary officers.

With regard to the appointment of military medical sanitary officers for the larger stations, as directed by the new medical regulations, it is apprehended that such appointments will be made in India. The medical officer so appointed should be specially conversant with sanitary duties. He should perform the inspectorial duties required of such officers by the new Army Medical Regulations; he should make representations to the officer commanding at the station, who, in his turn, should represent defects requiring remedy to the local executive authority, which authority should be directed to execute the necessary improvements with as little delay as possible.

(2.) *Duties of Sanitary Inspectors at Stations, Bazaars, and Native Towns.*

It is of the greatest importance that the sanitary administration should be special, and that the local authority should make it some one's special duty at each station to remove, abate, or prevent all nuisances, either by bringing cases before the magistrate, or by himself and his agents taking whatever steps may be necessary to keep the station and its vicinity in a good sanitary condition. It is found to be indispensable for this purpose in home practice for every Local Board of Health to appoint inspectors to see to the execution of various sanitary works and measures ordered by the local authority; one of these officers is called Inspector of Nuisances, whose duty it is (in larger districts) to report nuisances for removal by other officers, or to combine in his own person the inspectorial and executive functions. It is suggested that perhaps an officer of this latter class would best suit the case of Indian stations and smaller towns. Wherever there are municipal councils, commissioners, or other executive sanitary authorities, the Inspector of Nuisances should be an officer acting under that authority. He should be an efficient and well paid officer, and should have a sufficient staff for all cleansing purposes placed under him. In larger towns and cities it would be advantageous to divide the town into manageable districts, each with its sanitary staff.

Appointment of inspectors.

If such an officer is appointed, it would be necessary to lay down—

Duties of inspector.

a. The limit within which he is to perform his duty. This limit should be extensive enough to prevent any nuisances or causes of disease, beyond the limit, being injurious to the health of troops.

b. The inspector to see that the whole area within the prescribed limit is kept free of nuisance or removable causes of disease;

To prevent any deposit of filth on the surface; and to provide suitable means for collecting all house and other refuse matter;
To see to filling up of broken ground, and to levelling the surface;
To draining away of foul water from the surface of the ground;
To removal of all refuse matters from the station and its vicinity;
To prevention of dung heaps and other accumulations of foul matter;
To see that animals kept within his district are so kept as not to be a nuisance or injurious to health;
To see to cleansing, filling up, and abolishing of all cesspits;
To see that all gutters and surface drains are kept clean and in proper level, so that no water may accumulate in them;
To see that all latrines and urinals are duly cleansed;
That slaughter-houses are properly kept and offal disposed of immediately;

To prevent ground within his district being fouled by the native population;
To see that sources of water supply are kept from contamination;
To see that old walls and useless buildings are removed, and that the growth of underwood likely to be injurious to the health of the station is prevented;
To do all other matters and things required for the cleansing, keeping clean, and preventing a recurrence of nuisance within his district.

If these inspectorial and executive functions are properly carried out by the inspector of nuisances, the regimental or medical sanitary officers of stations will have fewer complaints or representations to make. If they did complain, it would be rather a proof that the Inspector of Nuisances had failed in his duty. And there would hence be an efficient check over him.

There is another duty placed on sanitary inspectors in England which it would be very desirable to extend to India, if practicable. And that is the inspection of meat sold in bazaars. Bazaar fed pork is unfit for human food; and the sale of it should be prevented, at all events in as far as concerns the soldier.

In the comparatively small area of the city of London many tons of meat are seized by the inspector every week, of which it may be said that it is much more wholesome than bazaar pork.

Markets to be constructed.

With reference to the question of bazaars generally, it would be very desirable to consider whether properly constructed markets for the sale of all articles of human food might not be erected by Government or by the local authority, and placed under suitable regulations as to drainage, water supply, cleanliness, inspection of food, &c.

Bye laws.

It would be almost impossible in any general regulations as to duties to provide for every case likely to happen over such an immense extent of country. And it would be necessary to provide for making bye-laws to meet special cases. Under Sanitary Acts in England these bye-laws are drawn up by the local authorities, and sanctioned by the Home Office.

(3.) *Regulation of Bazaars and Native Dwellings.*

A common cause of unhealthiness of stations is the want of some regulation respecting native dwellings and bazaars. Bazaars and native population are apt to increase almost imperceptibly in cantonments. The people encourage their relatives to live with them. These bring others; and eventually there is little real limit to their numbers. It sometimes happens that the native population encroaches on cantonments in every direction, so that, except to the initiated, there is apparently no cantonment boundary. With such a state of matters, sanitary regulation is hardly possible. At present there appear to be doubts as to the legality of interfering with these encroachments. And it is necessary in any sanitary code to provide for the difficulty.

Heads of regulation.

There appear to be many bazaars which ought to be removed entirely from their present position. Powers to effect this removal are required. The simplest way of meeting the difficulty in new stations, or in cases when bazaars or native dwellings can be removed, or where they have become ruinous, and require to be rebuilt, would be for some authority to provide,—

That bazaars and native dwellings shall in future be erected to the leeward of stations, at a safe distance from the nearest point of the station to the nearest point of the bazaar.
That a plan be prepared by the local authority, showing the position of the houses and the general arrangement of the bazaar.
That streets be so arranged and of such width as to ensure freedom of ventilation.
That streets be drained in such manner as to remove readily all rain-fall and other water.
That provision be made for a water supply; and for cleansing and preventing nuisances, in the manner already pointed out.
That public latrines be provided; and nuisance at the outskirts of the bazaar prevented.
That excavations in the ground be prohibited.
That provision be made for the sanitary inspection and cleansing of the bazaar by the Inspector of Nuisances.
That the local authority draw up bye-laws, subject to approval, for the regulation of the bazaar,
And that infringement be punished.

Beyond this there should be powers for removing nuisances, draining, water supply, laying out streets, cleansing, &c., of native houses near stations, similar to those required for bazaars.

(4.) *Sanitary Police of Native Lines.*

A defective sanitary condition of native lines is not only a cause of disease among native troops, but is likely to re-act on the health of European troops in the vicinity. The sanitary defects in these lines, as described in evidence, are— Causes of disease.

Crowding of surfaces;
Irregularity of arrangement;
Absence of suitable drainage and water supply;
Bad water;
Excavations and broken ground among the huts;
Foul drains or ditches;
A filthy state of the surface;
Want of latrines.

To obviate this state of matters, it is suggested that before native lines are constructed plans should be prepared, showing a healthy arrangement and suitable distance between the huts, also roads, pathways, drainage, latrines and water supply. With regard to existing lines, provision should be made in the code, in order that nuisances be prevented, the ground properly drained, levelled, and kept clean, and suitable arrangements made for supplying latrines and water.

(5.) *Officers of Health appointed for Civil Duties in Towns.*

A very important recommendation (No. 35)* in the Report of the Royal Commission is the appointment of officers of health for civil purposes, to act for towns and districts, in the same way as military sanitary officers are to act for stations. We have considered that it may be useful to give the following general suggestions as to the duties to be fulfilled by this class of officers.

The special object of the inspectorial duties of the civil officer of health appointed for cities and towns is, in the first place, to keep himself thoroughly acquainted with the movement of disease and mortality among the population over which he is placed; secondly, to ascertain as far as practicable what are the causes, local, personal, and climatic, which influence the prevailing amount of sickness and mortality, especially when epidemics prevail, or threaten to do so; thirdly, to report on the whole subject to the local authority charged with executive duties for protecting the public health, in order that the local authority may take steps necessary for removing local causes of disease, or for mitigating attacks of epidemics. Duties.

In fulfilling these duties the officer of health of any city, town, or district should keep himself acquainted with the nature and amount of disease, especially of epidemic or endemic disease prevailing among the civil population; also of the mortality, with the diseases from which it has arisen. To ascertain amount of disease.

He should be prepared at all times to make such reports or representations on the subject of prevailing diseases and mortality to the executive authorities under whom he is acting as he may consider necessary to bring before them. To report to authorities.

He should make a careful examination into the sanitary state of the city, town, or district for which he is acting, in regard to the following points:—

1. Water supply:—With reference to the amount and chemical constitution of the water, especially to the amount of organic matter, animal and vegetable, which it contains, together with his opinion as to the influence of the water supply on health:—State of the tanks and other water sources, with special reference to the condition of the water they contain, and to the cleanliness of the ground around them; the risk of filth being washed into the water; the use of water from the same sources for drinking, washing, or bathing; the manner of storing water for use among the population; the manner in which refuse water is disposed of; and into all other points regarding water supply in which the health of the population is involved. On water supply.

2. State of the drainage of the district, and of the bazaars, streets, compounds, villages, houses, &c.; whether the drains are built, or merely covered, or open, with the condition in which they are kept; whether they convey away or retain filth or water near the houses; the condition of any ravines or nullahs likely to affect the health of the popula- On drainage.

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* *Recommendation of the Royal Commission as to Appointment of Civil Officers of Health.*

"35. That trained medical officers of health be appointed to act in peace as in war in connexion with these [Presidency Sanitary] Commissions."

tion; the existence of broken ground, water-pits, cesspools, and their influence on health; the state of the subsoil drainage, whether it is sufficient to keep the subsoil dry and prevent malaria; the extent of damp, wet, or marshy ground, and the extent of wet cultivation; the extent of tank surface, or of muddy ground on the banks of rivers or creeks sufficiently near to affect the health of the people.

On surface cleansing.

3. The condition of the surface drainage, paving, and cleansing in public streets, bazaars, and other public places; whether the streets are paved; with the nature of the paving, as to its material, its surface equality or inequality, its power of turning off or absorbing moisture and impurities, and its adaptation for facilitating surface cleansing; similar particulars as regards the state of the surface of private streets, passages, and courts, including compounds; the condition of open spaces of ground, ruinous buildings, river and sea margins in the vicinity of the town, as regards their cleanliness, the growth of underwood, prickly pear, or other rank vegetation, dung heaps, nuisances, obstructions to ventilation.

On sanitary works and measures.

4. The provision of latrines, urinals, &c., for the population, arrangements as to their cleansing, the condition in which they are kept, and their probable effect on public health.

5. The general state and efficiency of the sanitary or conservancy police.

6. The influence of the general structure and arrangement in streets, courts, &c., on the external ventilation of the town, especially as regards the effect of ruinous or useless walls and buildings which it might be desirable to remove, or of closed courts or alleys requiring to be opened up.

7. The effect of the construction of houses on ventilation and on the health of their inmates.

8. The existence of overcrowding in houses or on town areas, setting forth the proportion of inhabitants in different districts to a square mile.

9. The condition of stables and other places where animals are kept, of slaughter-houses, skinning ghauts, &c., offensive or unwholesome trades, such as tanners, curriers, cowhide stores, soap manufacturers, &c., and nuisances proceeding from any such causes.

On food and drink.

10. Much disease is engendered in India by unwholesome food; the officer of health should therefore, as far as practicable, ascertain and report on the condition of articles of food exposed for sale.

11. Unwholesome or poisonous drinks are frequently sold in Indian bazaars. This subject should also be from time to time carefully reported on by the officer of health.

On disposal of dead.

12. The officer of health should further examine into the state of burial-grounds, burning ghauts, and generally into the manner of disposing of the dead, and into the effect of this on public health. He should also recommend to the local authority such precautionary measures on the subject as he may deem necessary at all ordinary times, but especially when epidemics prevail.

Times of reporting.

13. He should report at least once a week at ordinary times, and oftener during epidemics. And he should prepare an annual report, entering minutely into the whole subject for the preceding year.

(6.) *Precautions against Epidemic Diseases.*

Sanitary Inspectors.

It should be a special duty of the officer of health to keep a constant watch over the health of the population, particularly with regard to the occurrence of epidemic disease. He should take means to ascertain this point; also the nature and extent of the disease, the localities where it has appeared, especially as regards the first cases; the sanitary condition of affected houses and districts in regard to the points already mentioned, viz., water-supply, drainage, state of the surface and subsoil, cleansing, nuisances, ventilation, proximity of rank vegetation, ruinous buildings, old walls, overcrowding of houses; also as regards any other circumstances connected with food, habits, &c., of the population, which may have tended to predispose them to the disease.

In his reports to the executive authority the officer of health should enter with sufficient fulness into these particulars, and should indicate any causes of disease which in his opinion require to be removed by the executive authority.

Measures during epidemics.

Some general regulations appear to be required as to the sanitary measures to be adopted when epidemic diseases are imminent either among troops or among the civil population of the station. These measures will of course receive the best attention from the Presidency medical authorities. But, in order to ensure unity of action, it might be advisable to lay down some general enactments; and to give the authorities power to issue special regulations and to see to their execution.

The following points are suggested by the evidence and reports obtained by the Royal Commission.

a. Promptitude of action on the first suspicion of epidemic disease among the native population.

b. Taking every necessary measure for protecting the public health in districts threatened by the disease.

c. Spreading the population and removing part of them into the open air.

d. Thinning the troops out of barracks, and the sick out of hospitals.

e. Cleansing and removing nuisances.

f. Lime-washing.

g. Examination of the water supply.

h. Providing dispensaries, medicines, medical relief, including inspection of the troops for the discovery of diarrhœa, when cholera or dysentery prevail. And, as far as possible, similar measures for the native population.

i. Devising measures for safely disposing of the dead.

During the prevalence of epidemics, the civil officer of health might be intrusted with certain executive duties of a medical kind, such as keeping an oversight of the measures of medical relief provided for the population, especially as regards the treatment of the premonitory symptoms of cholera and other epidemics, the removal of people from infected houses and districts; and seeing to the satisfactory carrying out of temporary measures of cleansing, lime-washing, &c., in the houses.

Section VI.—Registration of Deaths, &c.

The concluding recommendation (No. 39) * of the Report of the Royal Commission is, that a system of registering deaths and causes of death should be established in the large cities of India, with a view to publication as in England. We have communicated with the Registrar-General of England on the subject, who has been kind enough to forward to us copies of the forms in use in his office, the heads of which we append. He has further suggested that for Calcutta at least a method of dealing with the mortality statistics similar to that adopted in London should be introduced, viz., that a weekly mortality table should be prepared and published, showing the deaths and diseases of the preceding week. We beg to recommend that the Registrar-General's suggestion be carried into effect, as one specially adapted, not only to Calcutta, but to Madras, Bombay, and, indeed, to all the larger groups of population throughout India.

The occurrence of epidemic diseases among the native population always indicates more or less of danger to troops in the vicinity; and it is highly desirable that the earliest possible information as to the movement of epidemic diseases among the natives should be available for the purpose of prevention, both among them and among the troops.

Weekly return of deaths.

A weekly publication of the mortality statistics in London, and even a daily summary during epidemic seasons, has been found of the greatest public service; and it is presumed this will be still more the case in India.

How obtained in London.

1. The method of obtaining the facts in London is as follows:—

London is divided into districts and sub-districts; to each of the former is appointed a superintending registrar, to each of the latter a registrar, who is supplied with a register book, divided into columns, as follows: —

1836.—Deaths in the *District* of *Marylebone, North*, in the County of *Middlesex*.

No.	When and where died.	Name and Surname.	Sex.	Age.	Rank or Profession.	Cause of Death.	Signature, Description, and Residence of Informant.	When registered.	Signature of Registrar.
17	*5 February.*	*William Green.*	*Male.*	*43*	*Carpenter.*		*Rebecca Green, Widow, 17, North Street, Marylebone.*	*5 February.*	*John Cox, Registrar.*

[The Words and Figures in *Italics* in this Schedule to be filled in according as the Case may be.]

* *Recommendation of the Royal Commission respecting the Registration of Deaths.*

"39. That a system of registering deaths and the causes of death be established in the large cities of India, and be gradually extended so as to determine the effects of local causes on the mortality of the native as well as of the European population, the results to be tabulated and published annually by the (Presidency Sanitary) Commissions."

In this book each death is registered from information supplied by some person present at the death, who is required to produce a medical certificate on the following form :—

Name _____
Age _____
Last seen _____
Died on _____
At _____
Causes of Death _____
(*a*) _____
(*b*) _____
Signed _____
Date _____

Certificate of Cause of Death.

To the Registrar of the Sub-District in which the Death took place

I hereby certify that I attended _____ *aged* _____ *last Birthday; that I last saw h__ on* _____ 186__ *that he died on* _____ *at* _____

and that the cause of h__ death was

	Cause of Death.	*Time from attack till Death.*
(*a*) First		*
(*b*) Second		*

Signed _____
Prof^{l} Title _____
Address _____
Date _____

* Each form of Disease, or Symptom, is reckoned from its commencement *till Death.*

When the death is registered by the officer, he gives a burial certificate, which is produced and placed in the hands of the clergyman by the undertaker at the cemetery, thus authorizing the funeral. Without this certificate the burial cannot take place, except in rare cases of urgency, when the clergyman himself is bound under a penalty to give the registrar notice. The registrar's books are examined by the Superintending Registrar, who keeps the books, when filled up, in safe custody for future use. He is bound to give certificates of deaths to any one who asks for them, and who pays the stipulated fees.

The registrars in London supply copies of the entries of all deaths occurring in the week ending on Saturday, in the form No. 1, which reaches the central office by post on Monday morning, and in the course of that day the forms are analysed on the abstract sheet form No. 2, according to the nomenclature and classification given on form No. 3. The total deaths in form No. 2 are then classified on a precisely similar form, except that the sums of each order and class of diseases are given instead of the deaths from individual diseases, and both are published. A very important summary is made on form No. 4 which is intended to show the number of deaths during the week in each registrar's sub-district in London from zymotic diseases. This summary if adopted for Indian cities would enable the state of health of the native population to be readily ascertained. A further summary of deaths in public institutions is made on form No. 5, which is intended to show the total weekly mortality in each class of establishments, and also in each separate workhouse, prison, hospital, &c. The abstracts of the registrars' returns are sent to the printer on Monday evening, with a meteorological table supplied by the Astronomer Royal, and a short commentary. This constitutes the weekly return for London of the Registrar-General. It is sent to the newspapers on Tuesday, and published for public information on Wednesday morning. After the facts are abstracted from the registrars' returns, these returns are sent to the officers of health of the different London parishes on Wednesday, and as they contain not only the causes of death but the residences of each fatal case, the officers of health are enabled to ascertain the movement of disease and mortality in every part of their districts.

Quarterly returns.

2. Besides the weekly return of London, the births and deaths for every registration district in the kingdom are published once a quarter in the "Quarterly Tables," and also annually.

The registration of deaths is conducted on the same principles all over England. But the facts are supplied to the Registrar-General in a somewhat different manner, as follows :—

How obtained.

Every registrar in England and Wales is required to fill up the form No. 6 at the end of each quarter, and to transmit it to the Registrar-General. In this form he enters the total births and deaths for the quarter, with notes on the movement of births and deaths and of the causes of mortality, in compliance with the requirements printed on the form. At the Registrar-General's office the sums total of births and deaths contained in these quarterly returns are entered on form No. 7. Copies of the same form answer for both purposes, *i. e.*, one copy of the form is used for abstracting the births, another for abstracting the deaths. The facts so tabulated for the registration divisions, counties,

and districts in England are published in the Registrar-General's quarterly report. This report contains also the meteorology of the quarter, the state of the crops, the prices of provisions, together with any points of interest regarding the movement of the rate of births, deaths, marriages, diseases, &c., contained in the notes appended to the registrar's return.

Certified copies of the marriage registers are collected by the registrars and transmitted to the central office in London once a quarter, but on account of unavoidable delay in their collection the quarterly publication of marriages does not take place for three months later than the publication of births and deaths.

3. Duplicate copies of all registers in England certified by the superintending registrars are sent every quarter to the central office, at which indexes are made. Annual reports.

The Registrar-General's annual report is made up at the central office by abstracting the facts, not from the registrars' quarterly returns, but from the original certified copies of their books, which have been sent as already mentioned by the registrars to the Registrar-General. The quarterly and annual totals for the annual report are abstracted from these books on form No. 7. The same form No. 7 is also used for abstracting the births, and in doing so, legitimate, illegitimate, and multiple births are distinguished. From the same sources, but by a separate examination, the causes of death, with the sexes and ages for the whole year, are abstracted on form No. 8. How made up.

The marriages for the year are abstracted from the certified copies of the registrars' books in the Registrar-General's office on form No. 9 for the annual report.

The annual report, besides the statistical tables, contains much useful information on various subjects connected with the public health, occasional papers and occasional tables illustrative of special points in vital statistics.

The weekly report is published within three days of the time when the data are received; the quarterly report within 30 days, and the annual report within 15 months from the end of the year.

In every country in Europe, not excepting the remotest provinces of Russia, the births, deaths, and marriages are now registered. And there appears to be no reason why this should not ultimately be done in India, with such machinery as is suitable to that country.

The circumstances of the population in Indian cities differ so materially from those of the people of England, that it may not be practicable to introduce so complete a system of collecting facts. It is necessary, of course, that the methods employed should be fixed by the India Government. The results in the first instance may be by no means satisfactory, but we should consider it of great importance, nevertheless, that they should be obtained to the utmost practicable extent, and in the best practicable way, in the expectation that in time this important branch of the public service will become sufficient for all necessary purposes.

RICHARD AIREY, Quarter-Master General and President.

DOUGLAS GALTON, Assistant Under Secretary of State for War.

JOHN SUTHERLAND.

T. G. LOGAN, Inspector-General of Hospitals.

EDWARD BELFIELD, Deputy Director of Works, War Office.

PROBY T. CAUTLEY, Member of the Council of India.

J. RANALD MARTIN.

ROBERT RAWLINSON, Local Government Act Office.

J. J. FREDERICK, *Secretary*,
Barrack and Hospital Improvement Commission,
War Office, 15th July 1864.

REGISTRATION FORMS.

Form No. 1.

DISTRICT _____

SUB-DISTRICT _____

N.B.—This Return is to be posted sufficiently early to secure its delivery by Ten o'clock on Monday morning.

During the Week ending Saturday the _____ day of _____ 18 , there were registered the following numbers of Births and Deaths :—

Notes.—If no Births or Deaths were registered in the week, write "None" in the blank space.

Births.	
Males - - -	
Females - -	
Total - -	

When a Birth or Death has been included in the Return of any week, it should NOT, though re-registered, appear again in the Return of any subsequent week, except in the case of Coroners' Inquests, *when a reference to the previous entry should invariably be made in the margin.* Proper precaution should be taken against counting the same person twice; and when the form below is filled up, the *males* and the *females* should be counted *separately*, and care taken that the respective numbers and total correspond with the numbers of Deaths stated at the top of the Return.

Deaths.	
Males - - -	
Females - -	
Total - -	

In filling up the Particulars of the Deaths in the Form below, the registrar is requested,—

1.—To use more than one sheet if the number of Deaths exceeds 25, and to fold all in one enclosure.

2.—When a Death has been returned by the Coroner, to write "Inquest" after the verdict; and in all other cases to add after the cause of death "Certified," or "No Medical Attendant," or "Not Certified," according as such may stand in the Register Book.

3.—To add "*post mort.*" when an examination has been made after death.

4.—To copy from the Medical Certificates the *durations* of illness and of the several modifications of disease, with due regard to the distinctness of each clause. For it sometimes happens that the Certificate is copied so improperly as to leave it doubtful whether the terms denoting duration should be referred to the whole illness or to a certain stage of it.

5.—If possible, to state age accurately in hours, days, years, or other definite measure of time. Such vague statements as "under 1 year" should be avoided.

6.—When persons suffering under illness are taken into hospitals, lunatic asylums, workhouses, or other public institutions, and die there, to state in Col. 2 not only the place where they had died, but also that whence they had been brought. *This latter fact is most important, and should never be omitted, when it can be ascertained.* Deaths in Public Institutions, as well as all others, should be registered with *as little delay as possible.*

7.—To make with brevity any observations regarding ill-cleansing, closeness, or overcrowding of habitations or streets, destitution, industrial depression, irregular habits, or to state any useful facts of which the Registrar has credible information.

PARTICULARS OF THE DEATHS REGISTERED IN THE WEEK.

No. of Entry in Register.	When Died and Where. (Street and No. of House.) (State also Homes of those who die in Institutions. See instruction above No. 6.)	Sex M. or F.	Age.	Occupation or Profession. (Distinguish Masters of Trades; Children and Women will in most cases be described as Sons, Daughters, Wives, Widows of Bakers, Tailors, etc.)	Cause of Death. (See above Instructions, Nos. 2, 3, 4.)	Observations. (See Instruction above No. 7.)

Form No. 2.

DEATHS IN LONDON FROM ALL CAUSES AT TWELVE PERIODS OF LIFE.

Registered in the _____ Week ending Saturday, _____ 186__.

Class.	Causes of Death.	Under 20 Years, 0	1	2	3	4	5	10	15		20 and under 40	40 and under 60	60 and under 80	80 and upwards	Total at all Ages.
I.	Order 1.														
	1. Small-pox -									Small-pox -					
	2. Measles - -									Measles -					
	3. Scarlatina -									Scarlatina -					
	4. Quinsy - -									Quinsy -					
	&c., &c. - -									&c., &c.					

FORM No. 3.

NOMENCLATURE AND CLASSIFICATION OF CAUSES OF DEATH USED IN FILLING UP FORM 2.

CLASS I.

ORDER I.

1 Small-pox.
2 Measles.
3 Scarlatina.
4 Quinsy.
5 Croup.
6 Whooping Cough.
7 Typhus (and Infantile Fever).
8 Erysipelas.
9 Metria.
10 Carbuncle.
11 Influenza.
12 Dysentery.
13 Diarrhœa.
14 Cholera.
15 Ague.
16 Remittent Fever.
17 Rheumatism
Other zymotic diseases.

ORDER II.

1 Syphilis.
2 Hydrophobia.

ORDER III.

1 Privation.
2 Want of Breast Milk.
3 Purpura and Scurvy.
4 Alcoholism (Del. Tremens, &c.)

ORDER IV.

1 Thrush.
2 Worms, &c.

II.

ORDER I.

1 Gout.
2 Dropsy.
3 Cancer.
4 Noma.
5 Mortification.

Order II.

1 Scrofula.
2 Tabes Mesenterica.
3 Phthisis.
4 Hydrocephalus.

III.

ORDER I.

1 Cephalitis.
2 Apoplexy.
3 Paralysis.

Class III.

4 Insanity.
5 Chorea.
6 Epilepsy.
7 Convulsions.
8 *Brain Disease, &c.*

ORDER II.

1 Pericarditis.
2 Aneurism.
3 *Heart Disease, &c.*

ORDER III.

1 Laryngitis.
2 Bronchitis.
3 Pleurisy.
4 Pneumonia.
5 Asthma.
6 *Lung Diseases, &c.*

ORDER IV.

1 Gastritis.
2 Enteritis.
3 Peritonitis.
4 Ascites.
5 Ulceration of Intestines.
6 Hernia.
7 Ileus.
8 Intussusception.
9 Stricture of Intestines.
10 Fistula.
11 *Stomach Disease, &c.*
12 *Pancreas Disease, &c.*
13 Hepatitis.
14 Jaundice.
15 *Liver Disease, &c.*
16 *Spleen Disease, &c.*

ORDER V.

1 Nephritis.
2 Ischuria.
3 Nephria.
4 Diabetes.
5 Stone.
6 Cystitis.
7 Stricture of Urethra.
8 *Kidney Disease, &c.*

ORDER VI.

1 Ovarian Dropsy.
2 *Uterus Disease, &c.*

ORDER VII.

1 Arthritis.
2 *Joint Disease, &c.*

Class III.

ORDER VIII.

1 Phlegmon.
2 Ulcer.
3 *Skin Disease, &c.*

IV.

ORDER I.

1 Premature Birth.
2 Cyanosis.
3 Spina Bifida.
4 Other malformations.
5 Teething.

ORDER II.

1 Paramenia.
2 Childbirth (*see* Metria.)

ORDER III.

1 Old Age.

ORDER IV.

1 Atrophy and Debility.

V.

ORDER I. (ACCIDENT.)

1 Fractures and Contusions.
2 Wounds.
3 Burns and Scalds.
4 Poison.
5 Drowning.
6 Suffocation.
7 Otherwise.

ORDER III.* (HOMICIDE.)

1 Murder and Manslaughter.

ORDER IV. (SUICIDE.)

1 Wounds { Gunshot. / Cut, Stab.
2 Poison.
3 Drowning.
4 Hanging.
5 Otherwise.

ORDER V. (EXECUTION.)

1 Hanging.

Other Violent Deaths (not classed.)

Sudden Deaths (cause unascertained.

Cause not specified or ill-defined.

* Order II. not applicable to Civil Population.

FORM No. 4.

DEATHS FROM ZYMOTIC DISEASES.

LONDON.—DEATHS from SMALL-POX, MEASLES, SCARLATINA, DIPHTHERIA, WHOOPING-COUGH, TYPHUS, DIARRHŒA, and CHOLERA, Registered in each REGISTRAR'S SUB-DISTRICT during the Week ending Saturday _____ 186 _____

Annual Series.

	Registrar's Sub-Districts.	ZYMOTIC DISEASES. Small-pox.	Measles.	Scarlatina.	Diphtheria.	Whooping Cough.	Typhus.	Diarrhœa.	Cholera.	[*Here any other prevailing Epidemics are inserted, (such as Dysentery, &c.)*]	Total.
Nos.											

FORM. No 5.

SUMMARY OF DEATHS IN PUBLIC INSTITUTIONS.

LONDON: DEATHS IN 116 PUBLIC INSTITUTIONS, Registered in the _____ Weeks ending Saturday _____ 186

186 . Quarter. No. of Week -	MALES.													DEATHS.			FEMALES.												
														Total.	Males.	Females.													
TOTAL DEATHS IN 116 PUBLIC INSTITUTIONS.																													
45 WORKHOUSES (*belonging to Unions or Parishes*) - - - -																													
12 PRISONS - - - -																													
4 MILITARY AND NAVAL ASYLUMS -																													
15 GENERAL HOSPITALS - -																													
7 HOSPITALS FOR SPECIAL DISEASES -																													
4 LYING-IN-HOSPITALS { *Women* - / *Children* -																													
7 MILITARY AND NAVAL HOSPITALS - - { *Men* -																													
3 HOSPITALS AND ASYLUMS FOR FOREIGNERS - - - -																													
19 LUNATIC ASYLUMS - - -																													

FORM No. 6.

Superintendent Registrar's District of _____

Registrar's Sub-District of _____

A Return of the Total Numbers of Births and Deaths registered in the Sub-District during the Quarter ending the _____ day of _____ 186 .

	Numbers Registered during the Quarter ending as above.	
	Births.	Deaths.
Males -		
Females -		
Total -		

INSTRUCTIONS TO REGISTRAR FOR FILLING UP THIS RETURN.

Write on the blank line at top the District of your Superintendent Registrar; and on the *line under it your own* Sub-District.

In counting your Births and Deaths, a case of double-entry must be reckoned not as two but as *one;* and when a Birth or a Death has been enumerated in any Quarterly Return, it must *not*, though re-registered, be included in subsequent returns.

To ensure accuracy you are recommended to count the *males* and the *females* separately; and to compare the sum of the two numbers with the total also separately counted.

The above is a true return.

(Signed) _____ *Registrar.*

N.B.—If the Deaths registered during the Quarter have been above or below the average, state whether, in your opinion, the fact is wholly or partially accounted for by *sanitary arrangements*, by *increase* or *decrease* of *population*, the *weather*, *Small-pox*, *Measles*, *Scarlatina*, *Whooping-cough*, *Fever* (including Typhus, Typhoid, Relapsing, Infantile Fever), *Cholera*, *Diarrhœa* (including Bowel Complaint), *Dysentery*, *Bronchitis*, or other disease. Also with regard to increase or decrease of Births, you may mention any circumstance to which it may be attributed. By "average" must be understood *not* the average numbers in *other quarters* of the year, but the average of *corresponding quarters in four or five previous years.*

The Registrar General trusts that you will NOT FAIL TO NOTICE, in conformity with this instruction, any epidemical diseases which have caused a large number of deaths; and where it would not be attended with too much trouble, he requests you will state also THE NUMBER OF DEATHS from any of the diseases above specified.

FORM No. 7.

	ENGLAND: DIVISIONS AND COUNTIES. (Or Districts, similar form, or Sub-Districts, similar form.)	Population. 1851.	Population. 1861.	Males. Registered in the Quarter ending the last day of: March.	June.	September.	December.	Total.	Females. Total.	Registered in the Quarter ending the last day of: March.	June.	September.	December.	Males and Females. Registered in the Quarter ending the last day of: March.	June.	September.	December.	Total.
	ENGLAND - -	17,927,609																
	DIVISIONS.																	
1	London - - -	2,362,236																
2	South-Eastern - -	1,628,416																
3	South-Midland - -	1,234,332																

FORM No. 8.

DISEASES AND AGES.

DEATHS, 186 Sex

Vol. , No. Ending District of

Ages - - - {	Months. 0	3	6	1.	2.	3.	4.	5.	10.	15.	Ages.	20.	25.	35.	45.	55.	65.	75.	85.	95 and upwards.	Total.
CLASS I.—ORDER I.																					
1. Small-pox - - - -											Small-pox -										
2. Measles - - - -											Measles -										
3. Scarlatina - - - -											Scarlatina -										
4. Diphtheria - - - -											Diphtheria -										

FORM No. 9.

186 . Marriages, Division, County.

Quarters.	No. of District.	DISTRICTS.	According to the Rites of the Established Church. Special Licence.	Licence.	Banns.	Superintendent Registrar's Certificate.	Not stated.	Total.	Not according to the Rites of the Established Church. Total.	In Registered Places. Roman Catholics.	Other Christian Denominations.	Superintendent Registrar's Office.	Quakers.	Jews.	Total.	Marriages contracted between Bachelors and Spinsters.	Bachelors and Widows.	Widowers and Spinsters.	Widowers and Widows.	Re-married. Widowers.	Widows.	Under Age. Men.	Women.	Signed the Marriage Register with Marks. Men.	Women.	Both signed.	One signed.	Registered in the Quarter ending the last day of March.	June.	September.	December.
		March																													
		June																													
		September																													
		December																													

APPENDIX.

No. I.

Sewage Works for removing Solids only.

The following construction of tanks for this purpose has been found to answer in England.

The depositing tanks are simple and inexpensive. They consist of trenches, excavated in the subsoil, each two hundred feet in length, eighteen inches wide at the bottom, four feet six inches deep, and with slopes of one to one. The trenches are level, the bottom being about 12 inches below the outfall sewer; and are arranged in pairs, the distance between each pair being twelve feet. Manholes are built at each end of the trenches, having sluices for the purpose of diverting the sewage as required, and to allow of any number of trenches being used. Moveable strainers of wickerwork are placed in the trenches for intercepting flocculent and solid matter. Filtering by mechanical means is not aimed at, but straining and subsidence. The sectional area of the trenches is greater than the sectional area of the sewer in the proportion of ten to one allowing the velocity of the sewage to diminish in this proportion. The hurdle strainers can be removed from trench to trench, and by one of the most cheap and simple arrangements, any one trench or any combination of trenches, can be used at the same time, or the sewage can be passed direct to the outlet without entering any trench.

The trenches are cleansed periodically, and the solid matter removed. The cost of removal is about sevenpence per cubic yard. The sludge is landed on the sides of the trenches where it can drain and dry ready for removal. Disinfectants can be applied, when required, both to the fluid and the sludge after it is emptied from the trenches.

A tool-shed, tank, well, and pump should be provided for preparing lime-water, to be applied to the sewage when required.

No. II.

Improved Principles of Construction for Water Storage Reservoirs for English Use.

A natural valley may be made into an impounding reservoir by forming an embankment.

The puddle trench for an embankment should be carried down to sound ground.

There should be an outlet culvert laid in the solid ground on one side of the embankment; never in the made ground of the embankment.

There must be a bye-wash or overflow sufficient to remove safely flood-waters or storms of rain; provision being made for the heaviest storm to be anticipated.

Reservoir and embankment making will require special professional information. The work will depend on the form and extent of the valley, the nature of the subsoil, the dimensions of the proposed embankment, especially its vertical height, and the character of the material out of which the embankment is to be formed.

According to English experience, embankments of earthwork should have an inner slope of three to one, and an outer slope of two to one, with a thickness of top bank in proportion to the vertical height of the embankment. An embankment 40 feet high at its deepest part should have a top bank, width of not less than 10 feet, and should be finished not less than six feet vertical above the proposed top water level in the reservoir. Such embankment will be 210 feet at its widest portion of the base. The puddle trench in such an embankment should be 10 feet in width at the ground surface line in the deepest part, and diminish one inch per foot vertical on each side, so as to finish three feet wide at the top water line. Fine assorted material free from stones should be placed on both sides of the puddle at least six feet wide.

Puddle is made out of clay; the clay is chopped small, all stones are removed from it; water is then thrown over it, and the whole is worked and incorporated into a pulpy mass, capable of forming a wall of clay perfectly water-tight in the embankment.

The inner slope of an embankment should be covered with a layer of stones not less than nine inches in thickness, broken so that the largest stone would pass through a ring four inches in diameter.

The outer surface of an embankment may be soiled.

Plan XXVII. shows the details of such a work, with an improved method of outlet.

Trees must not be allowed to grow upon an embankment or near to it.

No. III.

Data for the Construction of Tanks and Pipes in Use in England.

1. Water may be considered, roughly, to have pressure equal to ½ lb. on each square inch of surface for each foot in vertical depth; a tank 10 feet in depth of water must therefore support over the whole area of the bottom a pressure equal to 5 lbs. on the square inch. The sides and ends of such tank will have to support a pressure equal to half the vertical depth, or 2½ lbs. on each square inch over the entire area. A tank, 20 feet square and 10 feet deep, must support weight as under on the bottom and side plates:—$20 \times 20 = 400 \times 144 = 57{,}600 \times 5 = 288{,}000$ lbs. or 128½ tons nearly. The sides must bear an equal weight; area of sides, $20 \times 4 = 80 \times 10 = 800 \times 144 = 115{,}200 \times 2\frac{1}{2}$ lbs. or 128½ tons nearly. Or the pressure on the entire tank, bottom and sides, when full of water to a depth of 10 feet, will be equal to 257 tons nearly. The entire weight of the whole volume of water will only be about 111½ tons.

2. To calculate the weight of materials (iron work,) the following rules may be used, which will be near enough for a rough estimate.

Iron, square foot, and inch thick, say, weight 40 lbs,

Then for iron—

12 × 12 inches = 1 ft. square and $\frac{1}{16}$ in. thick = 2½ lbs.
" " " $\frac{1}{8}$ " = 5 "
" " " inch " = 40 "

Lead may be calculated as weighing 60 lbs. for each square foot and inch thick.

Then for lead—

12 × 12 inches = 1 ft. square and $\frac{1}{16}$ in. thick = 3¾ lbs.
" " " $\frac{1}{8}$ " = 7½ "
" " " inch " = 60 "

Good wrought iron for tie-rods may be estimated to carry safely six tons for each square inch of cross sectional area. This is about one quarter of the breaking strain.

3. A few short practical rules may be of use to enable the capacity of pipes and wells to be ascertained, as also roughly the pressure caused by vertical depth, or head.

Pipes have capacity in proportion to the squares of their diameters:—

A pipe 2 inches diameter - - $2 \times 2 = 4$
" 3 " " - - $3 \times 3 = 9$
" 4 " " - - $4 \times 4 = 16$

and so on. It will be seen that a pipe of four inches diameter is equal to four pipes of two inches diameter.

The sectional area of a pipe whose diameter is one is ·7854. Square the diameter in inches, and multiply the product by ·7854, and the true sectional area in inches will be obtained.

To find the volume of water any pipe or well will contain in each three feet in length, square the diameter in inches, and point off the right hand figure as a decimal; the product will be gallons and decimals of a gallon in each three feet of length, as under:—

2× 2 = 4 this will be - 0·4 gallons in 3 feet.
4× 4 = 16 " - 1·6 " "
12×12 = 144 " - 14·4 " "
20×20 = 400 " - 40·0 " "

that is, 40 gallons in each yard of length of a pipe 20 inches in diameter.

A well is six feet or 72 inches diameter, $72 \times 72 = 5184$ inches, or 518·4 gallons in each three feet of depth.

This rule is not absolutely accurate, but is within some two per cent. of the truth, and is handy for rough and ready purposes.

A gallon of water weighs 10 lbs., and, as previously stated for rough purposes it may be said that half the head in feet will be the pressure in lbs. per inch of surface.

A pipe 20 inches diameter and rising 180 feet, or 60 yards, vertical, will contain $20 \times 20 = 400$, or 40 gallons in each yard or 400 lbs. weight in each yard. Then 400 lbs. $\times$ 60 yards, the whole head,=24,000 lbs.

A pipe 20 inches diameter and 60 yards in length, will contain 2,400 gallons of water, which water will be 24,000 lbs. in weight, and if placed vertical the lowest end of such pipe must resist a pressure half 180 feet vertical, or 90 lbs. on the square inch of surface over the whole area of the pipe acted upon at this head.

Water obtains velocity through pipes in proportion to the square root of the head less friction.

A pipe having 16 feet of fall will deliver water equal to 4, as under:—

16 feet of fall	=	4	gallons,	say,	per	second.
25 "	"	= 5	"	"	"	
36 "	"	= 6	"	"	"	
49 "	"	= 7	"	"	"	
64 "	"	= 8	"	"	"	

So that it will be seen that a fall of 64 feet will be required to give double the fall of 16 feet.

No. IV.

Sanitary Duties of Medical Officers of British Regiments. (Extracted from the *New Medical Regulations*, October 7th, 1859.)

Some Clauses have been omitted as inapplicable to India, and the words in Italics have been inserted to show the manner in which the duties may be best discharged in that country.

SECTION II.

Duties of Inspectors-General and Deputy Inspectors-General.

Times of Inspections. 1. *The Inspector-General and Deputy Inspector-General of the British troops of the several Presidencies shall make an annual inspection of all the stations occupied by British forces according to the following instructions.*

To see to carrying out of Regulations. 2. The inspecting medical officer is required to see that all regulations for protecting the health of troops in barracks, garrisons, stations, or camps; for securing the sanitary condition of hospitals and for the careful treatment of, and attendance on the sick, are duly observed.

To examine Records. 3. He is to examine the medical, sanitary, and statistical records, to see whether they have been properly kept.

To ascertain the mortality from Zymotic and other Diseases; and their causes. 4. He is to ascertain from them the amount of disease and mortality among the troops, especially from diseases of the zymotic class, such as cholera, fever, dysentery, diarrhœa, scorbutus, &c.

5. He is to inquire into the causes of such diseases, and into the steps which may have been taken for their prevention or mitigation.

To advise with medical officer on the same. 6. He is to advise with the medical officer on any measures for the mitigation or prevention of disease that may be required: and he is to recommend to him, in writing, any additional precautions that he may consider requisite.

As to sanitary condition of barracks, &c. 7. He is to satisfy himself as to the sanitary condition of barracks, guard rooms, day rooms, school rooms, reading-rooms, and prison cells.

Cleanliness, ventilation, &c. 8. As to their cleanliness within and without; their ventilation, warming, and lighting.

As to number of inmates. 9. He is to ascertain whether the number of men accommodated in any barrack or guard room exceeds the number prescribed by regulation.

Drainage. 10. He is to satisfy himself that the drainage, latrines, urinals, ashpits, &c., are in a good sanitary condition.

Rations and cooking. 11. That the rations are good; that the kitchen utensils are sufficient and in good order; and that the cooking is sufficiently varied.

Lavatories, baths, &c. 12. That the lavatories and baths are sufficient for the number of men, and that the baths are sufficiently used, and bathing parades sufficiently frequent.

Gymnastics and games. 13. That games and gymnastic exercises are so conducted as to conduce to the health of the troops and to prevent injury.

Water. 14. That the water supply is good and abundant; that wells are properly covered, and that there is no soakage from cesspools, drains, &c., into them.

Local malaria. 15. He is to examine into any sources of local malaria in the vicinity of the garrison, station, barrack, camp, or hospital, with the view to recommending suitable precautionary measures in regard to them.

Sanitary state of hospitals. 16. He is to satisfy himself that the drainage, ventilation, cleanliness, water supply, water-closets, latrines, urinals, and sinks of every hospital are in good condition, and that the means of warming and lighting every hospital are sufficient.

As to proper number of sick. 17. He is to ascertain whether the number of sick in each hospital ward exceeds the number prescribed by regulation.

Whether excreta are promptly removed. 18. He should satisfy himself that the excreta of the sick are promptly removed from the wards.

Baths, lavatories, &c. of hospitals. 19. That the sick have suitable means of cleanliness, and that the baths and lavatories connected with the hospital are sufficient and in good condition.

Vicinity of hospital. 20. That the vicinity of the hospital is in a good sanitary condition.

Cleanliness. 21. Also, as to the cleanliness and sufficiency of the bedding, linen, ward furniture, and utensils.

Kitchen arrangements. 22. As to the sufficiency of the kitchen arrangements and utensils.

Diets and cooking. 23. As to the quality, variety, and cooking of the diets.

Diet tables. 24. *That the diet tables are in accordance with the authorized scale in India and properly hung up in the wards.*

Medical attendance. 25. That the medical attendance and nursing of the sick are efficient.

Whether hospital has been unhealthy. 26. He should ascertain whether there has been any unusual amount of disease or mortality originating within the hospital, and, if so, its cause.

Hospital epidemics. 27. Whether erysipelas, hospital gangrene, fever, dysentery, cholera, or any other epidemic disease, has shown itself in the hospital among the sick or attendants; whether wounds heal easily and cases of disease recover readily; he should endeavour to trace to its causes any epidemic disease that may exist, and in consultation with the medical officer in charge to decide upon the means of preventing or mitigating such disease.

State of surgery. 28. He should satisfy himself as to the state of the surgery, the quality and supply of medicines and medical comforts, and the means of preparing and dispensing medicines.

Surgical instruments. 29. As to the condition and sufficiency of the surgical equipments and instruments.

Hospital stores. 30. As to the state of the hospital stores.

Repair of hospital. 31. As to the state of repair of the hospital.

Convalescent and lunatic wards. 33. He should see that the convalescent and lunatic wards are kept clean and properly ventilated and the attendance and diets good.

Operating rooms. 35. He is to inspect the operating rooms, dead-rooms, and post-mortem rooms, to see that they are suitably provided with tables and other appliances, and are clean, well supplied with water, well ventilated, and warmed, if necessary.

Burial of the dead. 36. He is to inquire as to the arrangements for the burial of the dead, and whether they are sufficient to prevent injury to health, and whether they are properly attended to.

Report of inspections to commanding officer and Director-General. 37. To prevent loss of time, the inspecting officer should give any advice in writing on the spot that may appear requisite, on any matter included under these instructions, to the commanding officer and medical officer of the regiment or corps, and as soon as his inspection is completed he should report in detail to the Director-General, stating fully all defects in the medical, sanitary, and statistical departments of the service, the recommendations he has made, with the result of the same, with any suggestions for improvement that may occur to him. On foreign service a similar report should be sent by the inspecting medical officer to the general commanding the forces, as well as to the Director-General.

Section VII.

Hospitals.

Sanitary duties. 1. Wherever a general hospital is organized *for British troops*, all sanitary duties connected with the hospital shall be performed by a medical officer appointed by the *principal medical officer, British troops*, to discharge the sanitary duties of such hospital, as detailed in these regulations. In regimental hospitals the surgeon or medical officer in charge shall perform all the sanitary duties connected with his own regimental hospital.

Cubic space. 2. *The minimum space to be allowed for each bed in any permanent hospital should be* 1,500 *cubic feet and* 100 *feet superficial area, and a maximum of* 2,000 *cubic feet with* 130 *to* 140 *superficial area according to site and local climate.*

Inspection of buildings for hospitals. 4. Before any building is taken possession of for a temporary hospital, the sanitary officer, principal medical officer, or regimental medical officer, as the case may be, shall, together with such combatant officer as may be appointed for the purpose, make a careful sanitary inspection of the building and its vicinity, and shall note the condition of the building as regards external and internal cleansing, drainage, water supply, ventilation, lime-washing,

and general cleanliness, the number of beds the building is capable of containing, the number and size of windows, doors, and fire-places, the amount of light, the state of latrines, privies or waterclosets, as well as all other matters likely to affect the health of the hospital or the purity of the air in the wards. The sanitary or medical officer shall report on the same, with his recommendations for removing defects, to the commanding officer, who, in terms of special authority given him for such purposes, will forthwith direct such recommendations to be carried out, unless he see reason to differ from them, in which case he will state in writing his reasons and transmit them, with the recommendations of the sanitary or medical officer, immediately to the superior authority. The sanitary or medical officer, as the case may be, shall at the same time transmit a copy of every such report to the principal medical officer, stating also the steps taken to carry out his recommendations, and the principal medical officer shall transmit forthwith every such report to the Director-General, with any remarks he may have to make on the same.

Sanitary Police of hospitals.

5. It shall be the duty of the sanitary or medical officer, as the case may be, to attend to the daily sanitary condition of the hospital under his charge. He shall require that the vicinity of the hospital be preserved in a good sanitary state, that the surface be properly drained and swept daily, that there be no nuisances, that the water supply be good and abundant, that the water-closets or latrines be in an efficient state, that the drainage be not obstructed, that the ventilation of the wards be at all times efficient by day and night, that the hospital be kept in a proper state of repair, that the walls be frequently lime-washed and cleansed by scraping if necessary, that the flooring, staircases, &c., be kept clean, and that the flooring of the wards be never washed except by the special direction of the medical officer.*

Convalescent wards.

6. In all hospitals wards should be set apart for convalescents, when practicable.

Section XX.

Sanitary Regulations.

Sanitary duties of the Army Medical Department.

1. The medical department of the army and its officers are charged not only with the medical care of the sick, but with the duty of recommending to commanding officers verbally or in writing, whatever precautionary measures as to barracks, encampments, garrisons, stations, hospitals, transports, diet, dress, drills, and duties, may, in the opinion of the department and its officers, conduce to the preservation of the health of the troops, and to the mitigation or prevention of disease in the army. But in the event of any verbal representation not being complied with, the medical officer shall make a representation in writing on the subject to his commanding officer.

Periodical inspection for detection of disease.

14. *A medical inspection of the* men *will be made weekly* for the detection of itch, cutaneous complaints, ocular disease, ulcers, and any ailments indicated by the countenance or skin, as fever, marasmus, small-pox, &c., and *the medical officer will* immediately adopt such precautionary measures as may appear to him to be requisite. Men with itch are, if possible, to be placed in a separate room, or in a tent, when the season will permit.

Vaccination. Small-pox. Re-vaccination.

4. He is required to report yearly whether every man, woman, and child belonging to the regiment bears unequivocal marks of either small, or cow-pox; and is to keep a register of the names and appearances, on the days of examination, of all patients vaccinated. In all stations where fresh virus can be procured, every doubtful case, not only of soldiers, but of their wives and children, should undergo re-vaccination. Any cases of small-pox are to be immediately reported to the *principal medical officer, British troops*, in a special report specifying the the name and age of each individual, and whether bearing satisfactory marks of vaccination, and by whom vaccinated.

If the patient be a soldier, and no marks of vaccination exist, such fact should be mentioned in the said report, with a statement showing the date of his joining the corps, by what medical officer examined on enlistment, and with a copy of any note or memorandum transmitted by that officer to the regimental surgeon. Whenever the medical officer has reason to believe that re-vaccination is necessary, he should proceed to re-vaccinate those who may require it.

Inspection of lavatories and baths.

5. The surgeon or medical officer in charge shall, at least once a week, inspect the lavatories and baths of all barracks, quarters, and hospitals, to see that they are in an efficient state.

6. He shall satisfy himself that the personal cleanliness of the men is properly attended to.

Personal cleanliness.

Gymnastics and games.

7. He shall visit periodically all grounds or places set apart for games or amusements for the troops, and shall give his advice on such matters, and also on the kind and amount of gymnastic exercises best suited to improve the health of the men.

Rations, drink, cooking, &c.

8. He shall, from time to time, examine the amount and quality of the ration supplied to the troops, and also the quality of articles of food and drink sold in the canteens, and the ventilation of the canteens themselves. He shall examine the cooking, and ascertain whether it be sufficiently varied; likewise the quality and amount of drinking water, and he must ascertain whether wells and other sources of water are protected from soakage from latrines, cesspools, drains, and other sources of impurity.

Barracks, Space in.

10. The minimum space to be allowed for men in permanent barracks is from 1,000 *to* 1,500 *cubic feet and* from 80 *to* 100 *superficial feet*.

Selection of quarters or hospitals.

11. Before any buildings are selected for the accommodation of troops or for hospitals, their sanitary condition shall be examined by a competent medical officer, and shall be reported on to the commanding officer, and such sanitary improvements indicated as may be requisite to secure the health of the men.

Ventilation and lighting.

14. *The surgeon or medical officer in charge shall satisfy himself* that every barrack, guard-room, hospital, and cell is suitably lighted and provided with sufficient means of ventilation to keep the air in a pure state by night as well as by day.

15. That married soldiers' quarters, schools, reading rooms, kitchens, wash-houses, lavatories, urinals, and latrines, are suitably ventilated and lighted.

Means of ventilation to be efficient.

16. That the means of ventilation provided for any barrack, guard-room, hospital, or cell, or for any school, reading-room, kitchen, wash-house, lavatory, urinal, or latrine, are in efficient operation.

Opening of windows.

17. That the windows of every barrack-room are opened sufficiently to allow of a free ventilation as soon as the men have risen, and that they are kept open to such extent during the day as the weather and season may admit.

Beds to be exposed.

18. That the beds and bedding are freely exposed to the air for at least an hour every morning before they are made up.

Barracks to be lime-washed.

19. That the walls and ceilings of barracks or quarters and hospitals are limewashed twice a-year, or oftener, if necessary, and that the walls are scraped at intervals.

Inspection of barracks by medical officer.

21. In order to fulfil these duties, the surgeon or medical officer in charge shall visit all barracks, quarters, guard-rooms, hospitals, cells, and married soldiers' quarters at frequent intervals, to examine their general sanitary condition and cleanliness. He shall note the state of cleanliness of the rooms and beds, the state of the atmosphere by day, and when the men are in quarters. He shall examine and make inquiry, at such times as he may consider necessary, into the condition of the latrines, drainage, urinals, water-supply, stables, general cleanliness, &c., so as to enable him to judge of the sanitary condition of the whole buildings. He shall keep notes of all such examinations, stating whether the results were satisfactory, the defects he discovered, the representations he made, verbally or in writing, to his commanding officer to have them removed, and the result.

Garrisons, Camps, and Stations. Duties of sanitary officer.

22. In garrisons, camps, and stations, where a special sanitary officer has not been appointed, the principal medical officer shall perform the duties of sanitary officer.

To watch over the sanitary state of garrison or station.

23. He shall exercise a general supervision over the sanitary condition of all parts of the garrison, camp, or station, and its vicinity, as regards drainage, cleanliness, removal of nuisances, water-supply, overcrowding, ventilation, lime-washing, lighting of barracks and hospitals, the state of latrines, and all other matters affecting the health of the troops.

To recommend precautions to commanding officer.

24. He shall represent any sanitary defects in the same, together with his recommendations thereon, verbally or in writing, to the officer commanding the troops, and in like manner the surgeon or medical officer in charge of any regiment or detachment shall represent and recommend to the commanding officer, verbally or in writing, whatever he may consider necessary for protecting the health of the troops, whether as regards the abatement or removal of local causes of disease, or as to any alteration of diet, clothing, drills, or duties, in terms of these regulations, subject to the condition already mentioned, that if any verbal representation is not complied with, the principal medical officer or medical officer in charge shall make a representation in writing on the subject to his commanding officer.

To recommend measures for preventing epidemic diseases.

25. Should any epidemic disease appear in any garrison, camp, or station, the principal medical officer shall immediately inquire into its cause, and in communication with the regimental medical officers, he shall, if necessary,

* When, in compliance with Recommendation 29 of the Report of the Royal Commission, "that the number of general hospitals in India be increased by the organization of such hospitals under the New Medical Regulations, at the largest European stations," General hospitals *under Governors* have been established, it will be necessary to appoint either a special sanitary officer or the principal medical officer to perform sanitary duties. Either officer will in this case report *to the Governor*, who, by the Regulations, has special authority to remedy all defects complained of.

recommend, in writing, to the commanding officer, such measures of precaution as may be requisite for mitigating or preventing such disease. In the case of regiments or detachments, similar written representations shall be made to the commanding officer by the surgeon or medical officer in charge.

Copies of recommendations to be sent to principal medical officer.

26. The surgeon or medical officer in charge shall transmit to the principal medical officer *of British troops* in garrisons, camps, and stations, and to the sanitary officer, when an army is in the field, copies of all written recommendations he may have considered it necessary to make, for protecting the health of troops, and, except when an army is in the field, he shall immediately send copies of such recommendations, stating the results to the *principal medical officer of the British troops of the Presidency.*

Commanding officer to consider and give effect to recommendations.

27. The commanding officer of any garrison, camp, station, regiment, or detachment, immediately on receiving any verbal or written representation or recommendation from the principal medical officer *of the British troops*, or from the surgeon or medical officer in charge, on any matter influencing the health of the troops, will take the same into his most careful consideration, and give the necessary instructions for remedying the defects represented, unless he have sufficient reasons for not doing so, in which case, and if the representation has been made in writing, the commanding officer will state such reasons in writing, and transmit the same forthwith, together with the representation or recommendation of the medical officer, to the Commander-in-Chief.

Section XXI.

Sanitary Regulations for Field Service.

Principal medical officer to appoint sanitary officer.

2. *The principal medical officer of British troops of the Presidency* shall recommend for appointment a competent sanitary medical officer, to be attached to the quartermaster-general's department, as sanitary officer to the army.

Principal medical officer to issue sanitary instructions.

3. *The principal medical officer of British troops of the Presidency* shall issue to the principal medical officer of *British troops* and sanitary officer of every army on active service, such a code of instructions for their guidance, on all matters connected with rations, clothing, shelter for troops, sanitary arrangements and precautions for preventing disease, in addition to any printed regulations or instructions on the subject, as he may see necessary to meet the specialities of each case.

Sanitary officer to make inspections of buildings, and to advise quartermaster-general.

4. The sanitary medical officer shall accompany the quartermaster-general, or such officer as he may appoint, in selecting buildings for occupation by troops, whether as hospitals, quarters, or stables. He shall examine into their sanitary condition, as respects cleansing, nuisances, drainage, ventilation, lighting, water-supply, lime-washing, cubic contents, and into all other matters connected with such buildings as are likely to affect the health of the troops or of sick; and he shall advise the quartermaster-general, or his deputy, on all such subjects, sending copies of all reports he may have considered it necessary to make, to the principal medical officer. The sanitary officer shall point out in his reports every sanitary defect requiring removal, and the number of troops or sick which can be safely accommodated in the buildings.

Also of towns and villages.

5 The sanitary medical officer shall further examine into the sanitary condition of towns or villages about to be occupied, and their neighbourhood; and he shall make recommendations for organizing a proper sanitary police, to preserve cleanliness and for removal of nuisances, as well as for the execution of such sanitary measures as he may consider necessary for protecting the health of troops in occupation.

Inspection of camp sites.

6. Before selecting any site for an encampment, the sanitary medical officer, on being directed by the quartermaster-general to do so, shall accompany him, or such other officer as the quartermaster-general may appoint, on his inspection, and the sanitary officer shall give, in writing, his opinion on the salubrity or otherwise of the proposed position, with any recommendations he may have to make, respecting the drainage of the site for a camp, the preparation of the ground, the distance of tents or huts from each other, the number of men to be placed in each tent or hut; the state of cleanliness, ventilation, water supply; the position and regulation of latrines and slaughtering-places; cleansing and disposal of refuse; burial of the dead and of carcases of animals, &c.

Sanitary officer to superintend sanitary arrangements.

7. The medical sanitary officer shall further superintend the sanitary arrangements of the camp and of occupied towns. He shall see that the surface and vicinity of camps and towns are kept clean and free from nuisances—that defects of the surface-drainage are remedied— that the dead are properly interred, and the carcases of animals and offal are properly buried or otherwise disposed of—that latrines are properly regulated—that the water-supply is preserved in a state of purity.

To recommend precautions for preventing disease.

8. He shall inform himself as to the sanitary condition of hospitals, huts, tents, houses, and other buildings in occupation, and shall recommend, in writing, such precautionary measures for the prevention of disease as he may think fit, whether as regards cleansing, draining, prevention of overcrowding, ventilating, lighting, lime-washing, removal of nuisances, improvement in water-supply, and on all other local matters affecting the health of the troops or the sick.

Principal medical or sanitary officer to give advice to Commander of the Forces.

9. The principal medical officer *of the British troops*, or sanitary officer, as the case may be, of every army in the field shall, on being consulted by the Commander of the Forces, give advice, in writing, on the composition of rations, clothing, shelter, sanitary arrangements and precautions for preventing disease, and on all other subjects bearing on the health and physical efficiency of the troops. Even where such advice is not requested, the principal medical officer of *British troops* shall, nevertheless, send, in writing, to the Commander of the Forces, the fullest information on all these subjects, with such recommendations as appear necessary for protecting the health of the troops.

Principal medical or sanitary officer to issue sanitary instructions.

10. The principal medical officer *of the British troops* or sanitary officer of every army in the field shall, with the sanction of the Commander of the Forces, immediately on the opening of a campaign, as well as at such other times as may appear to him to be necessary, issue such instructions regarding sanitary precautions to be observed for protecting the health of the troops as he may consider necessary for the guidance of the medical officers.

Prevention of zymotic disease.

11. The sanitary officer shall keep up a continual daily inspection of the whole camp, and shall especially inform himself as to the health of the troops, and of the appearance of any zymotic disease among them, and he shall immediately on being informed of the appearance of any such disease, examine into the cause of the same, whether such disease proceed from, or is aggravated by, sanitary defects in cleansing, drainage, nuisances, overcrowding, defective ventilation, bad or deficient water-supply, dampness, marshy ground, or from any other local cause, or from bad or deficient food, intemperance, unwholesome liquors, fruit, defective clothing or shelter, exposure, fatigue, or any other cause, and report immediately to the Commander of the Forces on such causes, and the remedial measures he has to propose for their removal, sending a copy of all such reports to the principal medical officer of the army, and he shall report, at least daily, on the progress or decline of the disease, and on the means adopted for the removal of its causes, until it is no longer necessary to do so.

Sanitary regulations for troops on march.

12. When troops are on the line of march, the sanitary officer, the principal medical officer *of the British troops*, or any medical officer appointed by him specially for such duty, or the regimental surgeon, as the case may be, shall accompany the quartermaster-general or the officer acting under his orders, and collect as much information as possible as to the medical topography of the district, with special reference to places which ought to be selected or avoided for camping grounds.

During epidemic seasons he shall also indicate the best means of mitigating or preventing attacks of disease on the march.

Refreshment for Troops before a march.

13. Troops, before proceeding on a march, should have some refreshment, especially during epidemic seasons.

Principal Medical Officer to report to Director-General.

14. The principal medical officer *of the British troops* and sanitary officer of every army in the field, shall send to the Director-General, at such intervals as the Director-General may determine, full information on all subjects connected with the hygiene of the army, together with such recommendations for improving this service as the principal medical officer or sanitary officer may consider requisite.

Medical officers to report.

15. All medical officers, in charge of general hospitals, divisions, and brigades in the field, shall transmit to the principal medical officer of *British troops* for the guidance of the sanitary officer, full information as to the sanitary state of the troops and hospitals, and on all matters affecting the health and physical efficiency of the men, at such intervals as the principal medical officer may appoint.

Sanitary officers to report.

16. Sanitary officers attached to any army in the field, or to any general hospital at the base of operations, shall draw up a weekly sanitary report on the state of the army or hospital, to be sent to the principal medical officer of *British troops*, for the information of the Commander of the Forces, a copy of which will be transmitted by the principal medical officer *of British troops immediately to the principal medical officer of the British troops of the Presidency.*

Section XXIV.

Regulations for Statistical and Sanitary Reports and Returns.

Reports of epidemic disease in a garrison.

11. When epidemic disease prevails among any population, in the neighbourhood of which any regiment or

detachment is stationed, or among the civil population of any garrison, station, or camp, sanitary reports or memoranda shall, in every such case, be sent by the medical officer in charge, week by week, to the *principal medical officer, British troops, together with the weekly statistical report.*

Epidemic diseases among troops.

12. If any epidemic disease attacks the troops in any regiment or detachment, the occurrence must be forthwith notified by the medical officer in charge, to the *senior medical officer of British troops of the division or district* and a report on the progress of the disease and the sanitary state of the troops must be sent to the principal medical officer, day by day, as far as it may be practicable to do so, till the disease has disappeared.

Reports to be strictly according to instructions.

18. All sanitary reports and memoranda sent by medical officers to the Army Medical Department must be drawn up in strict conformity with the instructions issued by the *principal medical officer, British troops, and the Director-General.*

INSTRUCTIONS ON THE PRECEDING REGULATIONS.

Section VIII.

Additional Sanitary Instructions for Officers of the Quartermaster-General's Department.

When an army is about to take the field, the *principal medical officer of the British troops of the Presidency* will select a competent medical officer to be attached to the quartermaster-general's department, to act as sanitary officer of the army, and as sanitary adviser to the department.

The sanitary officer, or, in his absence, the principal medical officer, *British troops*, or any other medical officer appointed by him should on the line of march accompany the officer of the quartermaster-general's department, who precedes the troops, and should be directed to give his advice on the selection of quarters or camping grounds, and in the adoption of precautions for protecting the health of the men.

Previous to the selection of a site for encampment, the sanitary officer will accompany the quartermaster-general, or his deputy, in his inspection of the ground proposed to be occupied, and will report his opinion in writing as to its fitness in point of salubrity, and will send a copy of such report to the principal medical officer, *British troops*, who will make any comment he thinks right upon it, for the information of the General commanding.

He will indicate such precautions as may be required for improving its sanitary condition.

He will examine and report on the amount and quality of the water supply, point out the best sources of supply, and also indicate the sanitary precautions required in collecting, storing, purifying, and distributing water for use.

He will point out the best position for latrines, stables, slaughtering-places, offal-pits, and burial-grounds, and give his advice as to the best mode of regulating them.

The quartermaster should make arrangements for a camp police to cleanse and keep clean the surface and the vicinity of the camp, to prevent nuisances, and to carry into effect all sanitary regulations; and the sanitary officer should be instructed to report to the quartermaster-general any defects or negligence in carrying out the duties of the camp police.

Proposed camping grounds, especially in low flat districts, should be examined as to their natural drainage, by trial holes dug at different points to a depth of three or four feet, to ascertain if there be water near the surface. Ground in which this is the case should be avoided if possible, but if it must be occupied the ground should be deep drained to remove the subsoil water.

In forming a camp, the tents should be pitched in single lines, with a sufficient interval between the tents to allow the air to circulate freely among them, and to admit of the spaces between the tents being swept and kept clean. The opinion of the sanitary officer should be required as to the most suitable distance for tents and huts under different conditions of ground.

A trench should be dug round each tent sufficiently deep to remove surface water and to keep the ground under the tent dry. This should be done in damp or wet ground even if the ground be occupied only for one night.

Before erecting huts the ground should be cleared and levelled, and a trench dug round the site of the hut sufficiently deep to drain the site.

Huts should not be dug out of the ground nor have earth heaped against their sides; they should stand detached and at a sufficient distance from each other, and from any neighbouring higher ground, to allow a free circulation of air around them. In warm climates the floor should be sufficiently raised above the ground to allow of a free circulation of air beneath it. The sanitary officer should be consulted on these points, also as regards the draining of sites, and the warming and ventilating of huts and tents.

When towns or villages are to be occupied, the quartermaster or assistant quartermaster general should direct the sanitary officer to inspect the places as to their general sanitary condition, especially as regards the sanitary state of houses and buildings intended to be used as quarters or hospitals, and to see that no more than the proper number of inmates be placed in each. Also to inquire into the amount and quality of the water supply, and to report on these, and on all other local matters likely to affect the health of the troops in occupation, and on the nature and extent of such sanitary improvements as may be required.

In all occupied towns or villages a sanitary police, properly organized, should be provided to carry out, from day to day, such precautionary measures as may be pointed out by the sanitary officer, who should be instructed to make periodical sanitary inspections and reports.

The quartermaster or assistant quartermaster-general should receive, and take into immediate consideration, all reports and recommendations made to him, in writing by the sanitary officer, respecting the health and sanitary condition of camps and occupied places, and should give effect to the same, unless military exigencies should make it undesirable, in which case the quartermaster or assistant quartermaster-general, as the case may be, should state his reasons for non-compliance with the recommendations of the sanitary officer, in writing, and transmit the same to the Commander of the Forces.

When it has not been considered necessary to appoint a sanitary officer, the principal medical officer, or in case of single regiments, the regimental medical officer will discharge the duties of sanitary officer; and assistant and deputy assistant quartermasters-general of divisions and brigades, and quartermasters of regiments being responsible for the sanitary condition of their camps, should comply with the recommendations made to commanding officers by the principal medical officer or regimental medical officer, as the case may be, on all matters contained in the preceding instructions.

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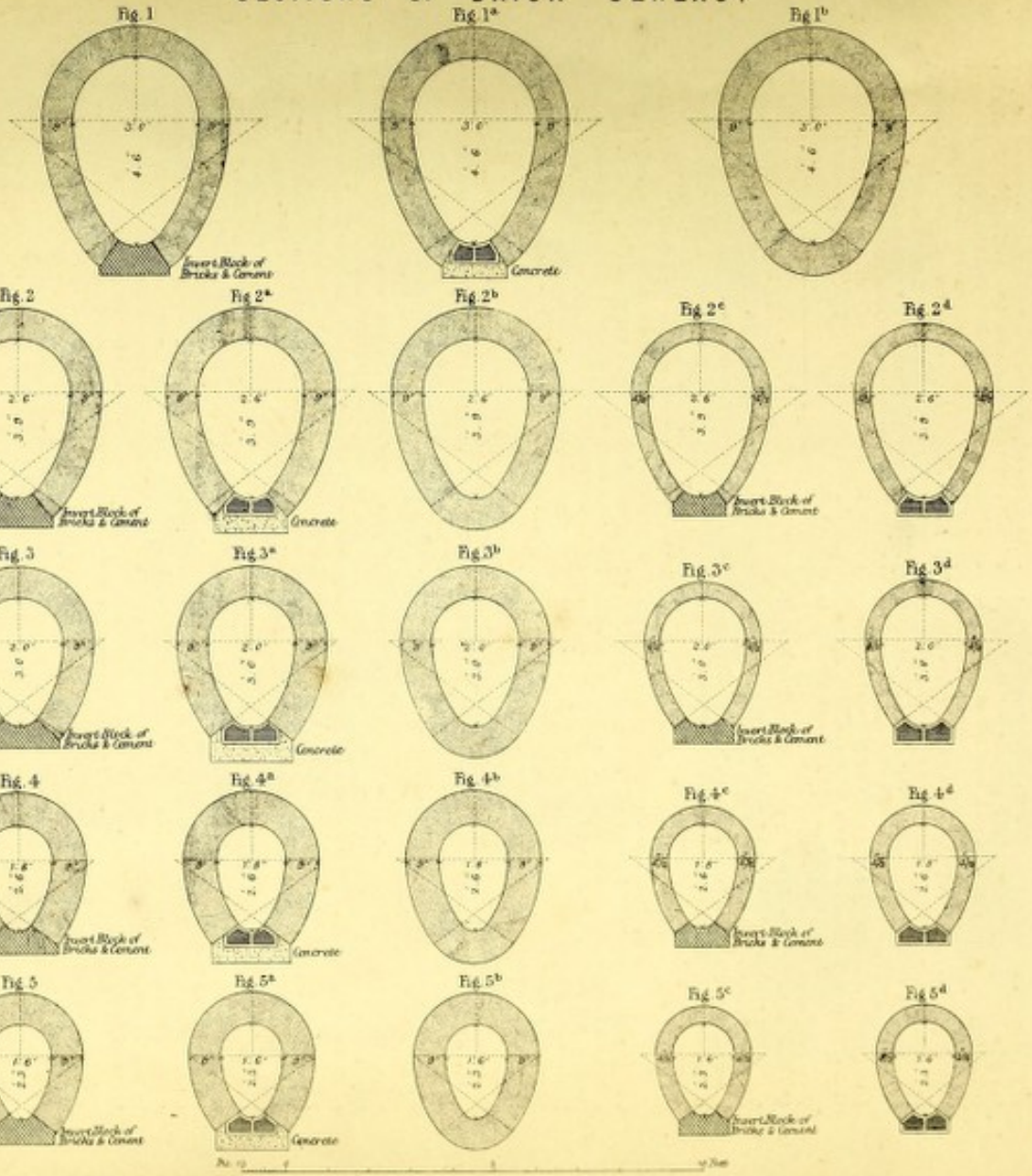
For Her Majesty's Stationery Office.
[1628.—750.—8/64.]

SECTIONS OF BRICK SEWERS.

Plan 1.

		No. of Bricks in 1 lin. yard, exclusive of Invert.	Cost in 1 lin. yd.
Figs. 1, 1a, 1b. Area 10.40 Sq. Ft.	Fig. 1	388	1. 18. 10
	Fig. 1a	384	1. 19. 2
	Fig. 1b	432	1. 17. 3
Figs. 2, 2a, 2b, 2c, 2d. Area 7.20 Sq. Ft.	Fig. 2	336	1. 15. 3
	Fig. 2a	336	1. 15. 9
	Fig. 2b	384	1. 13. 10
	Fig. 2c	156	1. 5. 3
	Fig. 2d	156	1. 5. 9
Figs. 3, 3a, 3b, 3c, 3d. Area 4.60 Sq. Ft.	Fig. 3	256	1. 10. 2
	Fig. 3a	256	1. 10. 8
	Fig. 3b	304	1. 8. 8
	Fig. 3c	116	1. 2. 4
	Fig. 3d	116	1. 2. 7
Figs. 4, 4a, 4b, 4c, 4d. Area 3.20 Sq. Ft.	Fig. 4	216	1. 7. 6
	Fig. 4a	216	1. 8. 0
	Fig. 4b	256	1. 5. 7
	Fig. 4c	100	1. 0. 9
	Fig. 4d	100	1. 1. 3
Figs. 5, 5a, 5b, 5c, 5d. Area 2.60 Sq. Ft.	Fig. 5	208	1. 6. 9
	Fig. 5a	208	1. 7. 3
	Fig. 5b	248	1. 4. 11
	Fig. 5c	92	0. 19. 11
	Fig. 5d	92	1. 0. 5

Bricks 30/ per 1000. Mortar ½ per 100 Bricks.
Brickwalling 1/2 per 100 Bricks. Excavation 5/8 per Cubic Yard.



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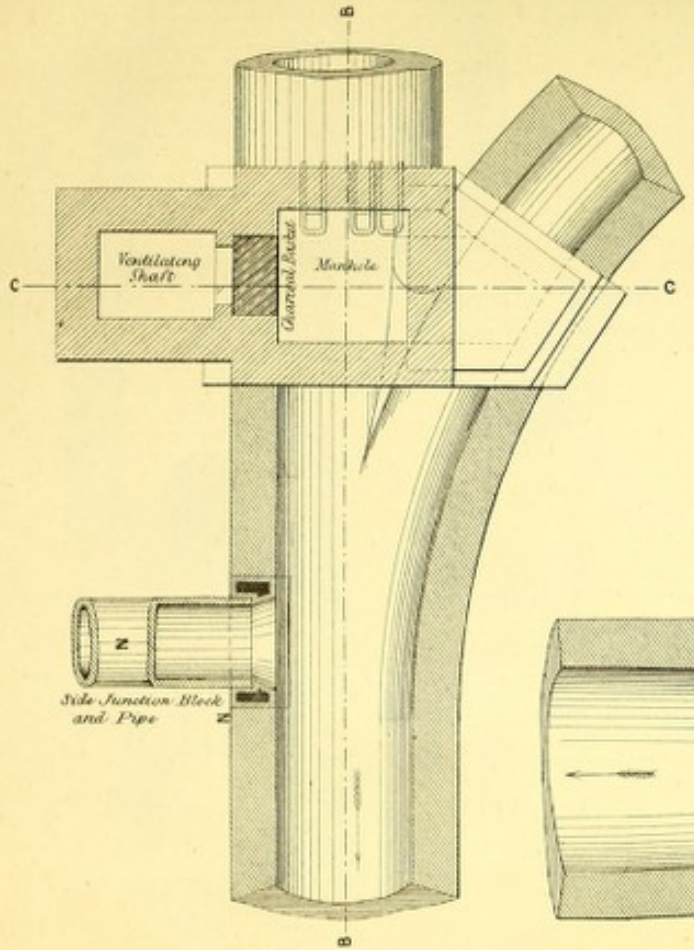
Day & Son Lith.rs to the Queen

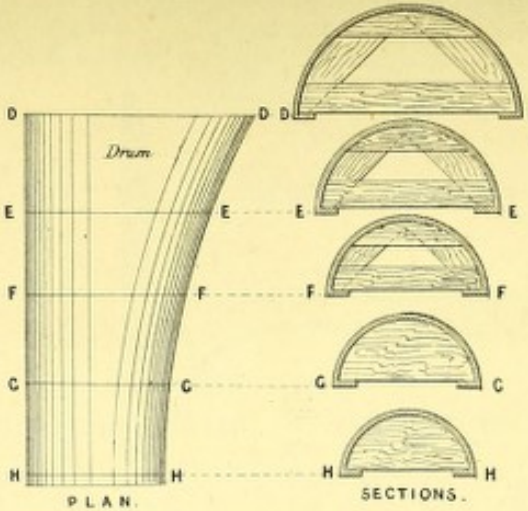
MANHOLE AND VENTILATING SHAFT AT JUNCTION OF BRICK SEWERS.

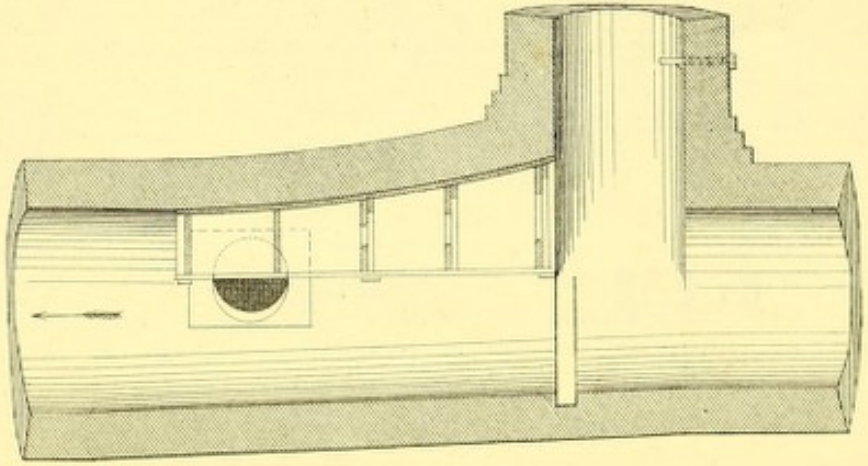
DRUM FOR BELL MOUTHED-ARCH.

Plan II.

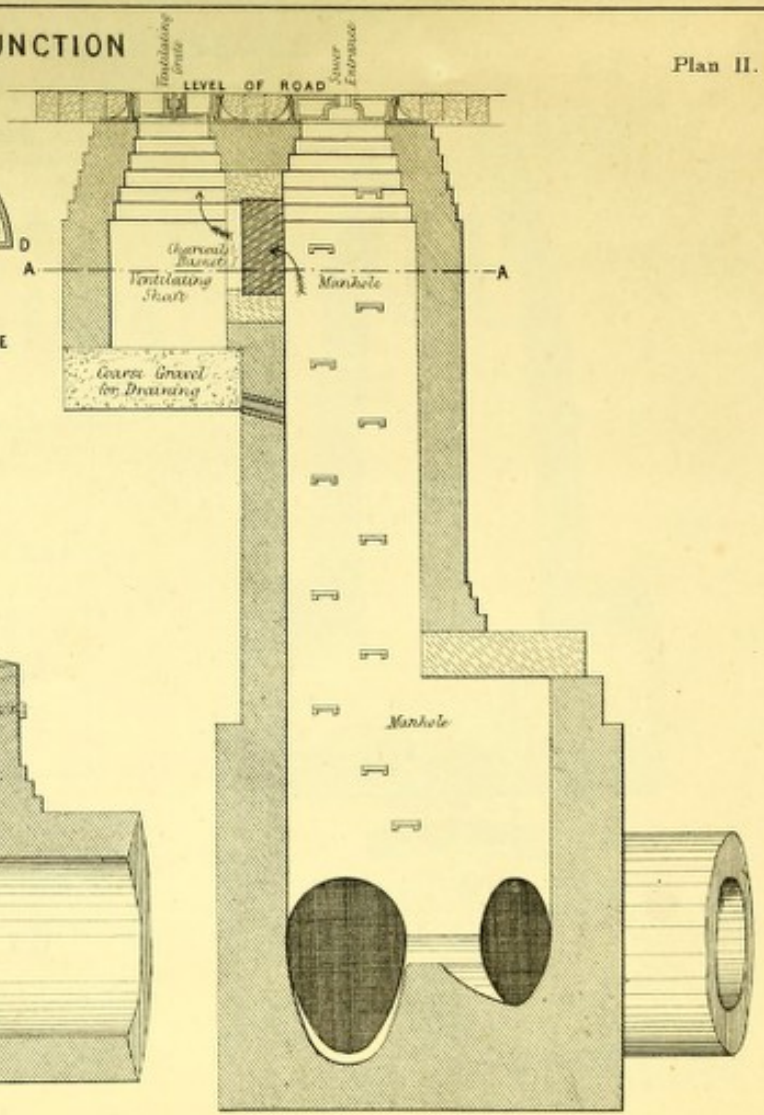


PLAN AT A. A.





SECTION B.B.



SECTION C.C.

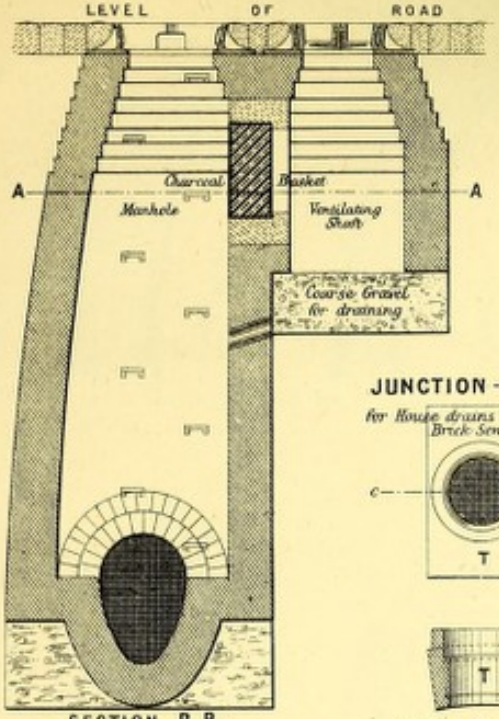
SCALE

Robert Rawlinson C.E.

MANHOLE & VENTILATING SHAFT ON BRICK SEWER

WITH DETAILS.

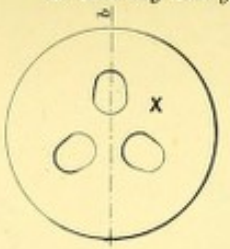
Plan III.



SECTION B. B.

DISC-PLUG

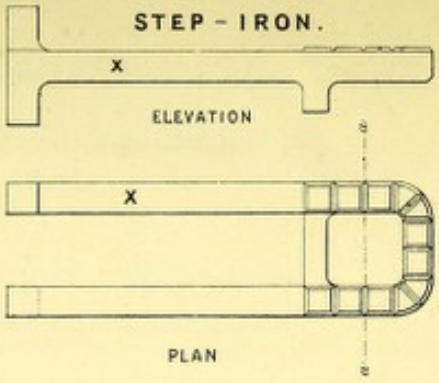
for securing side junctions.



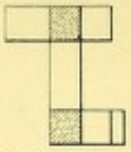
PLAN

SECTION b. b.

STEP-IRON.



PLAN



SECTION a. a.

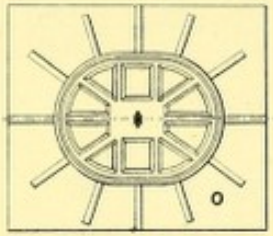
SECTION C. C

JUNCTION-BLOCK.

for House drains to be built in Brick Sewers

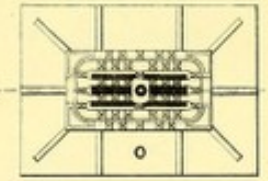
SECTION c. c.

MANHOLE-COVER.

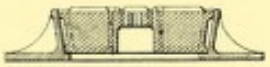


PLAN

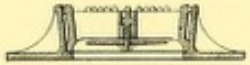
VENTILATING-GRATE.



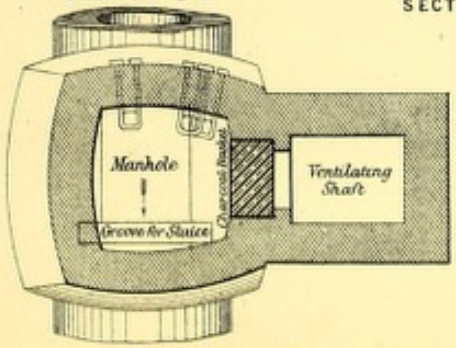
PLAN



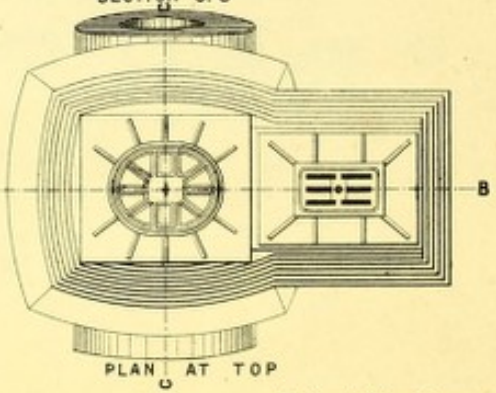
SECTION d. d.



SECTION c. e.



PLAN AT A. A.



PLAN AT TOP

SCALE FOR DETAILS.

XXXX	*Step-Iron and Disc-Plug*	*2 in.s to a foot*
TT	*Junction Block*	*¾" to a foot*
OOO	*Manhole Cover & Ventilating Grate*	*½" to a foot*

SCALE OF FEET

for Plans & Sections of Manhole &c.

In.s 12 0 1 2 3 4 5 6 7 8 9 10 Feet

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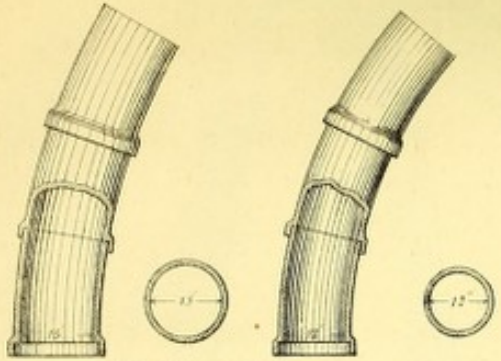
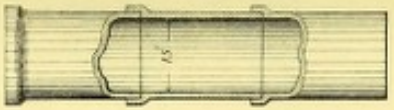
EARTHENWARE PIPE SEWERS.

Plan IV.

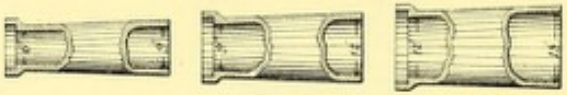


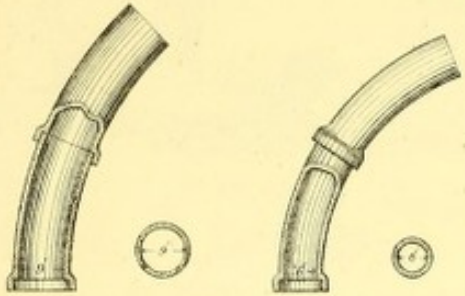
RADIATING MAINS

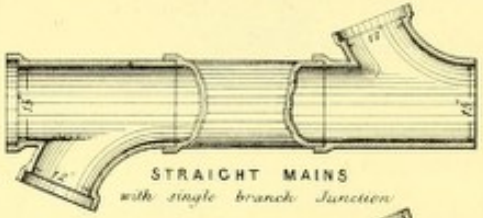


STRAIGHT PIPES

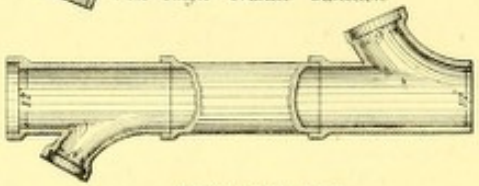
TAPERING PIPES

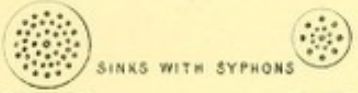






STRAIGHT MAINS
with single branch Junction





SINKS WITH SYPHONS

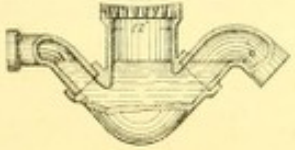


FIG. C

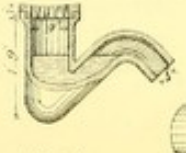
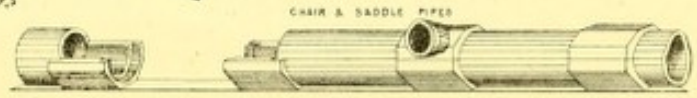


FIG. D



CHAIR & SADDLE PIPES

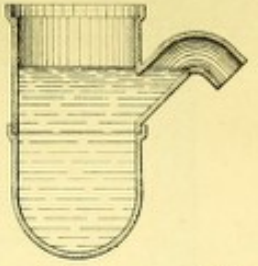


FIG. A

CULLIES

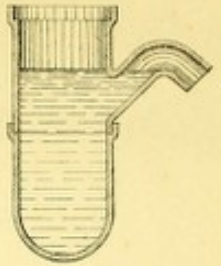
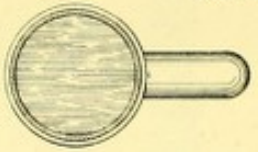
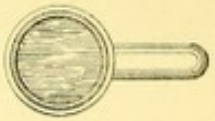
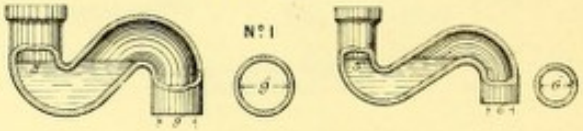


FIG. B

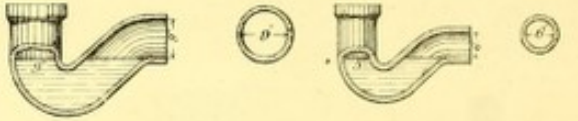




SYPHONS



N°1



N° 2

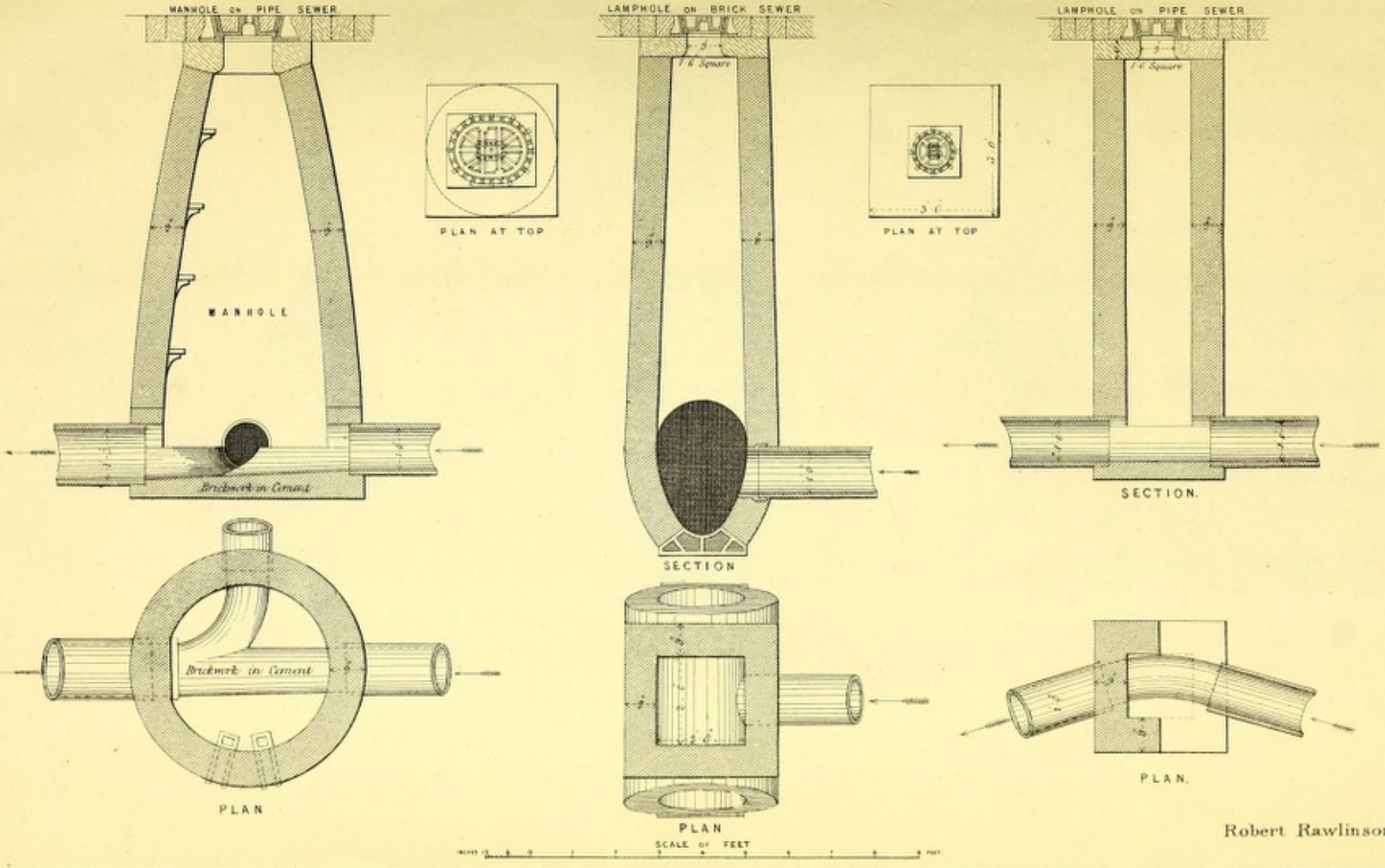
N° 3

Robert Rawlinson C.E.

DAY & SON LITH^RS TO THE QUEEN

MANHOLES & LAMPHOLES ON EARTHENWARE PIPE SEWERS

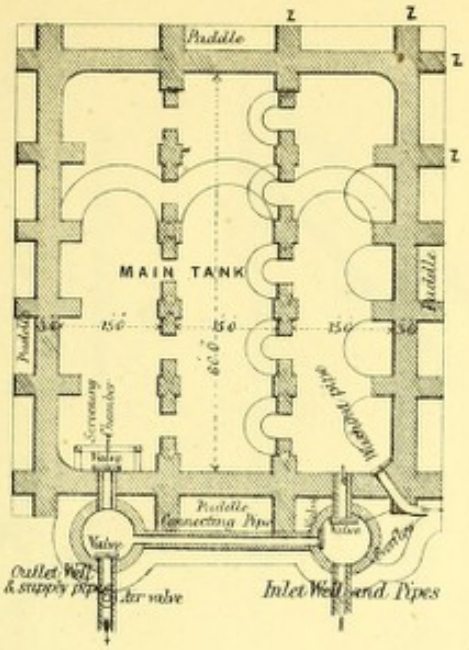
Plan V.



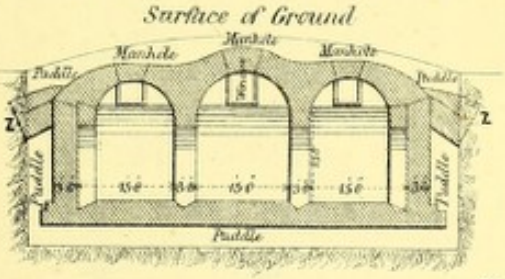
Robert Rawlinson C.E.

Plan VI.

PLAN OF TANK



CROSS SECTION THROUGH TANK

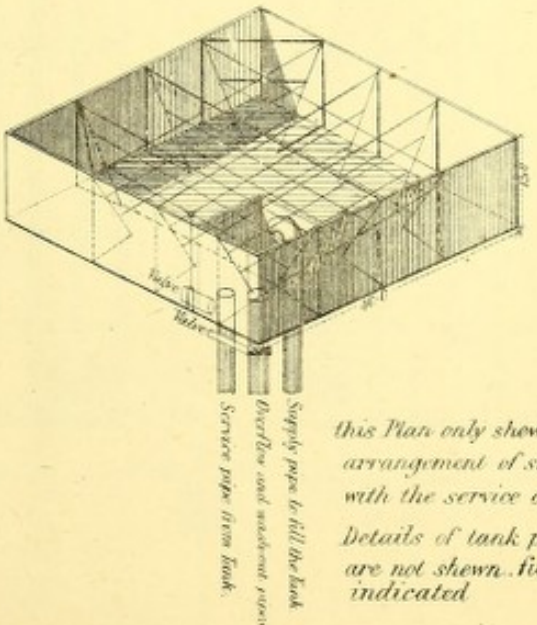


Puddle will be required on gravel sand, or on open jointed rock but not on water tight strata. The side walls must be securely supported at the line of thrust by main arches as shewn by counterforts at Z

The figures are feet & Inches

The arrangement shewn above will allow a supply of water going on independant of the main tank

CAST IRON TANK WITH SEPARATE SUPPLY CISTERN



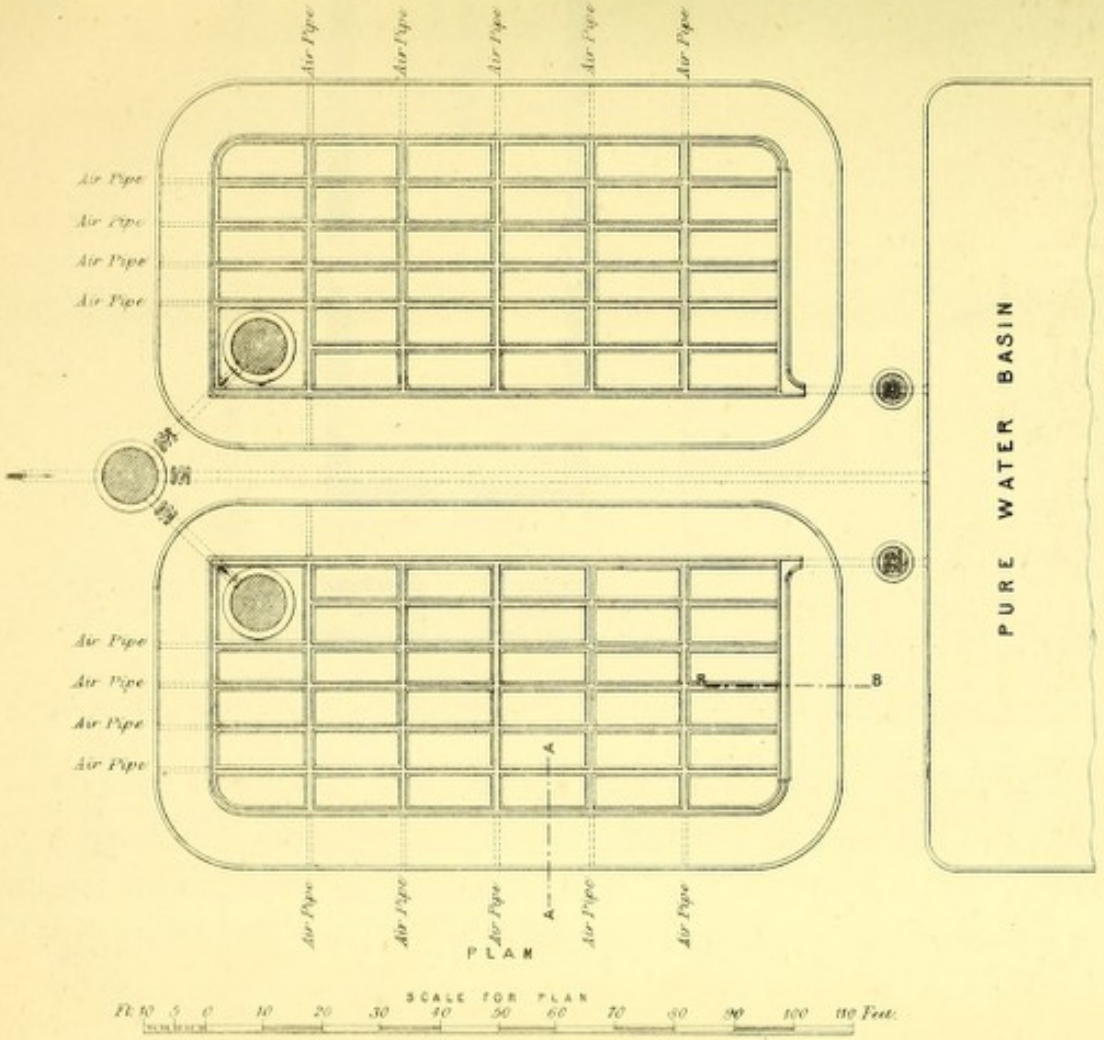
this Plan only shews the general arrangement of small inner tank with the service and supply pipes.

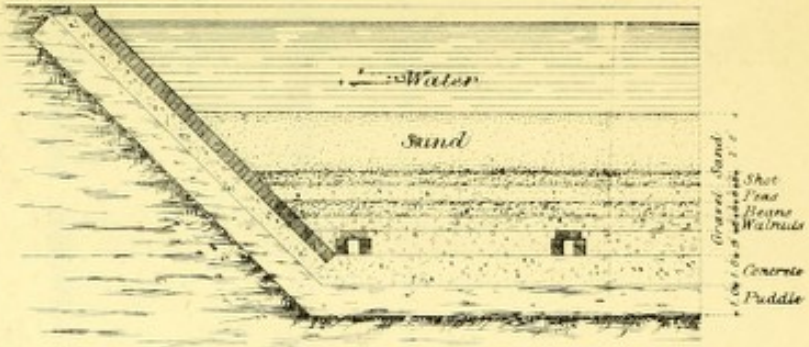
Details of tank plates and tie rods are not shewn fully but only indicated

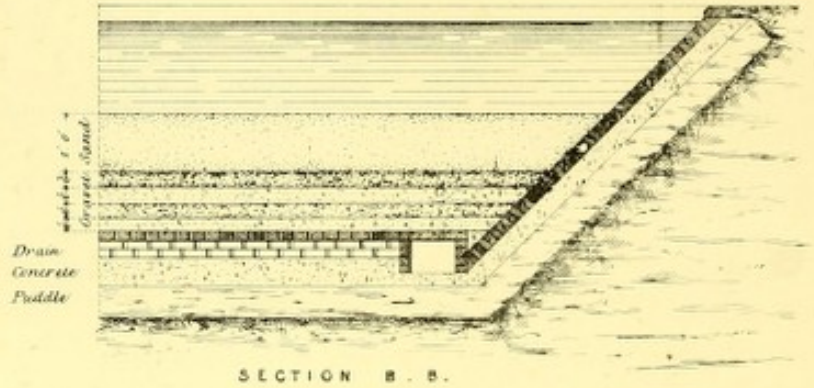
Robert Rawlinson
Civil Engineer

FILTER BEDS.

Plan VII.







SCALE FOR PLAN

Ft. 10 5 0 10 20 30 40 50 60 70 80 90 100 110 Feet.

SCALE FOR SECTIONS

Inc. 12 6 0 1 2 3 4 5 10 15 20 Feet.

Robert Rawlinson C.E.

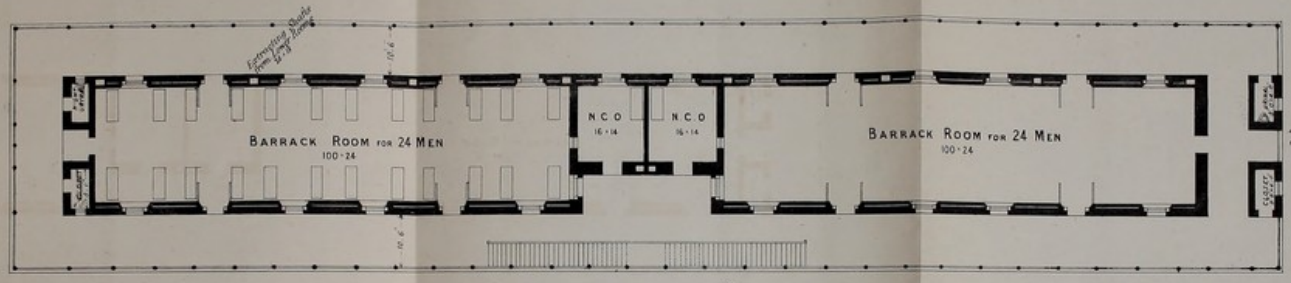
DAY & SON LITHRS TO THE QUEEN

DESIGN

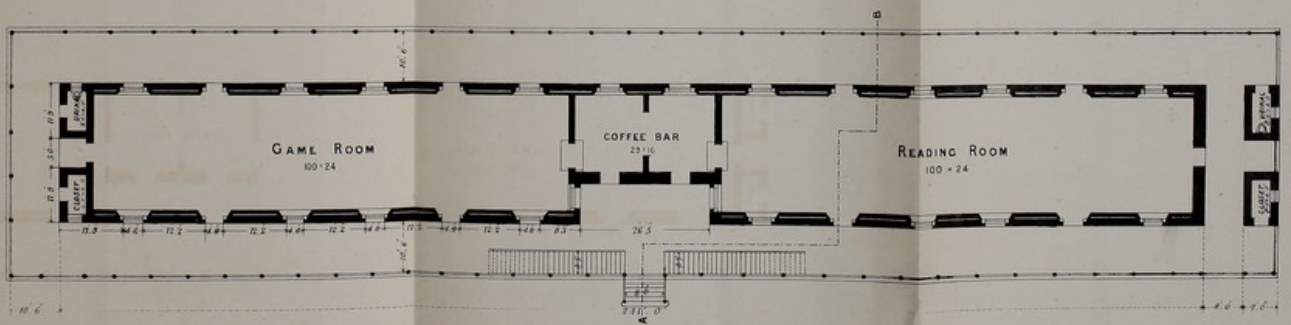
Intended to illustrate the principles of Barrack construction for India, and other warm climates, and embodying the requirements of the Royal commission on the Sanitary state of the Indian Army.

Plan VIII.

Space provided *100 Superficial & 1500 Cubic feet* per man to wall height.



PLAN OF UPPER FLOOR

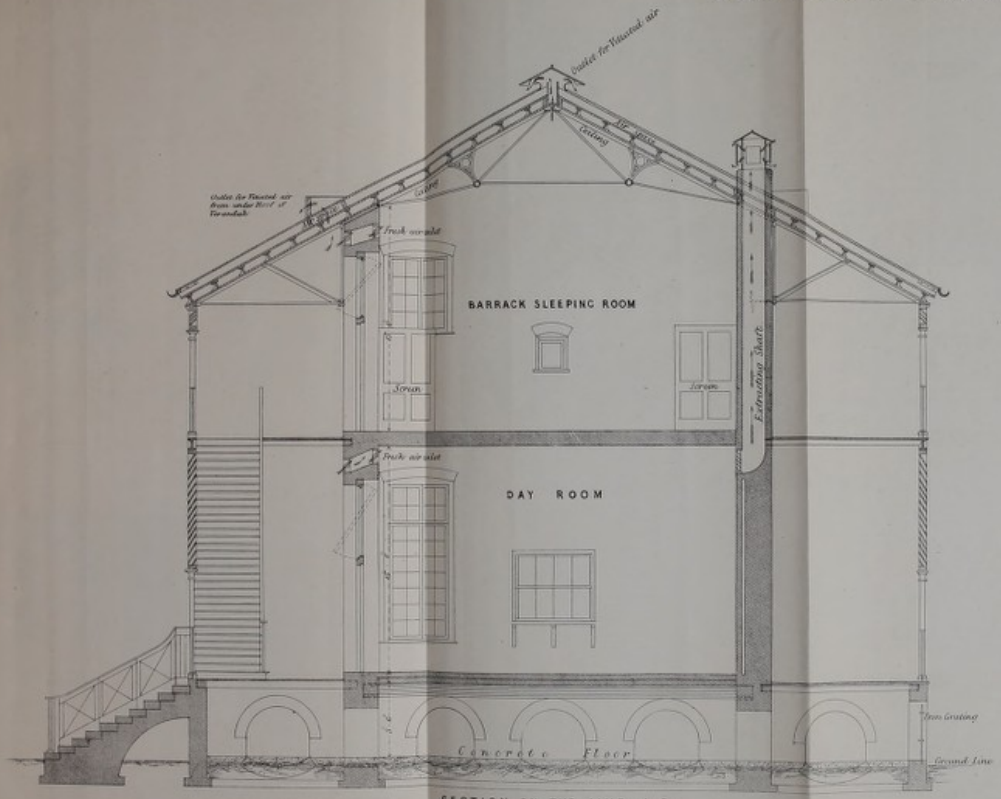


PLAN OF LOWER FLOOR

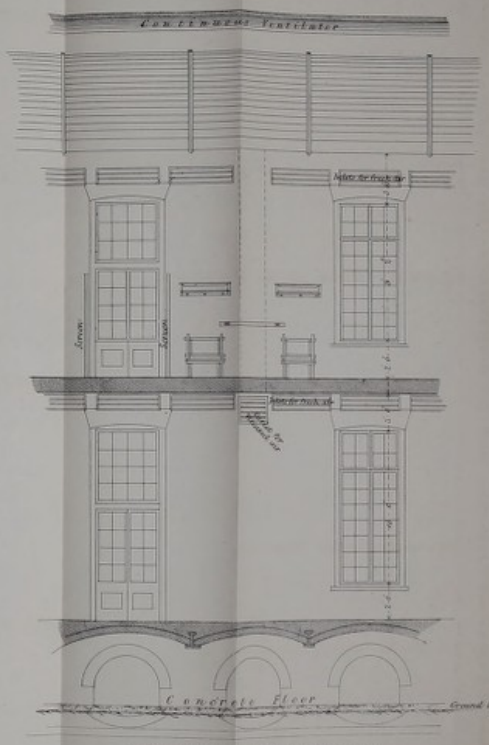
Scale of Feet

SECTIONS of BARRACK.

Plan IX.



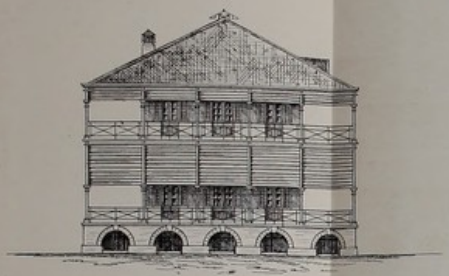
SECTION ON THE LINE A. B.



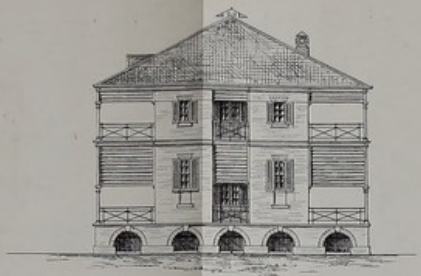
PART OF LONGITUDINAL SECTION

SCALE

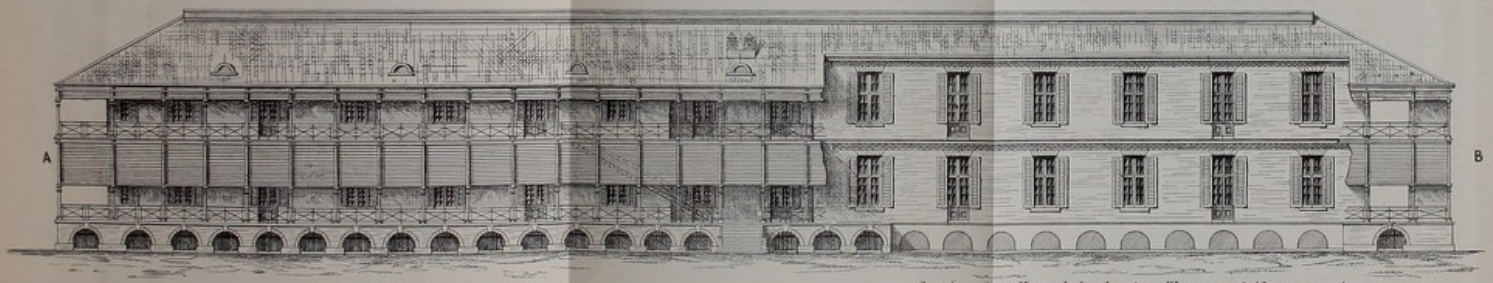
ELEVATIONS OF BARRACK.



End Elevation at A.



End Elevation at B.



Front Elevation shewing Verandah

Section thro' Verandah shewing Elevation of Alternative Arrangement of Night Urinal at end.

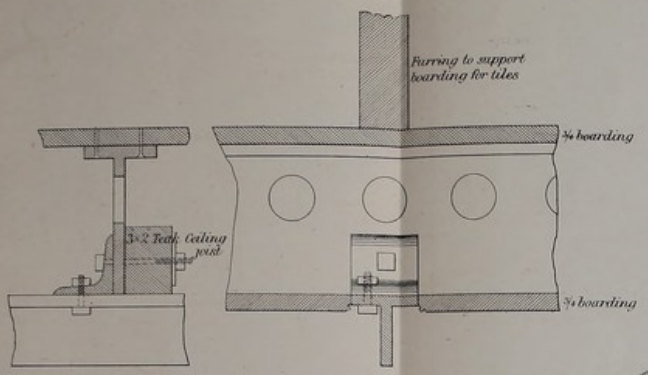
SCALE

0 5 10 15 20 25 30 35 40 45 50 Feet

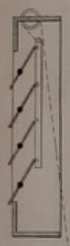
DETAILS OF CONSTRUCTION

of Roofs and Ventilation to Barracks and Hospitals

Plan XI.



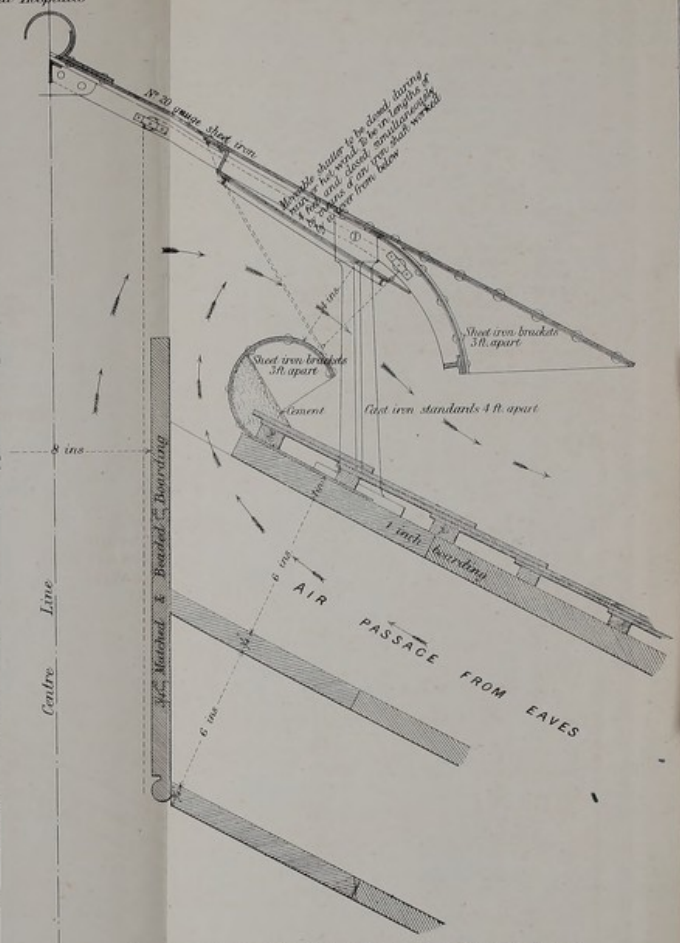
SECTION AND ELEVATION OF PERFORATED IRON PURLINS A.A.
¼ FULL SIZE



SECTION OF FRESH AIR INLET LOUVRES IN 5 FT. LENGTHS (MOVEABLE)
¼ FULL SIZE

SECTION OF ROOF

Scale of 0 1 2 3 4 5 6 7 8 9 10 11 Feet



SECTION OF CONTINUOUS VENTILATOR ON ROOF

Scale of 12 9 6 3 0 Feet

Day & Son, Lith.r to the Queen

VENTILATING GRATE, FOUL AIR SHAFT &c.

VENTILATING GRATE.
ELEVATION

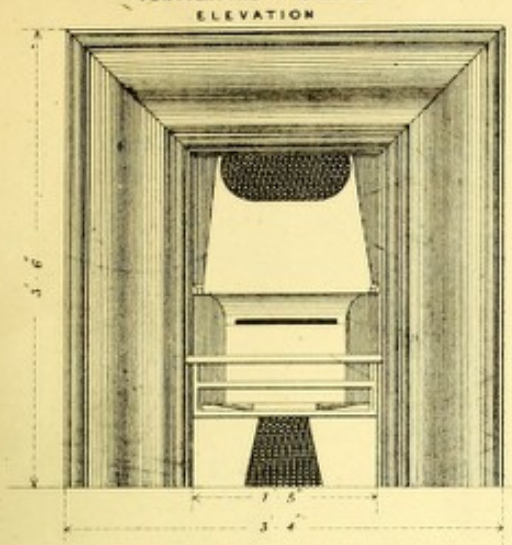
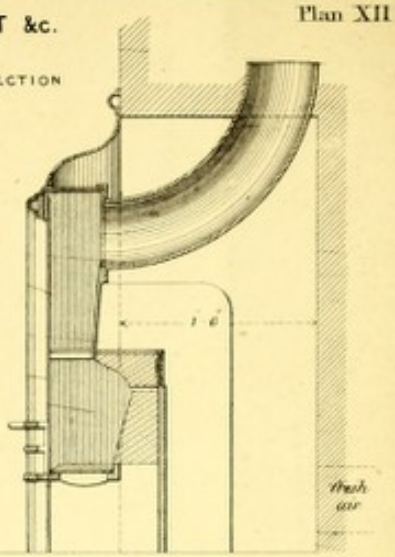


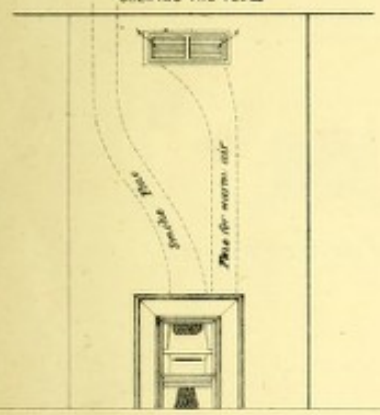
Fig. 1.

Width of Fire Opening	1' 3"	
Dº — Dº	.	1' 5"
Dº . Dº	.	1' 9"
Sizes of Stoves	3' 2"	× 3' 6"
Dº . Dº	3' 4"	× 3' 6"
Dº . Dº	3' 8"	× 3' 6"

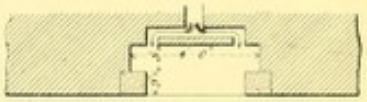
SECTION



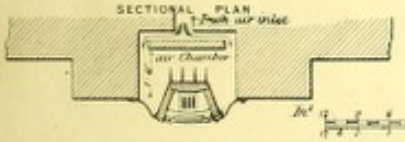
ELEVATION OF CHIMNEY AND STOVE SHEWING THE FLUES



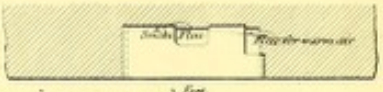
PLAN SHEWING THE METHOD OF FORMING THE AIR CHAMBER IN AN EXISTING 4 FT FIRE PLACE



SECTIONAL PLAN



PLAN OF COVERING STONE FOR AIR CHAMBER



SCALES

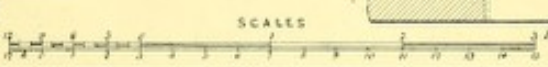
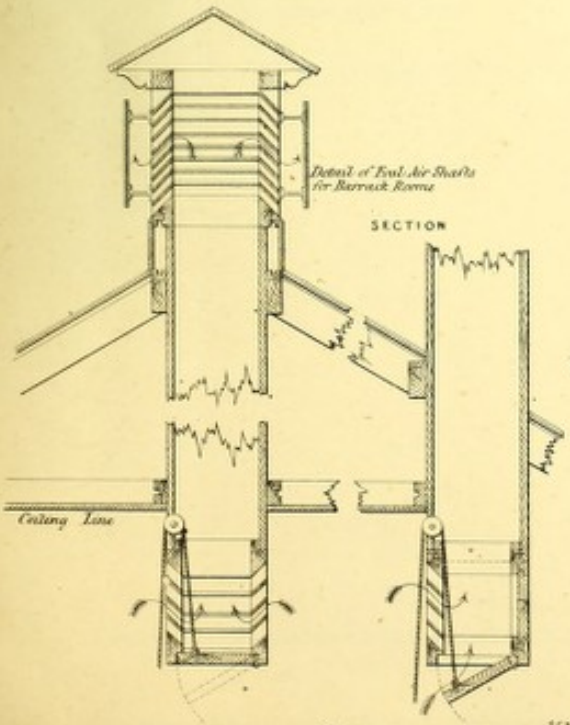
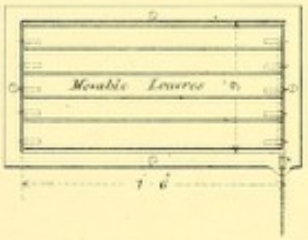


Fig. 2.

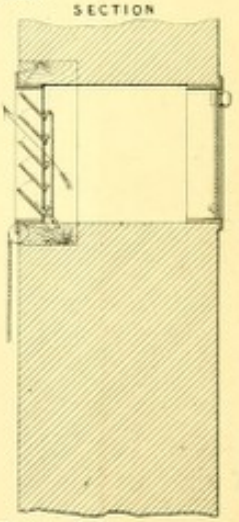
INLET FOR FRESH AIR.



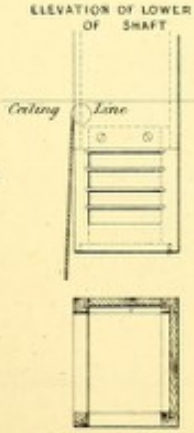
ELEVATION



SECTION

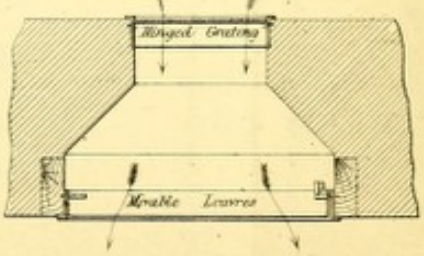


ELEVATION OF LOWER END OF SHAFT

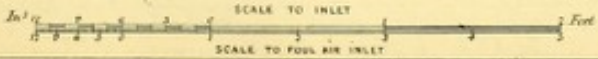


PLAN OF LOUVRE FRAME

SECTIONAL PLAN



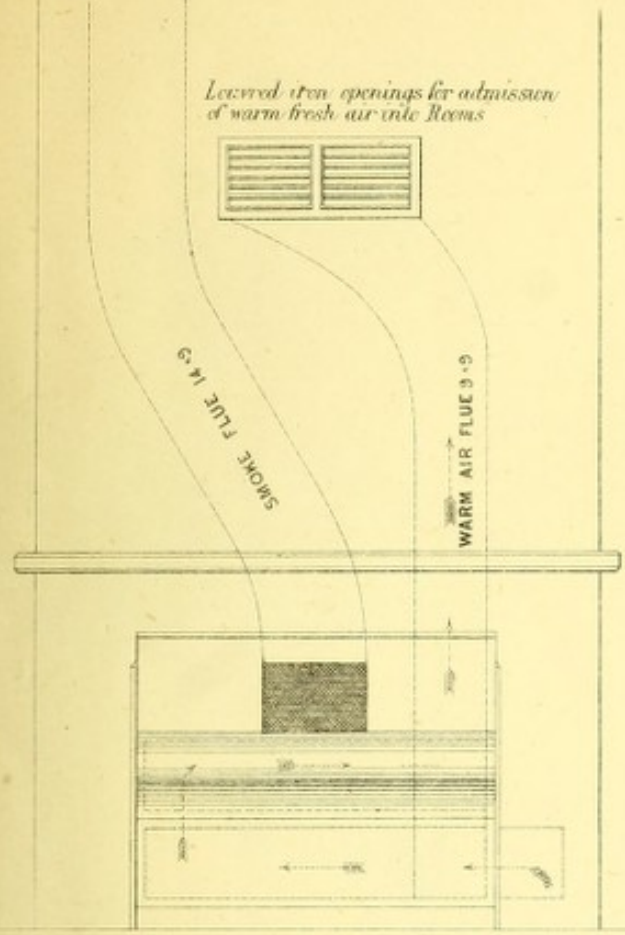
SCALE TO INLET



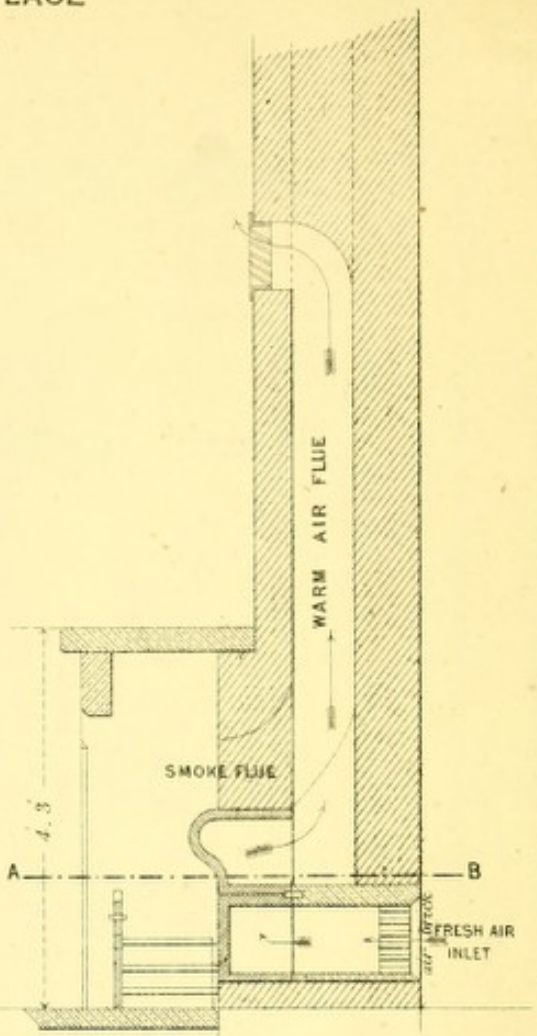
SCALE TO FOUL AIR INLET

Day & Son, Lith.rs to the Queen.

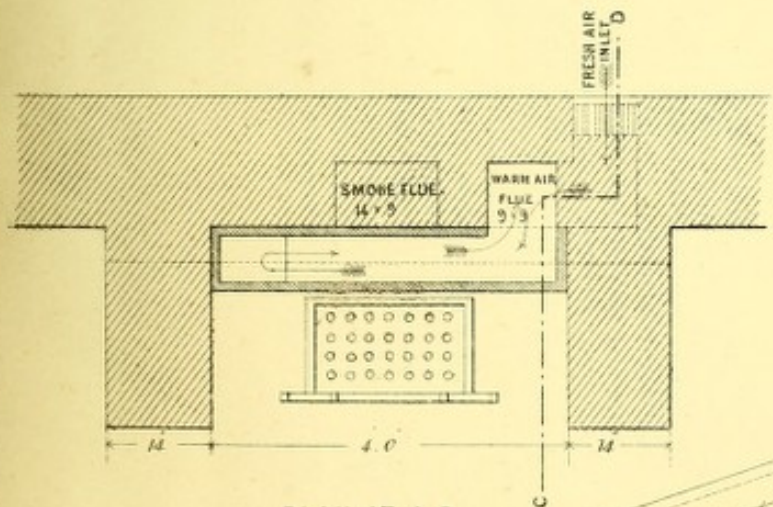
DETAILS. OF FIREPLACE
FOR BURNING WOOD



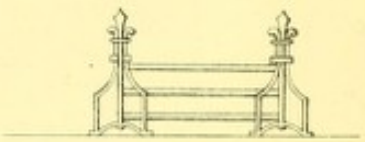
ELEVATION OF FIRE PLACE



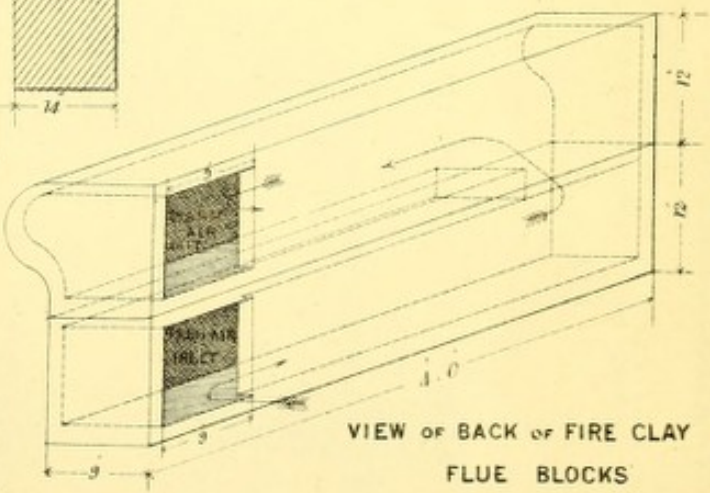
SECTION C.D ON PLAN.



PLAN AT A.B



ELEVATION OF FIRE DOGS

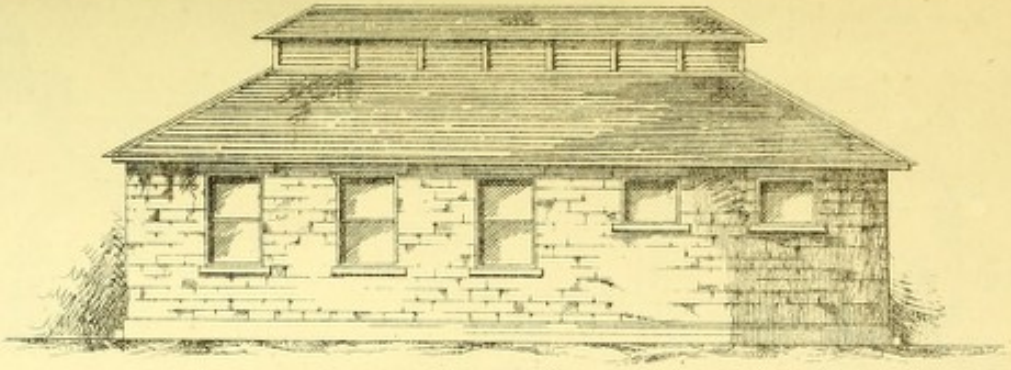


VIEW OF BACK OF FIRE CLAY FLUE BLOCKS

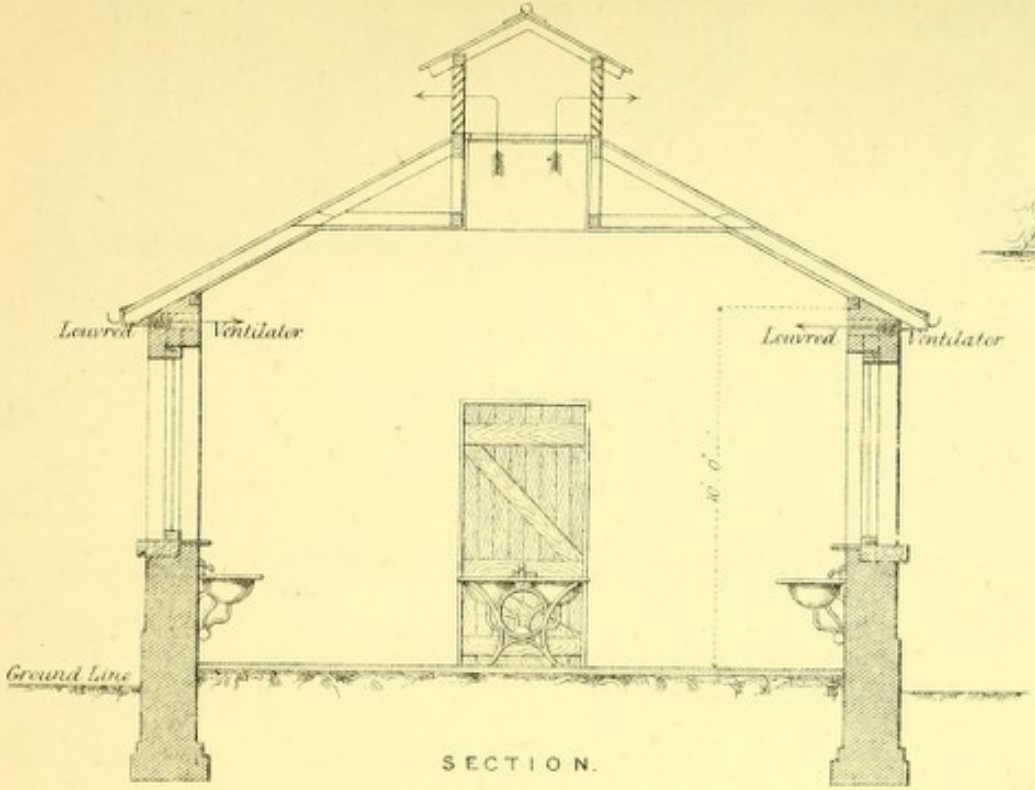
SCALE OF FEET

Day & Son Lith. to the Queen

ABLUTION ROOM & BATHS.



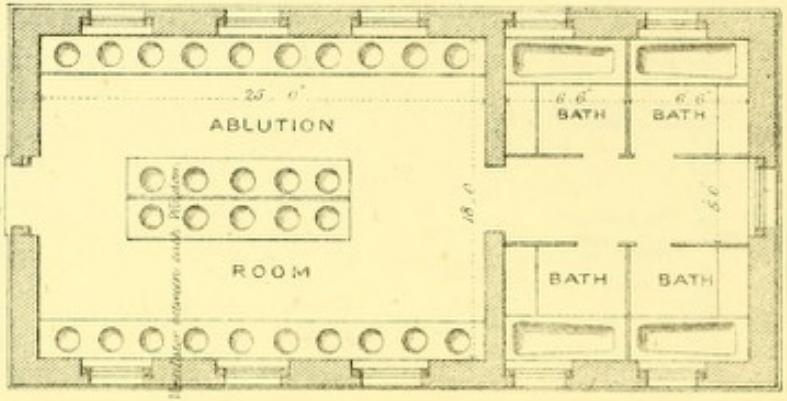
ELEVATION.



SECTION.

Scale to Section.

5 0 5 10 15 feet

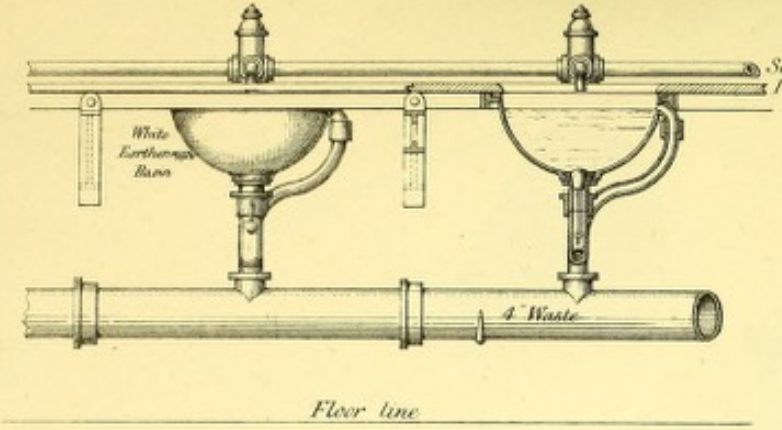


PLAN.

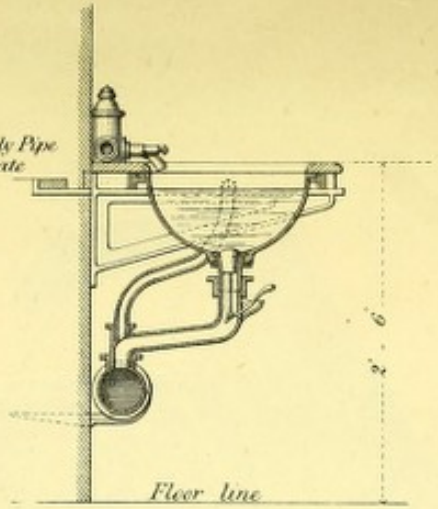
Scale to Plan & Elevation.

5 0 5 10 15 20 25 30 35 feet

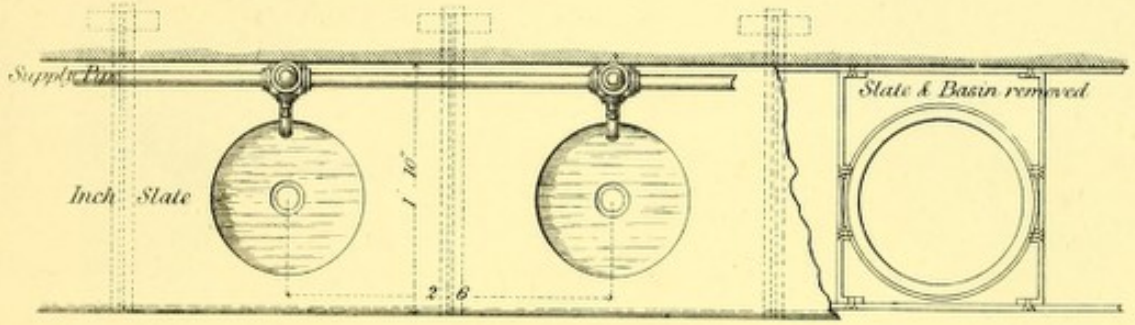
WASHING BASINS



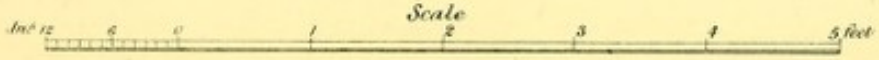
ELEVATION.



SECTION.

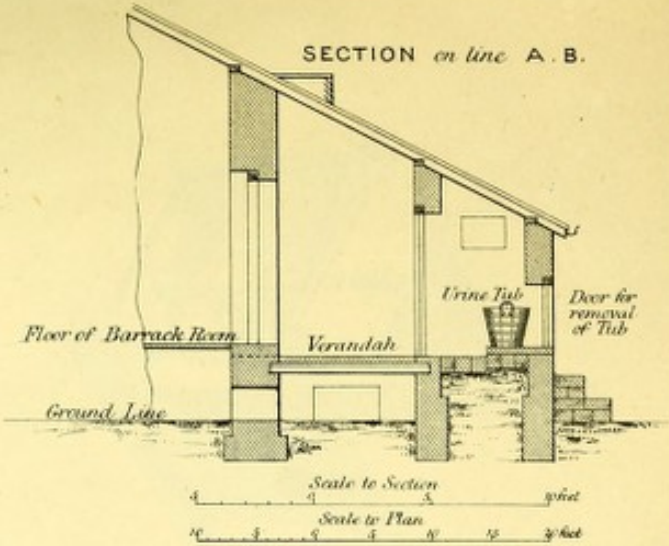


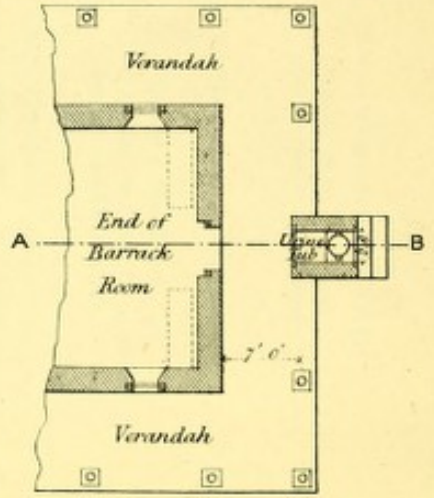
PLAN.



URINE TUB, &c.

SECTION *on line* A. B.





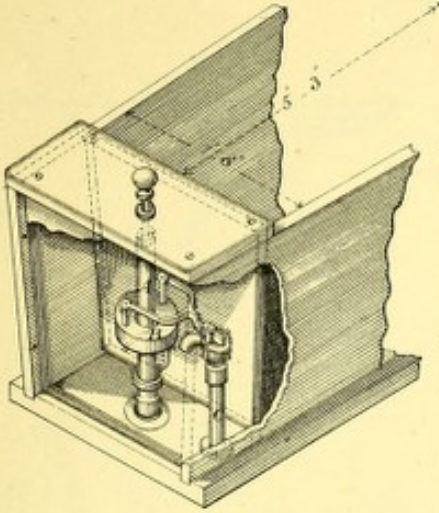
PLAN

Shewing position of Urine Tub under Verandah

Day & Son Lith. to the Queen

JENNING'S SLATE BATH

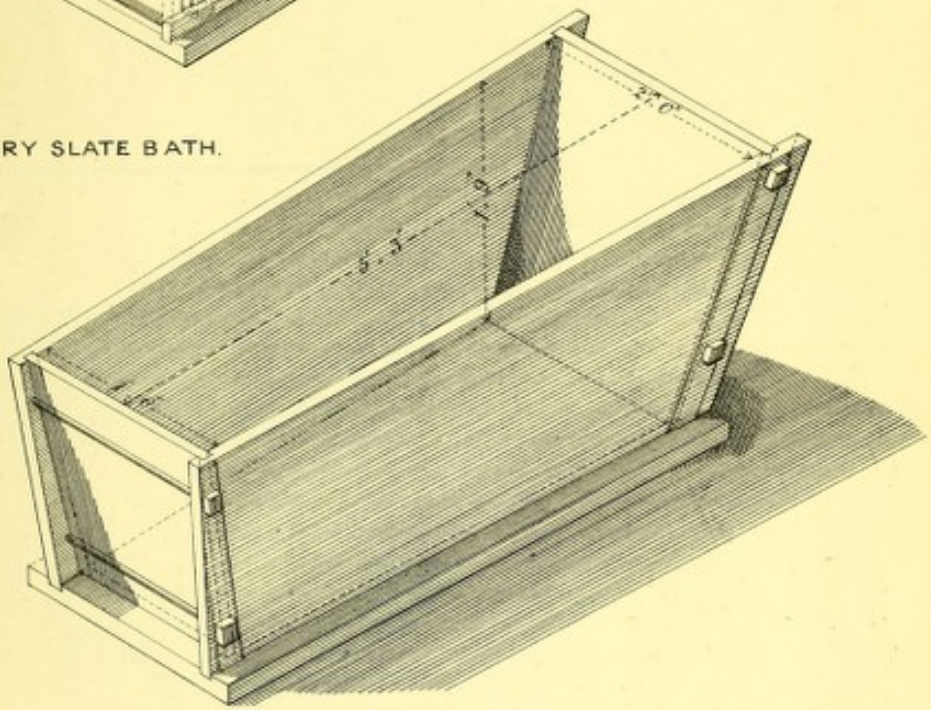
Drawing shewing Supply and Discharge Apparatus.



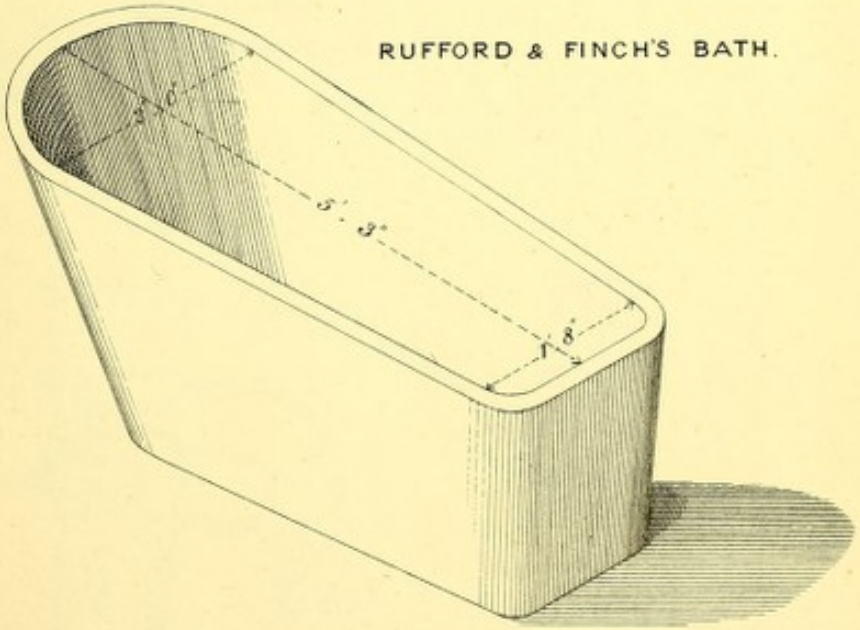
A. *Hollow Plug & Waste.*
B. *Float.*
C *Supply & Hydrostatic Valve to prevent the Bath being filled beyond 9 inches in depth.*

Note. *This Bath is of the same internal dimensions as that figured below.*

ORDINARY SLATE BATH.



RUFFORD & FINCH'S BATH.



Scale of 12 6 0 1 2 3 4 feet

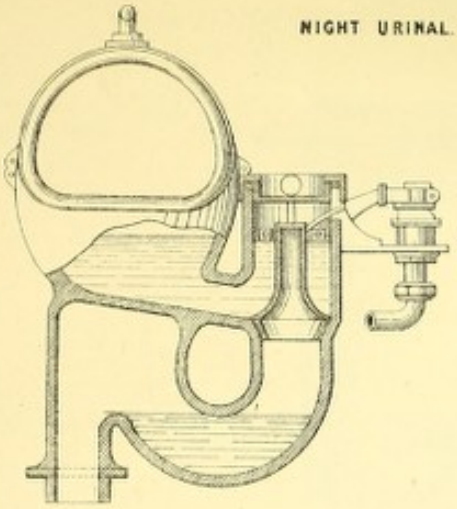
Day & Son, lith. to the Queen.

URINALS.

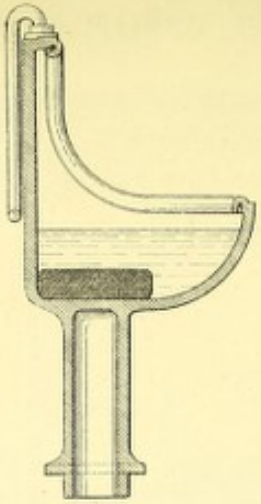
MANUFACTURED BY GEORGE JENNINGS.

LONDON.

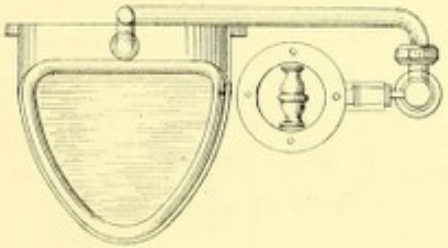
NIGHT URINAL.



FRONT VIEW.

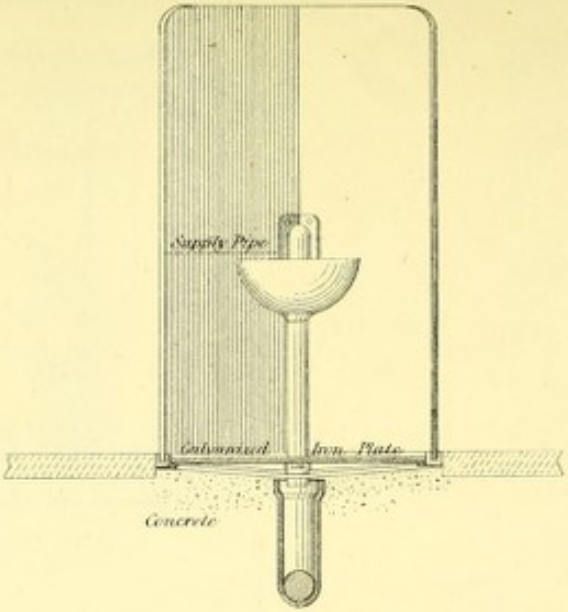


SECTION.

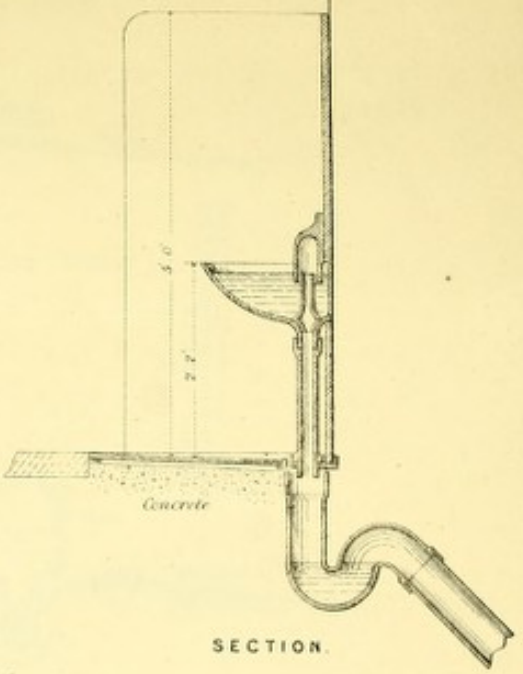


PLAN.

DAY-URINAL.



ELEVATION.



SECTION.

PLAN.

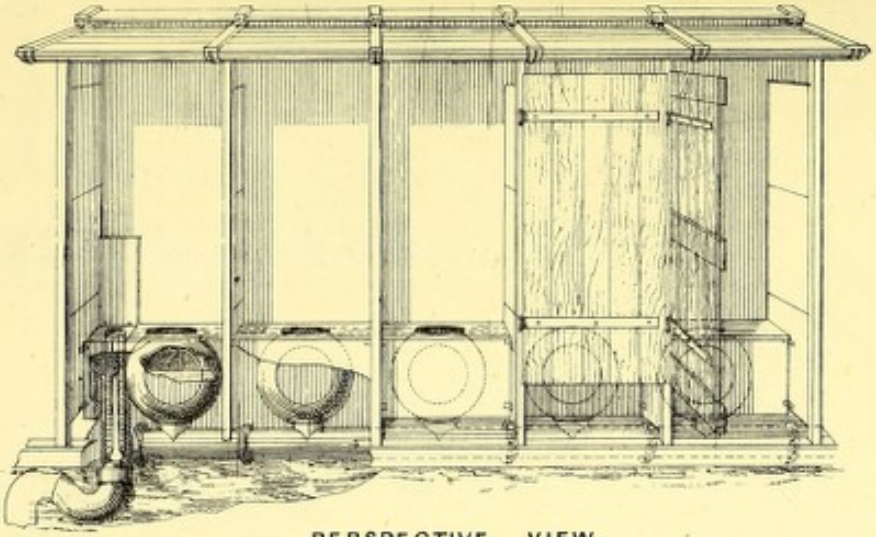
SCALE

SCALE

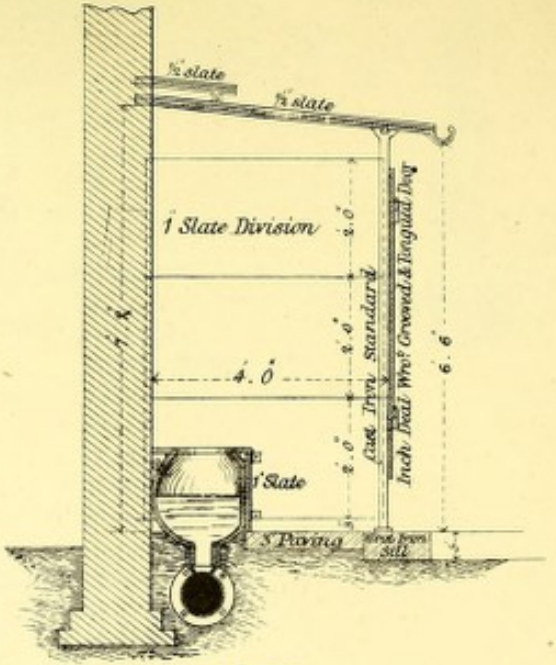
Day & Son Lith.rs to the Queen

LATRINES

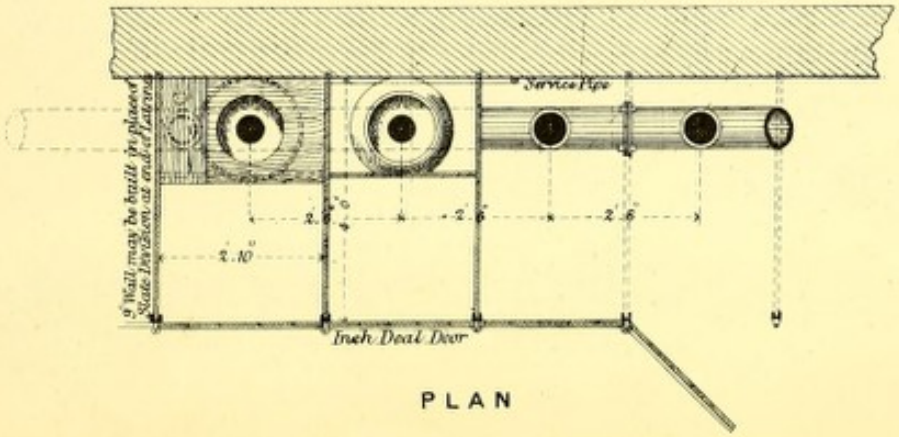
MANUFACTURED BY GEORGE JENNINGS LAMBETH



PERSPECTIVE VIEW



SECTION



PLAN

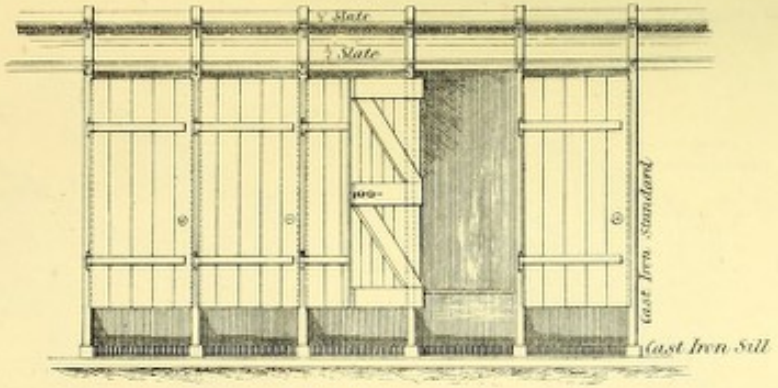
SCALE

Day & Son, Lith.rs to the Queen.

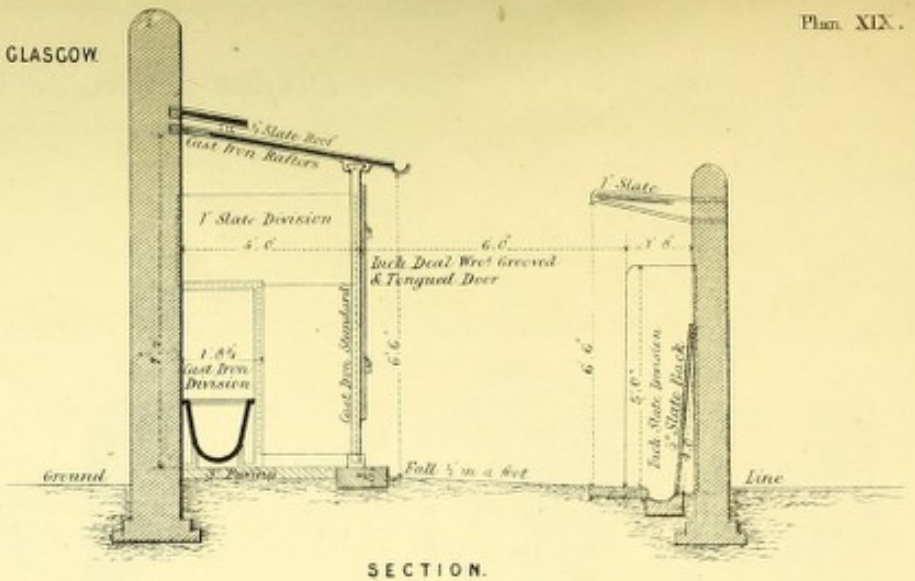
LATRINES & URINALS.

MANUFACTURED BY MACFARLANE & Co. GLASGOW.

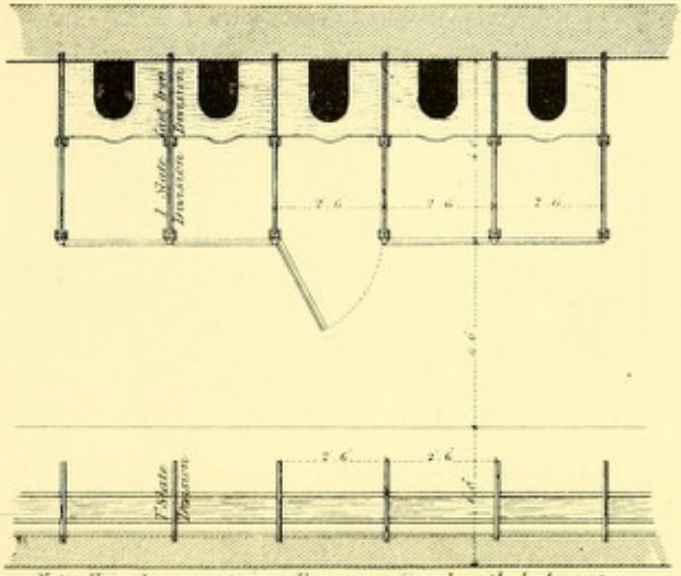
Plan XIX.



ELEVATION.



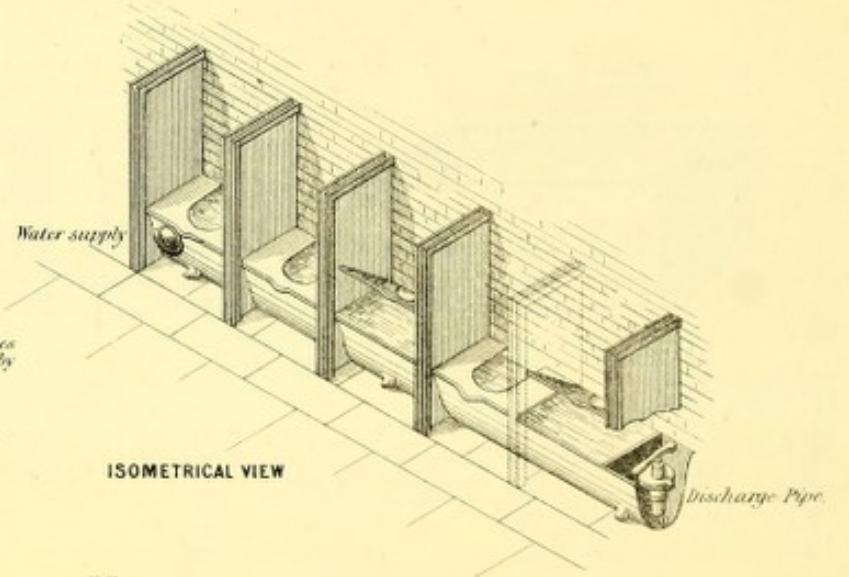
SECTION.



Note, Urinals are not in all cases fixed with Latrines.

PLAN.

Note. The Slate required for Latrines and Urinal is not supplied by Macfarlane & Co.



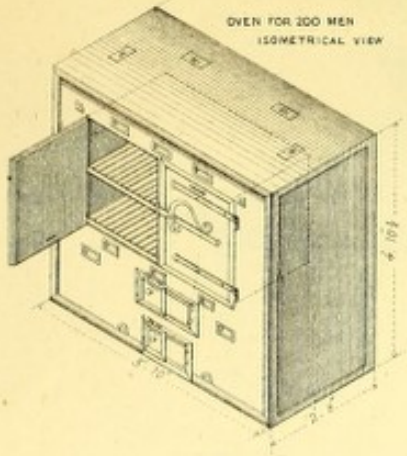
ISOMETRICAL VIEW

SCALE

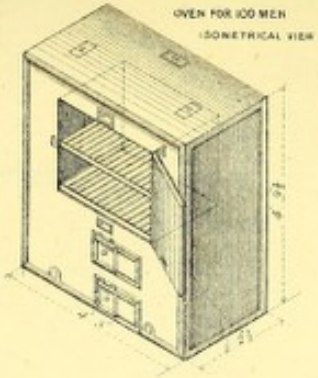
APPROVED PATTERNS OF STEEL COOKING OVENS & BOILERS.

MANUFACTURED BY EDWARD DEANE, 1 ARTHUR STREET EAST, LONDON BRIDGE E.C.

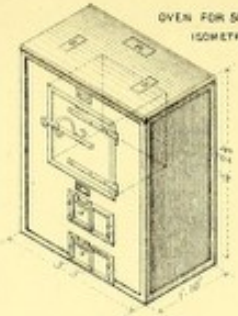
OVEN FOR 200 MEN
ISOMETRICAL VIEW



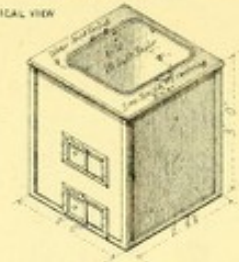
OVEN FOR 100 MEN
ISOMETRICAL VIEW



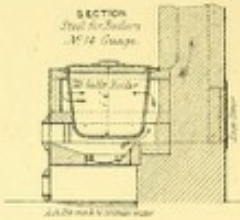
OVEN FOR 50 MEN
ISOMETRICAL VIEW



BOILER FOR 50 MEN
ISOMETRICAL VIEW

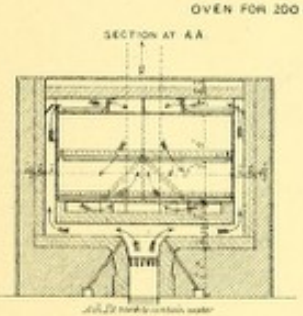


SECTION
Steel for Boilers
No 14 Gauge

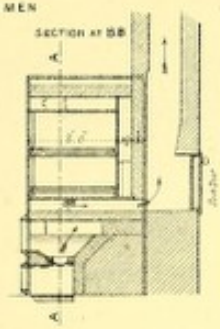


OVEN FOR 200 MEN

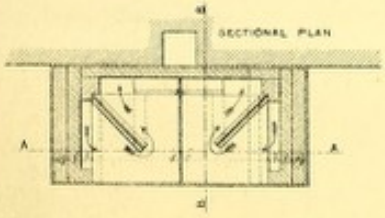
SECTION AT A A



SECTION AT B B

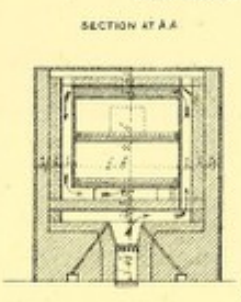


SECTIONAL PLAN

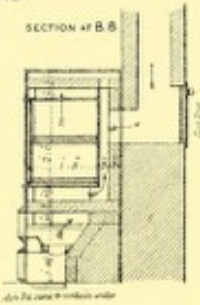


OVEN FOR 100 MEN

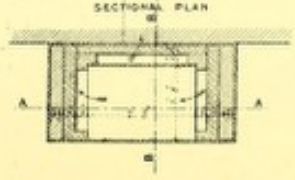
SECTION AT A A



SECTION AT B B

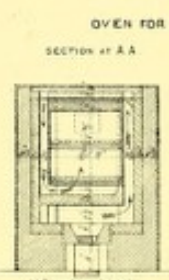


SECTIONAL PLAN

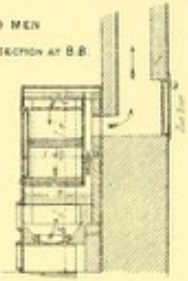


OVEN FOR 50 MEN

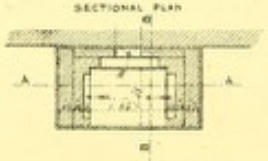
SECTION AT A A



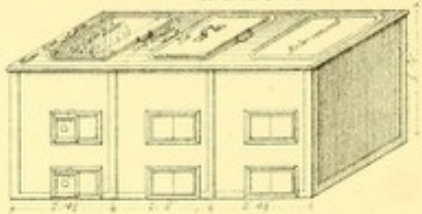
SECTION AT B B



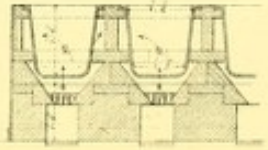
SECTIONAL PLAN



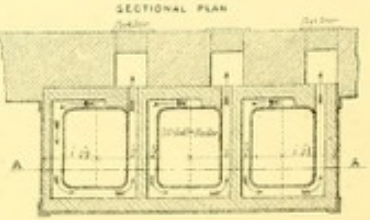
RANGE OF 3 BOILERS
FOR 50 MEN EACH
ISOMETRICAL VIEW



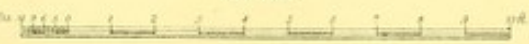
SECTION AT A A



SECTIONAL PLAN

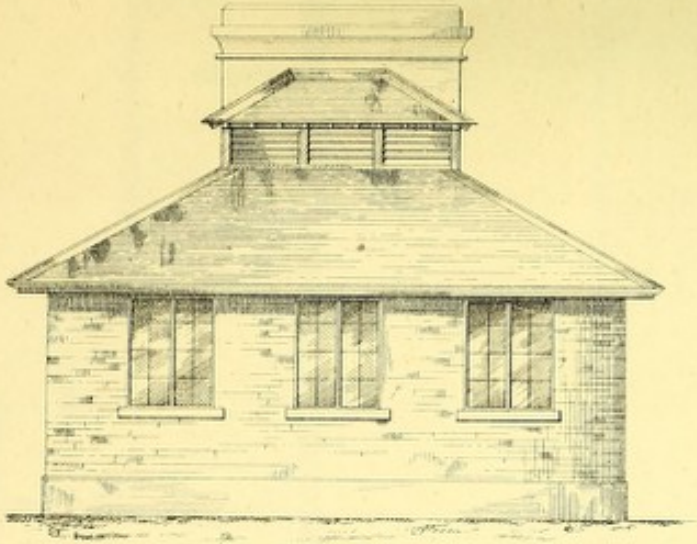


SCALE.

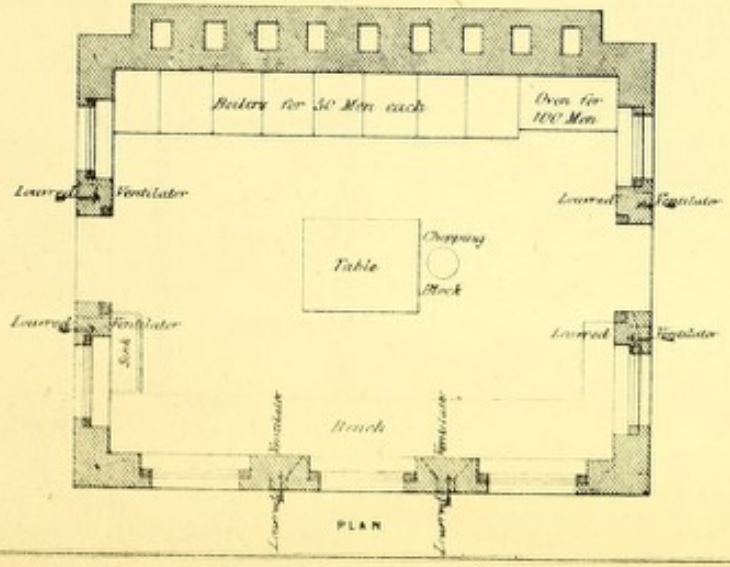


Day & Son, Ltd.ph. to-lith. Gate.

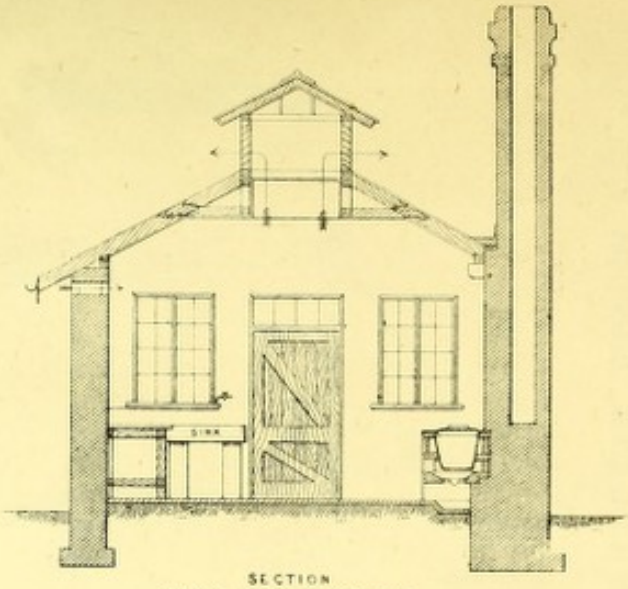
PLAN, ELEVATION & SECTION OF COOKHOUSE.



ELEVATION

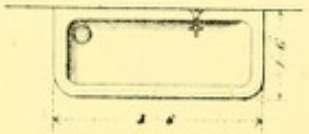


PLAN

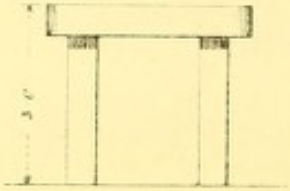


SECTION
SHEWING METHOD OF VENTILATION

SCALE OF FEET FOR PLAN ELEVATION & SECTION



PLAN

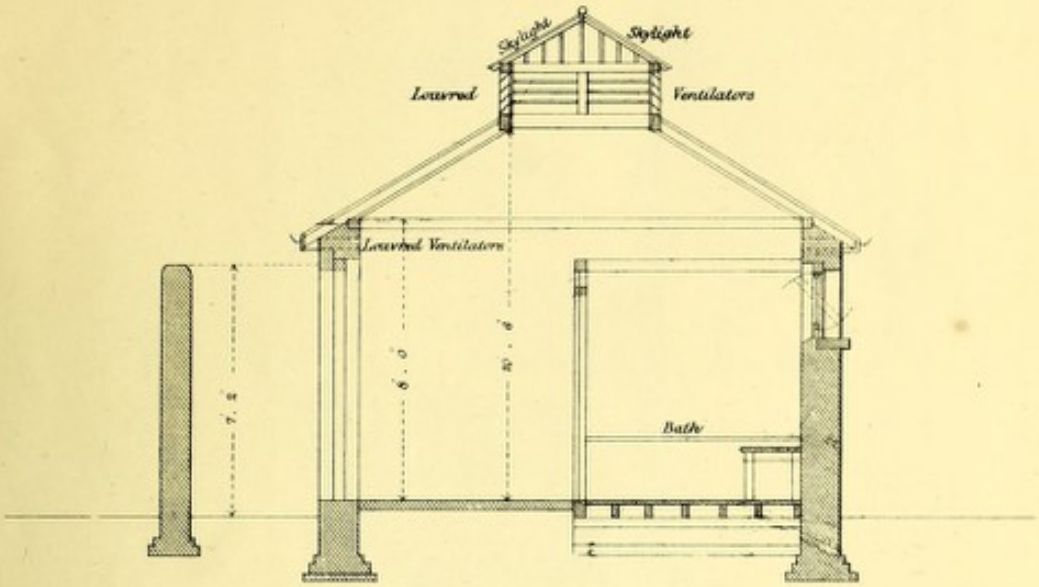


ELEVATION

SINK AND WATER SUPPLY.
3 inch scale.

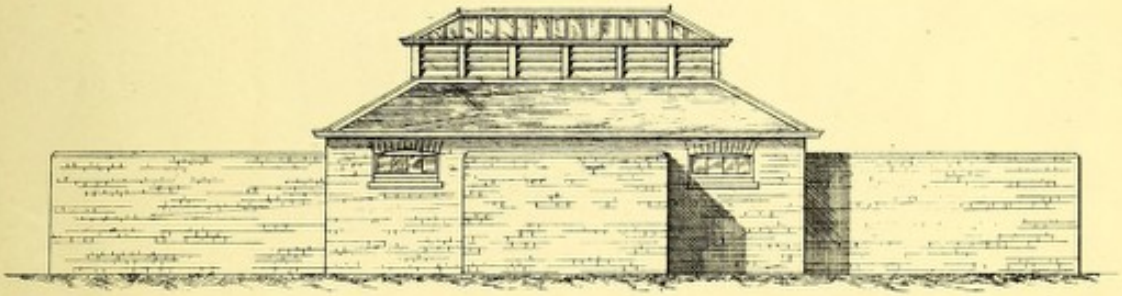
Hazell Watson & Viney Ltd Printers to the Queen

LATRINES ABLUTION ROOMS &c FOR MARRIED SOLDIERS' QUARTERS

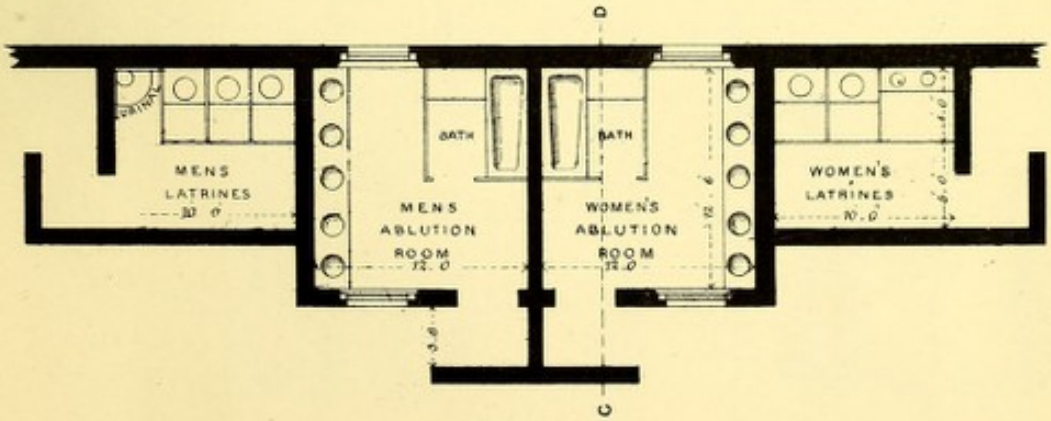


SECTION THRO' C D.

SCALE TO SECTION



ELEVATION



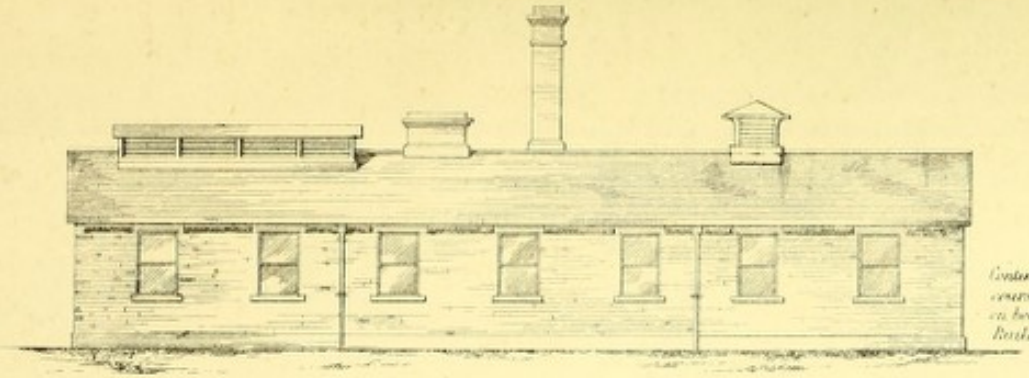
PLAN

SCALE TO PLAN AND ELEVATION

Day & Son, Lith.rs to the Queen

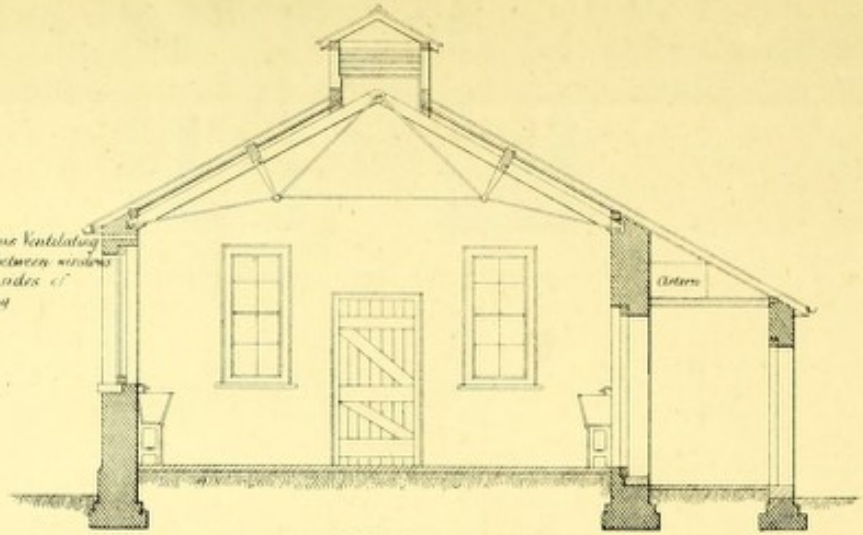
WASH HOUSE & LAUNDRY.

Plan XXIII.

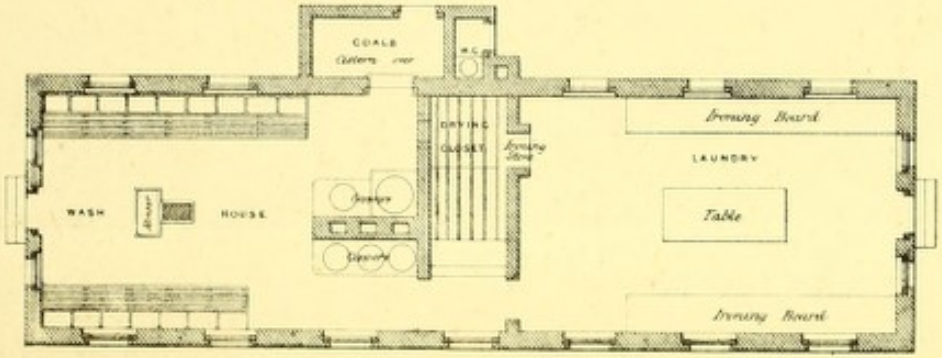


ELEVATION

Old Water only to be laid on to the Washing tubs.
The Ironing Stove & Drying Closet to be of the pattern made for the War Department by Miss Teakle & Co.



SECTION



PLAN

SCALE OF FEET FOR PLAN AND ELEVATION

10 5 0 10 20 30 40 50

SCALE OF FEET FOR SECTION

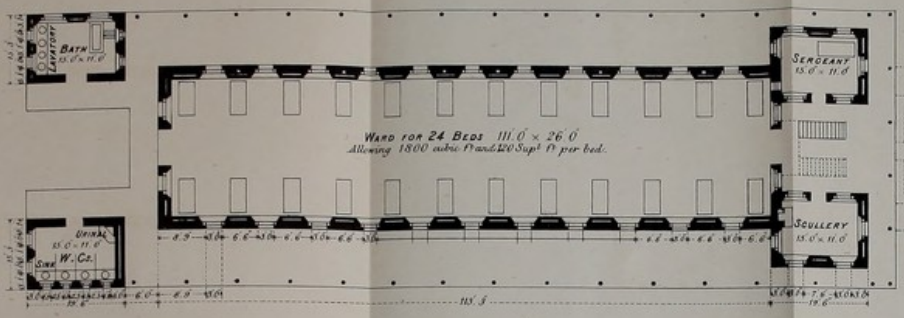
5 0 5 10 15 20 25

Day & Son, Lith.rs to the Queen.

DESIGN

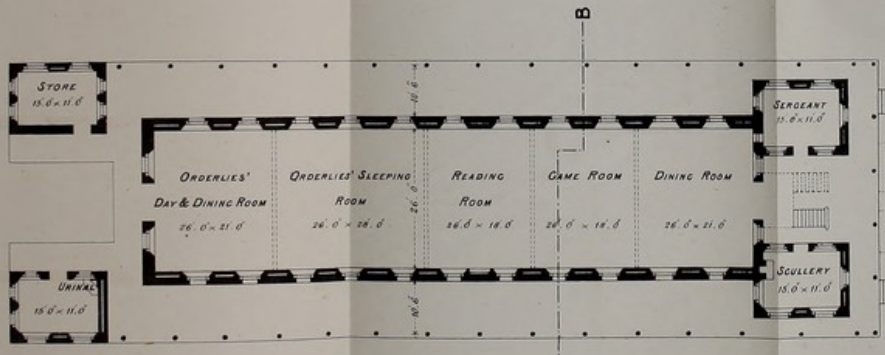
Intended to illustrate the principles of Hospital construction for India, and other warm climates, and embodying the requirements of the Royal commission on the Sanitary state of the Indian Army.

Plan XXIV.



The dotted lines shew position for operating Room if required.

FIRST FLOOR PLAN.



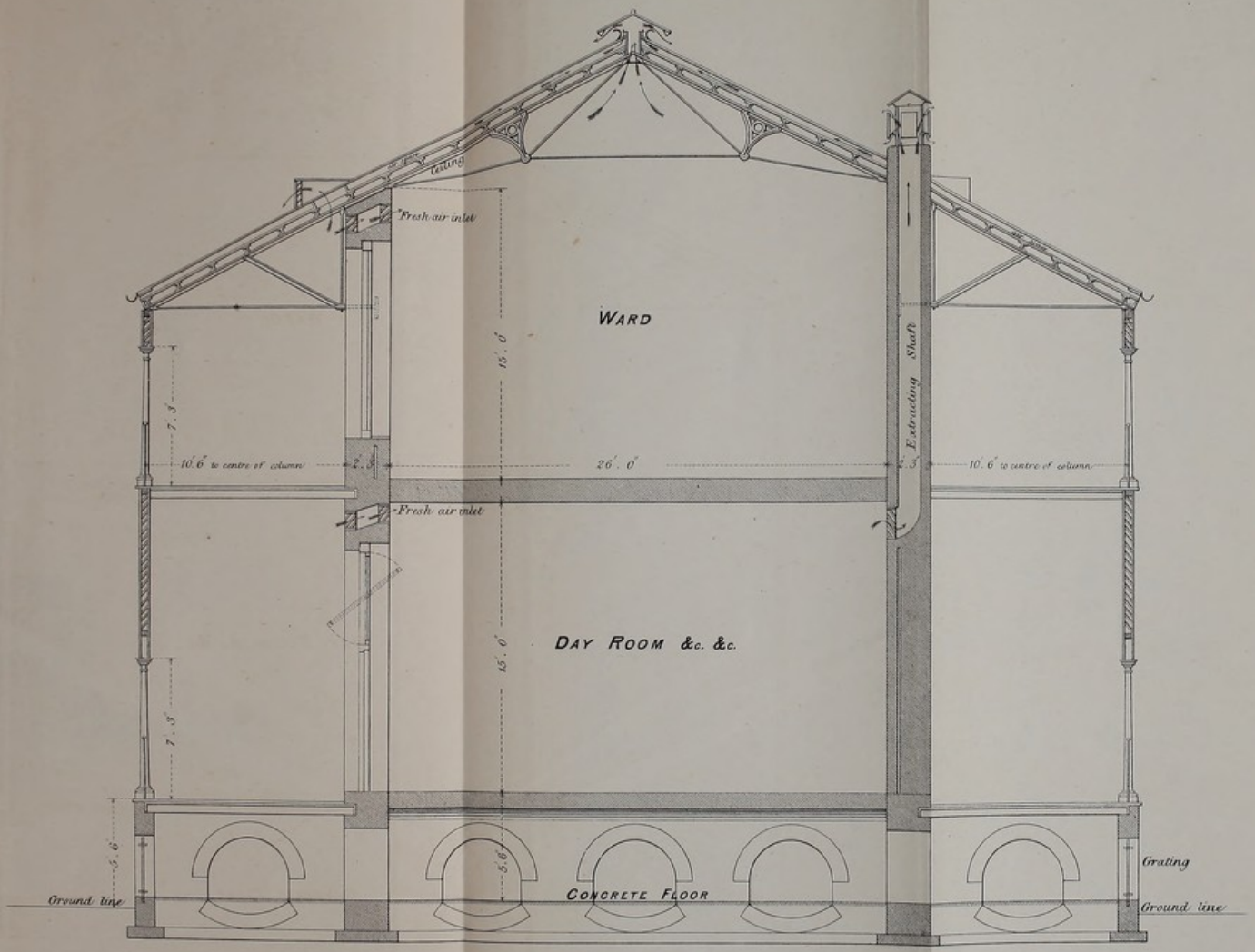
The dotted lines shew position for Surgery if required.

GROUND PLAN

Scale of 10 5 0 10 20 30 40 50 60 70 80 Feet

SECTION OF HOSPITAL

Plan XXV.

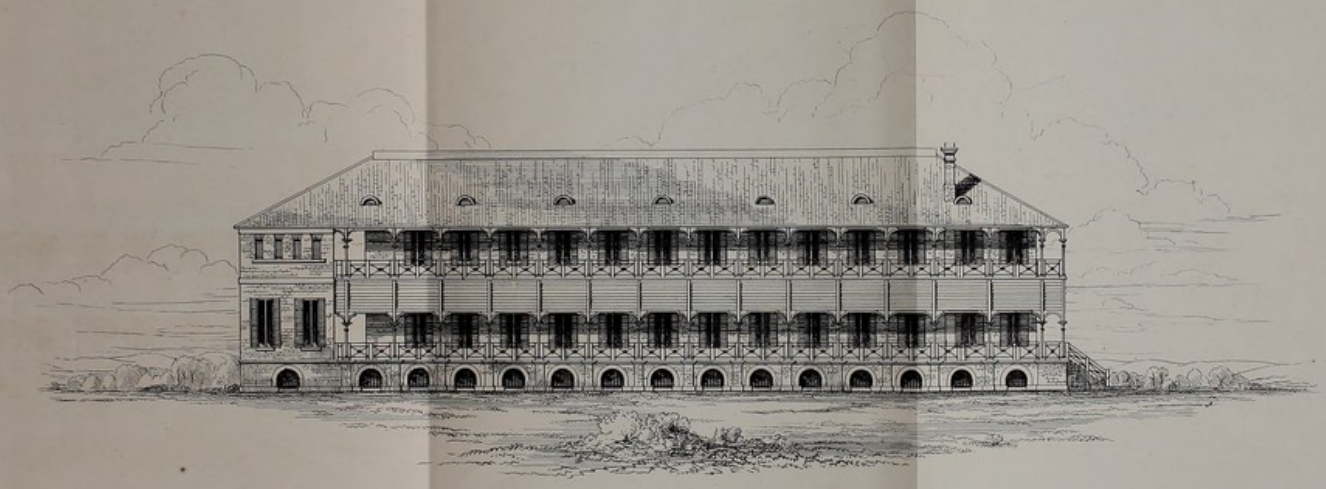


SECTION A.B.

Scale of 10 9 8 7 6 5 4 3 2 1 0 10 20 Feet

DAY & SON, LITH. TO THE QUEEN

ELEVATION OF HOSPITAL

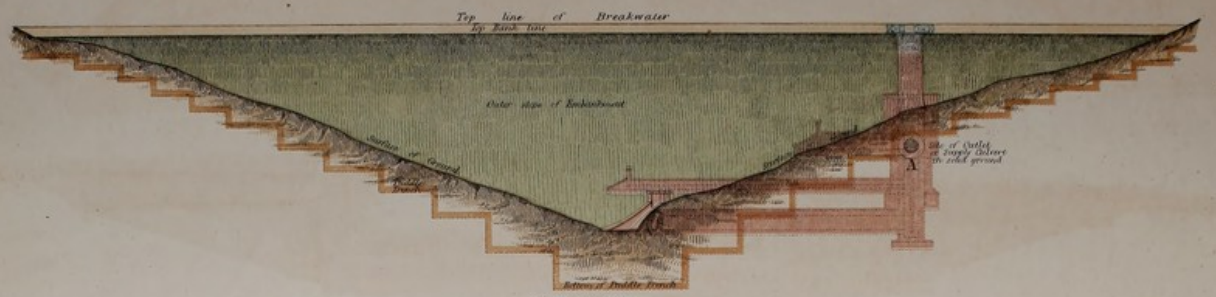


DAY & SON LITH TO THE QUEEN

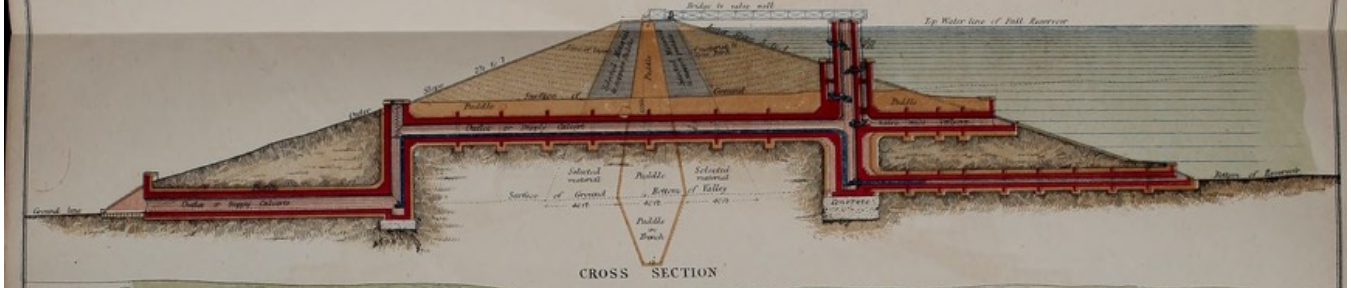
RESERVOIR EMBANKMENT, ENGLISH PLAN,

Plan, Sections & Details

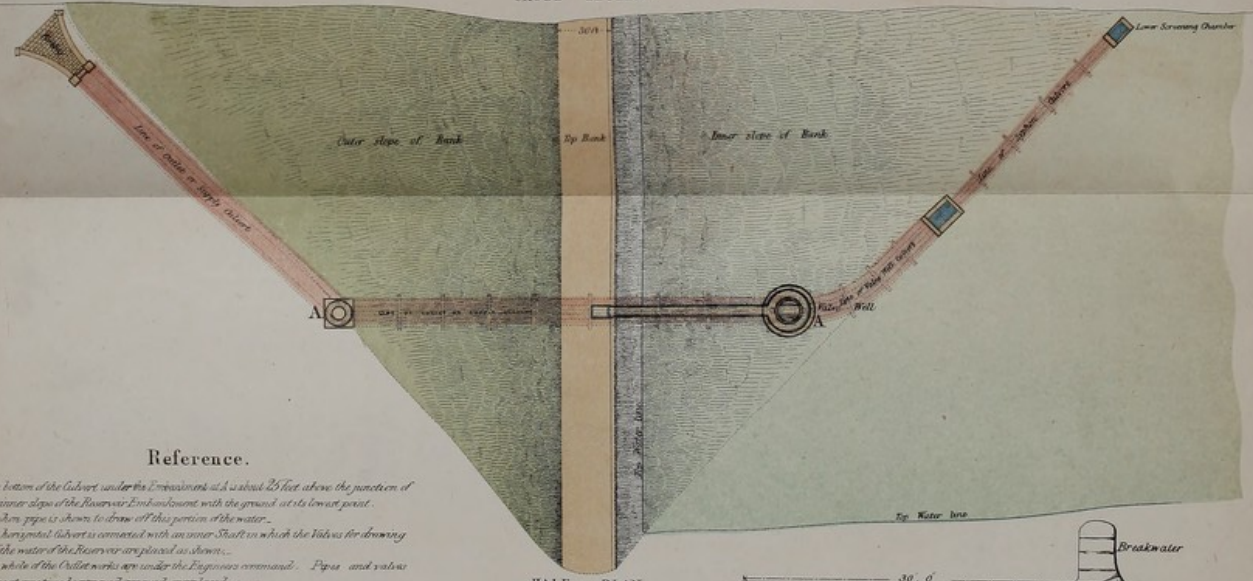
SHOWING OUTLET WORKS IN SOLID GROUND AT A.



ELEVATION.



CROSS SECTION



HALF PLAN

Reference.

The bottom of the Culvert under the Embankment is about 25 feet above the junction of the inner slope of the Reservoir Embankment with the ground at its lowest point.
Syphon pipe is shown to draw off the portion of the water.
The horizontal Culvert is connected with an inner Shaft in which the Valves for drawing off the water of the Reservoir are placed as shewn.
The whole of the Outlet works are under the Engineers command. Pipes and valves may at any time be removed, renewed, or replaced.
The valves can be closed on the inside by valve-spindles and screws. The inlet pipes can be closed on the outside by plugs as shown.

SCALE

ROBERT RAWLINSON, Civil Engineer
London, 1864.