APPENDIX B.

MEASURES TO BE ADOPTED TO PREVENT RATS OBTAINING ACCESS TO VESSELS.

1. There shall be a space of at least three feet between any part of the vessel and the wall of the dock or wharf.

2. All ropes and hawsers connecting the vessel with the dock or wharf shall be furnished with a circular concave convex rat-guard at least four feet in diameter fitting tightly with the concavity towards the wharf on the rope or hawser, and so fixed that no part of the margin of the guard shall be less than 24 inches from the rope or hawser, or any other pattern of rat-guard that may be approved by Government.

3. To prevent rats reaching the ship by means of a gangway, as few gangways shall be used as possible; all gangways shall be raised at night; and a watchman shall be placed on each gangway during the day from the time the gangway is lowered until it is raised.

4. A responsible person shall be deputed by the local Government to ensure these measures being applied immediately the vessel is berthed.

The following are the preventive measures recently adopted in the case of transports arriving in Bombay:—

(1) *Cholera.*—A ship is placed in quarantine in the stream even if a single case of cholera occurs until 14 days have elapsed after the last case, and is not released until all on board have undergone preventive inoculation and excreta of all contacts have been proved by bacteriological examination to be free from vibrios—and all possible chance of 'carrier' infection has been eliminated.

(2) *Small-pox.*—When the appearance of a single case of small-pox on board a transport occurs, compulsory vaccination of every detail on board including the crew is insisted on and the segregation of all when considered necessary.

(3) *Plague.*—When isolated cases of Plague occur with or without mortality among the rats on board, in every case the ship is placed in quarantine for 7 to 14 days after complete fumigation, disinfection and inoculation of all on board. Guinea-pigs are placed on board to serve as a trap for rat fleas and in the event of any infected fleas being found on these guinea-pigs (or the death of a guinea-pig itself from plague proved by post-mortem examination) the ship is subjected to a further period of quarantine until the Assistant Director of Medical Services has been satisfied that the last trace of infection has died out, by the careful ratting of every hold and corner of the ship.

Such routine measures of preventive action are not provided for by any Port Health rules and they cannot be applied by the Port Health Officer to the merchant ships.

CHAPTER II.

Collection, Removal and Disposal of Town Refuse.

Bombay Municipal Act, Calcutta Municipal Act, Madras Municipal Act and the District Municipal Act.

Bombay Act.

S. 365. For the purpose of securing efficient scavengering and cleansing of all streets and premises, the Commissioner (Chairman, President, or Chief Officer), shall take measures for securing—

(*a*) the daily surface cleansing of all streets in the City and the removal of the sweepings therefrom ;

(*b*) the removal of the contents of all receptacles and depôts and of the accumulations at all places provided or appointed by him under section 367 or 368 for the temporary depôsit of any of the matters specified in the said sections.

S. 366. All matters collected by Municipal servants or contractors in pursuance of the last preceding section and of section 369 shall be the property of the Corporation.

S. 367. (1) The Commissioner shall provide or appoint in proper and convenient situations public receptacles, depots and places for the temporary deposit or final disposal of—

(*a*) dust, ashes, refuse and rubbish ;

(*b*) carcasses of dead animals and excrementitious and polluted matter ;

(2) Provided that—

(*c*) the said matters shall not be finally disposed of in any place or manner in which the same have not heretofore been so disposed of, without the sanction of the Corporation, or in any place or manner which Government think fit to disallow ;

(*d*) any power conferred by this section shall be exercised in such manner as to create the least practicable nuisance.

S. 368. (1) It shall be incumbent on the occupiers of all premises to cause all dust, ashes, refuse and rubbish to be collected from their respective premises and to be deposited at such times as the Commissioner, by public notice, from time to time prescribes, in the public receptacle, depôt or place provided or appointed, under clause (*a*) of the last preceding section, for the temporary deposit thereof.

(2) Provided that the Commissioner may, if he thinks fit, by written notice, require the occupier or owner of any land, to cause all dust, ashes, refuse and rubbish to be collected daily, or otherwise periodically, from the said land and from any building standing thereon and deposited

temporarily upon any place forming a part of the said land which the Commissioner appoints in this behalf, and it shall be incumbent on the said occupier to cause the said matters to be collected and deposited accordingly.

S. 369. When the Commissioner has given public notice, under clause (*a*) of section 142, of his intention to provide in a certain portion of the City, for the collection, removal and disposal, by municipal agency, of all excrementitious and polluted matter, from privies, urinals and cesspools, it shall be lawful for the Commissioner to take measures for the daily collection, removal and disposal of such matter from all premises situate in the said portion of the City.

S. 370. It shall be incumbent on the occupier of any premises situate in any portion of the City, for which the Commissioner has not given a public notice under clause (*a*) of section 142 and in which there is not a water-closet or privy connected with a municipal drain, to cause all excrementitious and polluted matter accumulating upon his premises to be collected and to be conveyed to the nearest receptacles or depôt provided for the purpose under clause (*b*) of section 367, at such times, in such vehicle or vessel, by such route and with such precautions as the Commissioner by public notice from time to time prescribes.

S. 371. In any portion of the City in which the Commissioner has given a public notice under clause (*a*) of section 142, and in any premises, wherever situate, in which there is a water-closet or privy connected with a municipal drain, it shall not be lawful, except with the written permission of the Commissioner, for any person, who is not employed by or on behalf of the Commissioner, to discharge any of the duties of halalkhors.

S. 372. No person—

(*a*) who is bound under section 368 or section 370 to cause the removal of dust, ashes, refuse and rubbish, or of excrementitious or polluted matter, shall allow the same to accumulate on his premises for more than twenty-four hours, or neglect to cause the same to be removed to the depôt, receptacle or place provided or appointed for the purpose;

(*b*) shall remove any dust, ashes, refuse or rubbish or any excrementitious or polluted matter, otherwise than in conformity with the requirements of any public or written notice at the time being in force under section 368, or use for the removal of any excrementitious or polluted matter any vehicle or vessel not having a covering proper for preventing the escape of any portion of the contents thereof, or of the stench therefrom;

(*c*) shall whilst engaged in the removal of any dust, ashes, refuse or rubbish or of any excrementitious or polluted matter, fail forthwith thoroughly to sweep and cleanse the spot in any street upon which, during removal, any portion thereof may fall, and entirely to remove the sweepings;

(*d*) shall place or set down in any street any vehicle or vessel for the removal of excrementitious or polluted matter, or suffer the same to remain in any street for any greater length of time than is reasonably necessary ;

(*e*) shall throw or place any dust, ashes, refuse or rubbish, or any excrementitious or polluted matter on any street or in any place not provided or appointed for this purpose under section 367 or 368 ;

(*f*) who is the owner or occupier of any building or land, shall allow any filthy matter to flow, soak or be thrown therefrom, or keep or suffer to be kept therein or thereupon, anything so as to be a nuisance to any person, or negligently suffer any privy-receptacle or other receptacle or place for the deposit of filthy matter or rubbish on his premises to be in such a state as to be offensive or injurious to health.

S. 373. If it shall in any case be shown that dust, ashes, refuse or rubbish, or any excrementitious or polluted matter, has or have been thrown or placed on any street or place, in contravention of clause (*e*) of the last preceding section, from some building or land, it shall be presumed, until the contrary is proved, that the said offence has been committed by the occupier of the said building or land.

The cleansing of a city forms the basis of all health reforms and devolves on the Sanitary Authority.

The term 'sewage' means all excrementitious and polluted matter capable of being removed by drains and sewers in a liquid or semi-liquid state.

'House refuse' is defined in the London Public Health Act, 1891, as consisting of ashes, cinders, breeze and night-soil filth, but does not include trade refuse.

In India, the term 'household and street refuse' includes all waste material from houses and shops which cannot be removed by drains, and includes very little cow-manure but large quantities of horse-stable manure and refuse, and bullock droppings, street sweepings and gully refuse, leaves, garden refuse, fruit and vegetables, old glass, tin and much paper, dead animals, etc.

In India decomposition is so rapid, and flies and other insects are so numerous, that decomposing matter is more dangerous than in temperate and cold climates.

Diarrhœa, Dysentery, Cholera, Enteric are much more liable to be spread by flies conveying the germs from infected refuse.

'Trade refuse' means the refuse of any trade, manufacture or business or of any building materials.

It is always necessary to collect and convey refuse some distance, and as a rule transhipment of the refuse from carts to Railway wagons is necessary, and then again another unloading. All this is expensive and dangerous to health.

COMPOSITION OF ENGLISH AND INDIAN REFUSE, HOUSEHOLD AND STREET REFUSE.

Various methods are adopted in cities and towns in India for the collection and removal of refuse. The actual method varies somewhat. Bullock carts are the usual form of motive power. In Calcutta horses are used. Steam and petrol wagons have been adopted in Bombay; the refuse thus collected is carried to Railway sidings and then hauled outside the Island and used for reclaiming land. In Calcutta and Madras, some of the refuse is thus disposed of and part of it is incinerated; in other places it is mixed with night-soil and trenched.

In London the house refuse amounts to 1¼ million tons per annum, 4—5 cwts. per head per annum, but is much heavier, bulk for bulk, than Indian refuse.

WEIGHT OF HOUSE REFUSE PER 1,000 PEOPLE.

The average weight in towns away from the coal fields is 15 cwts. per 1,000 of the population per day. But in mining districts the average weight is 35 cwt. per 1,000 of the population per day.

BOMBAY.

The amount of refuse in Bombay including all household waste, stable manure from private stables, road sweepings, shop sweepings and office paper and garden refuse works out to 2·2 lbs. per day per head of the population, or ·36 of a ton per annum, about 7 cwts. per head per annum.

This does not include dung from milch-cattle stables during the dry months, as this is used for cow-dung cakes.

In tropical climates this refuse decomposes much more rapidly than in more temperate countries, especially in the rains, and it is thus necessary that the storage of refuse should not be allowed but that it should be removed twice a day at least.

This entails a large outlay, both in manual labour and vehicular plant, more supervision and a larger staff, as much depends on the rapidity and thoroughness with which the work is done.

The habits of the people in throwing all waste matter into the streets tend to make the work of cleansing the City more difficult, while their customs and modes of cooking and cleaning utensils increase the amount of household refuse.

Indian refuse or *cutchra* contains very little coal or cinders, and is largely composed of stable bedding, horse dung, and vegetable refuse, mixed with street sweepings, kitchen refuse, old glass, metals, etc.

COMPARISON OF AN AVERAGE SAMPLE OF A LARGE INDIAN CITY'S REFUSE WITH THAT OF LONDON REFUSE.

	REFUSE OF INDIAN CITY.	
1.	Hay	42·4
2.	Waste Paper	21·2
3.	Dry leaves, *bidees*, &c.	14·3
4.	Vegetable matter (green)	8·2
5.	Dung	4·6
6.	Drain stuff	4·0
7.	Dust	3·0
8.	Straw	1·5
9.	Ashes	1·5
10.	Garden clippings	1·0
11.	Offal, fish refuse, &c.	·9
12.	Glass	·6
13.	Green leaves, grass, &c.	·6
14.	Cotton waste	·3
15.	Tins	·2
16.	Rags	·1
17.	Cinders	·4
18.	Broken crockery	·1
19.	Bones	·1
	Total	100·0

	REFUSE OF LONDON.	
1.	Cinders and ashes	63·69
2.	Dust	19·51
3.	Vegetable, animal and various mineral matters	4·61
4.	Waste paper	4·28
5.	Straw, &c.	3·22
6.	Bottles	·99
7.	Coal and Coke	·84
8.	Tins	·79
9.	Crockery	·55
10.	Bones	·48
11.	Broken glass	·47
12.	Rags	·39
13.	Iron	·21
	Total	100·0

During the monsoon it is generally very wet and soft, wet vegetable refuse lies so close that air cannot penetrate it to support combustion, and unless special means are employed to burn it, no satisfactory results may reasonably be expected.

COLLECTION AND REMOVAL OF REFUSE.

The practice of depositing refuse and waste material on the roadside or foot-path is common in most cities.

This is to be avoided by providing sanitary bins into which the refuse should be deposited and which should be emptied by travelling-carts twice a day.

All refuse carts should be covered, so that when full there will be no nuisance as they proceed along the streets.

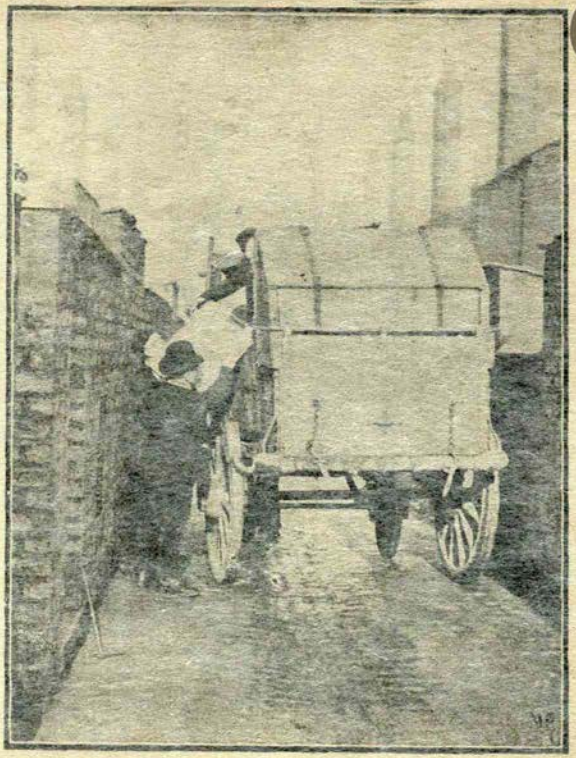
The refuse thus collected can be taken either direct to the incinerator or reclamation ground or to the Railway siding. In the latter case, the siding should be so arranged that the carts can tip directly into the wagons.

A Railway wagon holds 12 to 15 tons of refuse.

The maximum amount of work a pair of bullocks well-fed can do in a day is to travel 20 miles and draw a load of 8 cwts. in a 2-wheeled, or 16 cwts. in a 4-wheeled cart on a level and good road. This means loaded one way and empty for the return, and no detention for loading, *i.e.*, on return with an empty cart, they should be yoked to a cart loaded ready for removal. If the cart has to go from place to place collecting refuse, the number of trips that it makes will be less than if working with a duplicate cart. A cubic yard of house refuse in India weighs about 8 cwts. to 10 cwts. and this weight represents the capacity of a Bombay City refuse cart.

In Bombay, the life of a bullock may be taken as 5 years; the cost of haulage of this household and street refuse by bullocks is :—

REMOVING AN ASHBIN, LONDON.



DUST BIN CART, LONDON.

		Rs.
(*a*)	Cost of a pair of bullocks	265
(*b*)	Feed of a pair of bullocks at Rs. 40 per mensem for 5 years, 40 × 12 × 5	2,400
(*c*)	Shoeing and veterinary treatment for a pair at Rs. 5 per mensem=5×12×5	300
(*d*)	A cart costs Rs. 500 and by taking the total number of carts scavengering and drain, it works out to that (each) pair of bullocks has 2 carts, hence	1,000
(*e*)	Repairs to (*d*) for 5 years	600
(*f*)	Stabling accommodation for (*a*) and (*d*) 15 p. c. of 600 ..	90
(*g*)	A cart-driver's pay is now Rs. 24 per mensem but deducting absentees will make the average	1,440
(*h*)	Accommodation for cart-driver at 10 p. c.	144

The total is Rs. 6,239 for 5 years, and during this period a pair of bullocks removes 2,190 tons, the cost of removal being Rs. 2-13-7 per ton.

As many as 2,300 carts are now unloaded at the siding in Bombay daily :—

Cost of unloading carts at the siding, loading wagons and haulage and unloading of the same calculated on an average of 2,200 *cart loads per day :—*

134 men at Rs. 23-8-0 per mensem each and 21 women at Rs. 19 each per mensem, 3 mukadams at Rs. 29 each per mensem, 2 trip markers at Rs. 70 each per mensem and 2 overseers at Rs. 135 and 110 per mensem=Rs. 4,020.

The number of trips made to the siding daily is about 2,200, *i.e.*, 880 tons, 26,400 tons per mensem, and to unload this costs Rs. 4,020 or annas two and pies five per ton.

The haulage from siding to reclamation ground costs Rs. 4 per wagon, unloading costs Rs. 7-1-4 per wagon, and as an average of 32 carts or 14 tons go to a wagon, 1 ton costs

	Rs. a. p.
or hauling and unloading.....	0 10 6
For up-keep of permanent-way..	0 2 2
Per ton ..	0 12 8

The up-keep of a wagon costs Rs. 140 per annum and as a

wagon carries roughly 14 tons and makes a trip a day, and one every alternate Sunday (340 a year),

$340 \times 14 = 4{,}760$ tons a year.

	Rs.	a.	p.
The cost of up-keep per ton is then	0	0	6
Summary of cost per ton—			
Removal from section to siding	2	13	7
Unloading at siding	0	2	5
Haulage to reclamation ground and unloading there	0	12	8
Up-keep of rolling stock	0	0	6
Rs. ..	3	13	2
Supervision on Rs. 3-13-2	0	9	2
Total Rs. ..	4	6	4
Total cost per ton	4	6	4

Feed of Bullocks.

Ooreed and moongh belong to the same class as grass, *viz.*, the bean tribe. The following is their composition, which will show their nutritive value to be almost exactly alike, if anything moongh is richer in nitrogenous matter than ooreed :—

	Ooreed.	*Moongh.*
Water	11·00	9·20
Nitrogenous matter	22·48	24·70
Fatty matter	1·46	1·48
Carbo-hydrates	62·15	60·36
Salts	2·91	3·26

Both of these form the food of cattle in parts of India.

	Gram.	*Bran.*	*Ooreed.*
Water	10·80	13·6	11·10
Proteids	19·32	13·6	22·48
Fat	4·56	3·4	1·46
Carbo-hydrates	62·20	54·9	62·15
Salts	3·12	5·6	2·91

As a food, bran by itself is useless in spite of its chemical composition, but as an adjunct to other foods it is undeniably valuable. Both gram and bran contain a larger proportion of fat than ooreed and in the majority of dietaries

fat finds a place, and when hard work is to be done an excess of fat is invariably taken. Hence gram and bran form a more nutritious food for cattle than ooreed alone.

The cost of feeding bullocks varies with the kind and price of food and the districts, size of bullocks, etc.

The daily ration of a pair of bullocks in Bombay is 10 lbs. gram soaked in water and the water drawn off, 1 lb. bran mixed with the gram, and 30 lbs. of hay.

Bombay produces about 960 tons of refuse daily (exclusive of milch cattle dung), or 365 tons per annum per 1,000 of the population, or 2·21 lbs. per head per day or ·36 ton per head per annum, against 250 tons per 1,000 of the population of large English towns or 1·52 lbs. per head per day or ·25 ton per head per annum.

The amount of house refuse to be removed is much less in English cities than in India, as a great part is burnt in kitchen fires in European towns, and the labour is more easily controlled than in Indian cities.

The household refuse is removed once or twice a week in English towns, while in India it should be collected twice a day, and the dust bin carts removed twice and three times a day.

In English towns large refuse carts capable of carrying one ton are drawn by horses and, accompanied by two men, pass through the streets and visit houses in rotation, weekly visits being made to each house.

The household refuse is collected and taken to the nearest depôt, which is rarely a mile away, and is either burnt or put into barges and taken down the river or canal and then disposed of.

In most towns in England motor vans are used.

In India, we cannot immediately reduce the amount of refuse to be removed, nor the frequency of removal but, by adopting the most cleanly and expeditious methods known, we can reduce the nuisance.

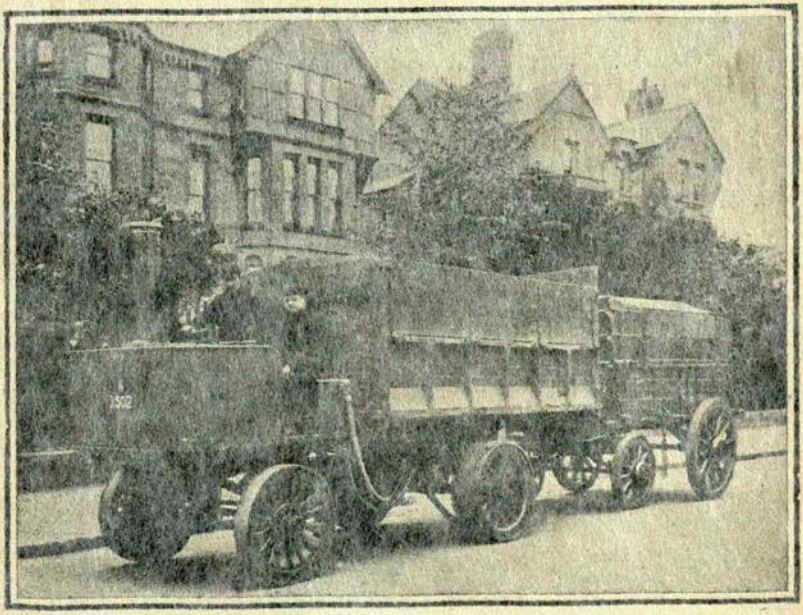
The custom in Indian towns, where no compounds exist, is for the household and trade refuse from shops, &c., to be thrown into the streets and narrow passages between the houses. They are swept and the garbage collected twice and thrice daily, deposited in the dust bin carts and removed as often as the magnitude of the staff and the strictness of supervision permit.

Sanitary dust bins should be provided and emptied twice daily.

Motor Vans.

Motor vans are used in most of the large towns of England for Municipal work.

These motors work day and night, in the day time collecting house and street refuse and in the night watering and sweeping the streets, the body of the cart being removed and replaced by a water tank.



REFUSE REMOVAL, LONDON

During the past few years, the use of motors for Municipal work has rapidly developed.

DESCRIPTION OF STREET CLEANSING IN THE CITY OF LONDON.

"Street cleansing in the City of London" refers only to that part of London known as the City, or about a 10th of the whole of London. The City contains nearly 48½ lineal miles of streets, courts, alleys and bridges within an area equal to only one square mile, and it is estimated that 1,250,000 persons and over 1,000,000 vehicles enter and leave the City daily and that more than 380,000 persons are engaged during the day within it.

Of the 48½ miles of streets, about 37 miles have both foot-ways and carriage-ways, the remainder being foot-ways only.

The carriage-ways are paved as follows:—Asphalte 225,722 super yards, wood blocks 175,856 super yards, and are paved with 83,421 super yards of asphalte and 245,187 super yards of York stone.

The rateable value of the City is £5,373,276.

For cleansing purposes, the City is divided into 4 districts, each having its own Divisional and Boys' Foreman, with a district staff of carmen, road sweepers, orderly boys, horses and vans.

Night Cleansing.—The work of cleansing the main thoroughfares begins at 8 p.m.; the night section numbers 91 men classified as follows:—

2 District Foremen.	1 Flushing Foreman.
18 Flushers.	4 Sweeping Gangers.
43 Sweepers.	12 Carmen.
6 Motor Drivers.	5 Assistant Motor Drivers.

The men work from 8 p.m. until 6-30 a.m. the following morning, except on Saturday and Sunday nights, when the hours are from 12 midnight until 9 a.m., 1½ hours being allowed for meals. During these hours practically the whole of the City is cleaned or washed by water from hydrants, or

water van with jet and hose, and by hand broom, squeegee and rotary brush.

The men commence in the main streets, where the traffic ceases after 7 p.m., paying particular attention to the streets in the immediate vicinity of markets, where business is resumed at an early hour in the morning.

Some two hours before midnight, the men commence to prepare the streets, where the traffic continues running until a late hour, by lightly watering so as to loosen the accumulation of mud, horse-dropping and grease ; these are then followed by the rotary brushes, which sweep the dirt to the sides of the roadway, leaving it to be heaped and picked up. Since the advent of the motor omnibus, considerable additional work has been entailed in keeping the streets in a proper state of cleanliness, owing to the large quantity of oil deposited upon the surface of the carriage-ways. When flushed or washed, the water runs off the surface without penetrating or affecting the greasy mud, so causing the pavement to dry very slowly and rendering gravelling very necessary.

In addition to the night cleansing, the main streets and bridges, leading to the various markets, are regularly gravelled to avoid, as far as possible, any loss of time in the produce arriving at its destination through bad travelling.

On Sunday at midnight flushers are engaged with jet and hose flushing main streets and courts, particular attention being given to those which receive more than an ordinary share of refuse.

In the winter months, when there is a possibility of frost, every care is taken in the use of water and frequently street washing and flushing is entirely suspended.

The quantity of water used during 1907 for washing and flushing streets, courts and alleys, was 77,424,000 gallons at a cost of £1,935-0-0, the number of nights when it was used being 303.

Day Cleansing.—The outdoor section consists of 450 men and boys, classified as follows:—

4 District Foremen.	4 Boys' Foremen.
13 Sweeper Gangers.	132 Sweepers.
16 Dusting Gangers.	71 Carmen.
6 Motor Drivers.	6 Assistant Drivers.

198 Street Orderly Boys.

The day section commences work at 6 a.m. and finishes at 4-30 p.m. except on Fridays and Saturdays, when they finish at 4 p.m. Each man is allowed 1½ hours daily for meals.

During the first two hours, a few men are engaged in sweeping side streets, courts and alleys left uncleansed by the night men, others are engaged on the main streets until 7-30 a.m.

At 8 a.m. the carmen and scavengers commence to clear the house refuse from the kerbs of the streets, named by the Commissioner of Police, from which refuse must be removed by 10 a.m.

This particular work requires every available horse, van and man owing to the limited time given for removal.

Galvanized iron skeps are sold at cost price to house holders requiring them.

At 7-30 a.m., the street orderly boys assist in cleansing all the main streets and several of the secondary streets and spread sand or shingle as required.

During wet weather they also squeege the foot-ways and assist the sweepers on the carriage-ways until 5 p.m., in the summer months and 4-30 p.m. in the winter.

From 10 a.m. to 4-30 p.m. the day sweepers are engaged in keeping the main and most of the secondary streets in a state of cleanliness by hand broom during dry weather and by squeeging the carriage-ways during wet weather, many streets being squeeged four or five times daily.

Frequently the streets are not sufficiently wet for squeeging but are in a greasy or pasty condition, caused by intermittent rain or damp and foggy weather; in that case

the roadways are watered by water van and squeeged immediately afterwards.

Up to 7-30 p.m. in summer and 7 p.m. in winter, about 50 boys, assisted by a few sweepers, are kept at work on the main streets only. On Sundays a few men and boys are engaged in the main streets from 11 a.m. to 7 p.m., clearing up litter, spreading grit or squeeging as required. Water vans are also out on Sundays during the summer months from 10 a.m. to 4 p.m.

On Bank Holidays, Christmas Day and Good Friday, a number of men and boys are engaged on the main streets.

From June to September inclusive, the street rain water entrances, numbering 2,650, are disinfected once a week. Special court flushing is carried out from June to September, some courts being flushed six times weekly. The quantity of water used for street watering in 1907 amounted to 9,221,000 gallons at a cost of £230-10-6; for flushing sewers, 2,068,000 gallons at a cost of £51-14-0, and from metered hydrants 3,619,000 gallons at a cost of £90-9-6.

Removal of Refuse.—It is estimated that there are nearly 27,800 houses and premises in the City of London, banks, hotels and large public buildings counting as one building only.

All house and trade refuse, street sweepings and slop are taken to Letts Wharf, Commercial Road, Lambeth.

The wharf has a frontage of about 395 feet.

There is one jetty and dock, with berths for seven barges.

The building comprises stabling for 91 horses, cart sheds, workshops, granaries, stores, offices for staff and dwelling houses for the Manager and Foreman Horsekeeper.

All orderly bin manure, old metal and clean waste paper is sold. Sacks for waste paper are provided free.

The charge for removing trade refuse is 7s. 6d. per load.

The bulk of the refuse removed amounts to:—51,077 van loads taken from premises, 31,977 van loads of street

sweepings and slop: Total 83,054 van loads or 270½ loads per working day, having a capacity of 4½ cubic yards per load, and weighing 74,490 tons. Of the total quantity of refuse, 17,065 tons of manure and street sweepings are sold to and removed by contractors.

Sewer Cleansing.—The Cleansing Department is responsible for the cleanliness of all sewers; the total length of the sewers is about 40½ miles, with 205 sewer entrances and 64 flushing gates and about 14,000 inlets from house drains.

Each sewer is cleaned at least once a month. The men employed on this work number 12 with a foreman.

The hours are 41½ per week.

Underground Conveniences.—The under-ground conveniences are under the control of the Cleansing Superintendent. They number 42, of which 29 are for men and 13 for women.

Street Orderly Bins.—393 street orderly bins are distributed throughout the City, each having a capacity of 5⅓ cubic feet for street refuse, and from 1 to 2 cubic feet for sand or shingle. There are also 25 larger bins, with a capacity of 15¾ cubic feet for refuse and 6¾ cubic feet for sand, &c.

Motor Vans.—The Corporation have steam motor vans which cost from £600 to £737 each. These have a capacity of 10 cubic yards, and remove on an average 40 tons of refuse each per week. The wear and tear of boilers, gear and tyres is considerable, and the cost of up-keep averages £133 per annum each van.

BOMBAY.

In Bombay the refuse, which includes road scrapings, is collected in each Ward from (*a*) streets and roads, (*b*) gullies, and (*c*) compounds.

The sweeping, collecting and removal and disposal is done by the Health Department.

Take Ward A in Bombay as a type of an Anglo-Indian

city, which is equal to a small town in England. The total length of streets and roads is about 28·50 miles; they are swept twice daily and the more frequented and important streets oftener, so that not less than about 57 miles are attended to in a day's work.

The population is 92,647.

There are 507 gullies or passages between houses, with a total length of 4·80 miles; they are also attended to twice daily, making 9·60 miles of gullies swept daily.

The total amount of refuse collected and removed daily from this section, which consists chiefly of dung, stable, kitchen and office refuse and road scrapings is about 300 cart loads, and weighs about 120 tons.

The staff employed to sweep this refuse and cart it away is—

Cart Drivers	77	Pairs of bullocks (including sick and spare) ..	102½
Begaris	331	Orderly boys	34
Women	187		

This does not include absentees and persons engaged in filling wagons and motors, and report bearers.

The actual staff is as follows:—

Cart Drivers (proper) ..	77	Orderly boys	34
Begaris	331	Stable Mukadam	1
Women	187	Mukadams	26
Pairs of bullocks	102½	Patels	3

It will be seen that each begari therefore has to sweep about 330 yards of road and 52 yards of gullies in a day.

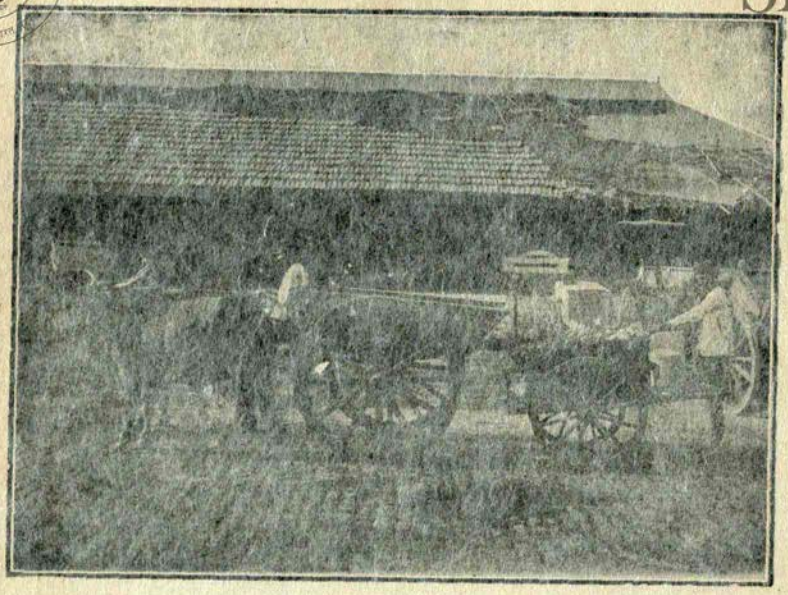
Each begari man and woman, or a gang of men, have a beat told off and they attend to this portion only.

The men sweep up the refuse and the women carry it either to a standing dust-bin cart or a travelling cart. The orderly boys pick up horse and bullock droppings.

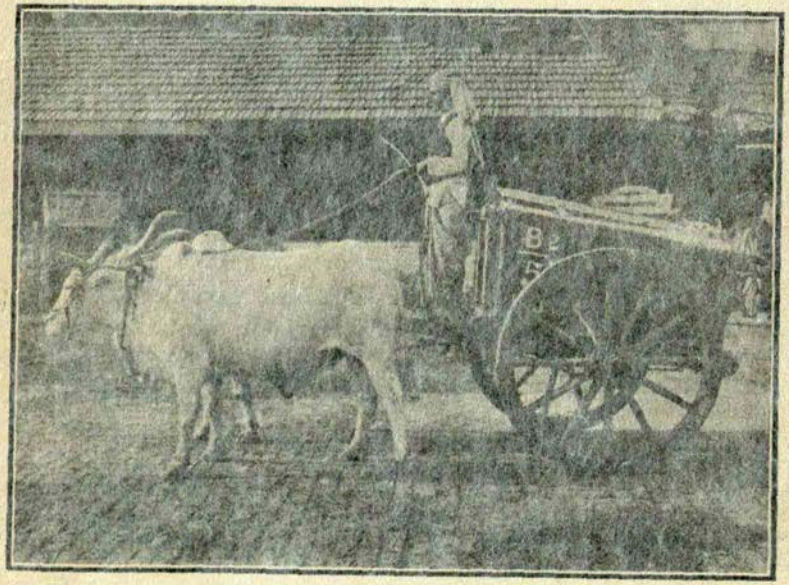
Hand barrows are used in some places where larger quantities of heavy refuse are collected in small areas, and have to be taken to distant stands.

The removal of household refuse from the compounds of houses is by sanitary bins.

2,000 sanitary dust-bins are in use at present and they



DRAIN CART AND HAND BARROW.



COVERED CART FOR STREET SWEEPINGS.

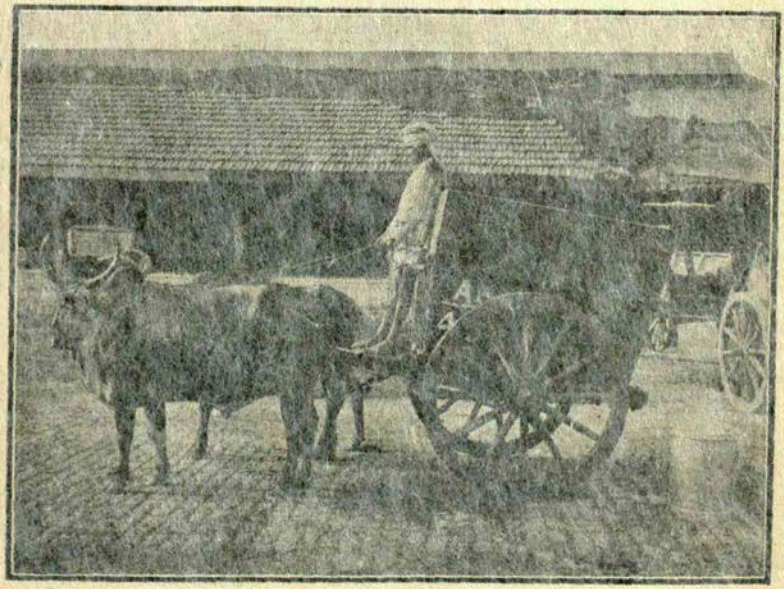
are emptied twice daily; in this way something like 60 tons is removed daily.

The refuse from the southern half of the Ward is carted to the Colaba loading siding, where it is deposited into wagons and removed by the B. B. & C. I. Railway Company.

Six wagons are utilized daily, and about 90 tons are thus railed to the depôt instead of being carted through the City. The refuse from the northern half of the Ward is taken to the Palton Road stables and from there loaded into motors which make 5 or 6 trips each to the depôt daily, taking about 5 tons per trip.

Thus no carts of A Ward, except 4 which take market offal to the main depôt, pass through the other Wards of the City.

41 orderly wire cages for light street refuse and paper are provided on foot-paths; they are emptied twice or thrice daily by travelling carts.



HIGH SIDED CART WITH SANITARY DUST BIN.

The hours of work are from 5-30 a.m. to 10 a.m. and from 1-30 p.m. to 5-30 p.m. A gang of 30 men and 27 women come on at 10 a.m. and work till 6 p.m. on prominent roads, attending to dust-bin carts and the sweeping of prominent streets.

In addition to sweeping, about 50 gullies are flushed daily.

Two engines are employed with the following staff:—

2 Drivers.	34 Begaris.
2 Firemen.	
4 Hosemen.	2 Mukadams.

The staff also sweep several compounds for which charges are preferred against the owners.

Steam or Petrol Motors.

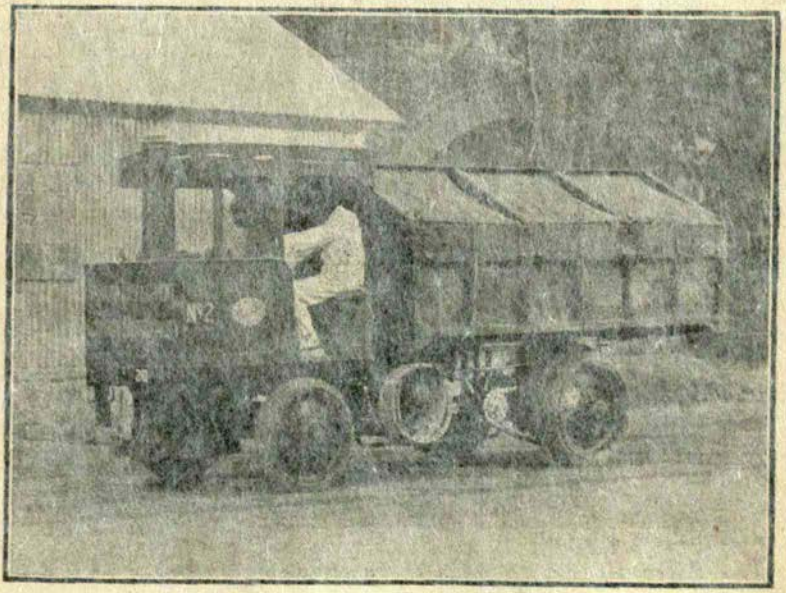
The capacity of the existing dust-bin carts in Bombay is 30 cubic feet. The maximum dimensions of the carrying body for a motor vehicle are about 11′-5″ long × 6′-3″ broad × 4′-3″ high, or 303 cubic feet. The minimum is 11′-3″ × 5′-10½″ × 4′-0″ or 264 c. ft. The new ones, being of the larger size, carry 12 to 14 cart loads of refuse, giving a load of 6 tons.

One spare vehicle for every two in service would be required to ensure regular runnings.

The initial cost of each set of three motor vehicles would be about Rs. 45,000 and to work them in two shifts (8 hours each) would cost (with one motor in reserve)—

	Rs.
3 Drivers at Rs. 75, 3 firemen at Rs. 23, 2 cleaners at Rs. 17, and allowing for absentees, etc.	5,904
Coal (almost a ton a day)	14,600
Wood	270
Oil	2,500
Packing	35
Grease	50
Repairs	2,400
Fitter	1,080
Lighting	75
Supervision	1,500
Fillers, 40 men at Rs. 18, less absentees	6,480
Inspection fee at Rs. 10 per motor	30
Interest on Rs. 45,000 at 4 %	1,800
Sinking Fund	4,882
Rs.	41,600

OLD STYLE, BOMBAY.



NEW STYLE, BOMBAY.

In working out the cost of the motor service per ton-mile, for comparison with the existing bullock service, interest on capital expenditure may be neglected and the cost per annum taken at Rs. 39,806.

Cost of removal of refuse up to the loading siding Rs. 39,806 per annum, to which the cost of unloading at Tardeo, *i.e.*, Rs. 4,020 per annum, has to be added ; total cost Rs. 43,826.

Ton-miles per day—21 miles loaded × 36 tons (6 tons and 6 trips) × 2 motors = 1,512 × 365 = 551,880 ton-miles.

	Rs.	a.	p.
Cost per ton-mile	0	1	5·4

DISPOSAL OF REFUSE.

The refuse of a city having been collected and conveyed to the place where it has to be disposed of, the method of disposal must be considered.

The tendency of sound Municipal administration is to utilise all waste to profit.

In rural and semi-rural districts, marshy and waste land can with advantage be reclaimed by depositing refuse.

In many places this is done with profit ; in India, especially, this is a sound method, particularly in towns and places which would otherwise be swamps. Land thus reclaimed in the neighbourhood of Bombay brings in a large income, the right of cultivation being sold annually.

In large cities, where the expense of haulage is very great, refuse is disposed of by destructors ; other methods are also employed which dispose of the refuse in some way.

Among these methods are :—

Mixing with earth and excreta and disposing of as manure.

Taking away in barges, by canal or river.

Taking into the sea in barges and sinking in deep water.

Selling to cultivators, brick-makers, manure-makers, &c.

From a sanitary point of view, the best method of disposing of refuse is that in which the refuse is got rid of in the

quickest way with the least handling without dust or smell, avoiding accumulation near houses.

In most of the cities of India, the refuse is conveyed to dumping grounds either directly by bullock carts or by rail.

The dumping ground should be well outside the city limits, the refuse discharged on to the ground and covered with a few inches of soil, and planted with suitable crops; maize, sugar-cane and a number of vegetables do well.

Land reclaimed with street sweepings in Bombay brings in from Rs. 75 to Rs. 100 per acre from cultivation. The land is put up to auction and with facilities for transit fetches these prices.

The land is prepared in May and, on the first appearance of the rains, maize, cucumber and gourd are planted—all in the same field in rows. When these crops are well-established in July or August, brinjals and beans are planted amongst them. The maize is collected from the plants and the stalks are beaten down and form a frame for the gourd and cucumber; vegetables and spinach are then planted and this is carried on until March:

English Name.	*Maratha Name.*
Maize or Indian Corn	Kanas.
Cucumber	Kakadi.
Gourd	Shiroli.
Brinjal	Wangi.
Legume	Gowar.
Spinach	Bhaji.

WEIGHTS OF STEAM MOTOR REFUSE WAGON AND BULLOCK CARTS USED IN BOMBAY.

STEAM MOTOR REFUSE WAGON.

Tare.	*Loaded.*	*Weight of refuse.*
Tons. cwt.	Tons.	Tons. Tons.
5 14	..	5½ to 6

NEW PATTERN TWO-WHEEL CART.

Loaded.

Tare.	*Light refuse.*	*Heavy refuse.*	*Weight of refuse.*
Cwt. qr. lbs.	Cwt. qr. lbs.	Cwt. qr. lbs.	Cwt. qr. lbs. Cwt. qr. lbs.
9 0 8	10 1 7	16 3 21	1 0 27 to 7 3 13

HIGH-SIDED TWO-WHEEL CART.

Loaded.

Tare.	*Light refuse.*	*Weight of refuse.*
Cwt. qr. lbs.	Cwt. qr. lbs.	Cwt. qr. lbs.
9 3 3	18 3 7	9 0 4

SUMMARY OF THE PRACTICAL APPLICATION OF THE FOREGOING BY THE SANITARY OFFICIAL IN INDIA.

In tropical and sub-tropical climates, the necessity for the removal of refuse is increased by reason of the higher temperature, especially in moist atmosphere, accelerating decomposition.

Flies, mosquitoes and vermin multiply more rapidly, and bacteria, harmless and otherwise, propagate in suitable surroundings. The necessity of immediate removal of refuse and cleansing of premises is obvious. The conditions of life and the habits of the people are in themselves important factors which have to be considered.

Ninety per cent. of the inhabitants of India have no conception of the value of sanitation, and the Sanitary Officer becomes as much a teacher as an executive officer, and this is an important part of his duty if he desires success.

It is a common thing to see a room occupied by the poorest, full of shining brass pots, but how are these pots cleaned ?

Road scrapings and dirty water, cow dung and silt form the material of cleansing. The milkman or *Gowli* cleans his milking pots in the same way; any moist earth, cow dung or sand available is used, and mixed with water from a dirty stream, foul well, or wherever it can be had.

At the bathing places where hundreds congregate, round a well or tank or stream, the clothes and mouth and teeth are all washed in the same water, while others can be seen cleansing their pots and cooking utensils and milk vessels with the dirty water and road scrapings surrounding the bathing place.

The practice of expectorating anywhere, and at any time, is so frequent as to be unnoticed by anybody, while a man will clean his nose with his hand, and wipe his hand on the nearest projection, lamp post, wall, a passing cart or his clothes.

Public latrines and urinals are provided, but are more often misused than not, while every corner or house-gully is used as a urinal even if accommodation is only a few feet away.

Every form of filth is thrown out of the window on to the street, and packets of paper or leaves containing excreta may constantly be seen descending on to the pavement or street, very often on the head of a passer-by.

In the most crowded thoroughfares of large cities, it is a common thing to see people performing their ablutions on the pavement, or sitting at their shop doors, washing themselves, and the waste water running across the footpath.

Every form of waste material is thrown on to the streets, the idea being that the Municipal sweeper will pick it up.

In many of the houses of the poor are to be seen goats and fowls, sometimes cows and calves, living in the same room, the animals living on the refuse in the streets and shops.

In towns where sanitary laws and bye-laws exist, some attempt can be made to improve these conditions by constant inspection, supervision, action and instruction.

The following notices are issued in Bombay and action is taken against the offender:—

NOTICE.

WASTE PAPER FROM OFFICES AND TRADE REFUSE.

A great nuisance is caused by the Hamals of shops and offices depositing all the waste paper, wrappings, cardboards, sweepings, &c., &c., in the wire cages on the footpath. These cages are simply meant to be orderly boxes to hold small quantities of paper and dry materials picked off the passages and streets pending the arrival of the conservancy carts.

The proper place for the deposit of the waste paper and sweepings from your office is the dust-bin cart or the travelling cart which calls 3 times a day between 6 a.m. and 9 a.m., 9-30 a.m. and 10-30 a. m., and 2 p.m. and 4 p.m. I must therefore request you to instruct your sweepers not to deposit office waste paper or dust sweepings in the wire cages but to either send it to the nearest dust-bin stand or place it in the travelling cart which passes your door thrice daily. If you will provide a sack, the waste paper can be easily removed without nuisance to you or the public if you will make an arrangement with this office. Trade refuse is not removed by the Municipality free of charge but must be taken at the producer's expense to Mahalaxmi Refuse Siding.

I attach a formal notice an infringement of which renders you liable to a penalty.

I have, etc.,

.....

Executive Health Officer.

NOTICE.

The attention of occupiers of houses and premises is drawn to Sections 372 (*e*) and 373 of the Municipal Act which provide respectively (1) that no person shall throw or place any dust, ashes, refuse or rubbish or any excrementitious or polluted matter on any street, or in any place not provided or appointed for this purpose under Section 367 or 368; and (2) that if it shall be shown that dust, ashes, refuse or rubbish or any excrementitious or polluted matter has or have been thrown or placed on any street or place in contravention of clause (*e*) of the last preceding Section from building or land, it shall be presumed until the contrary is proved that the said offence has been committed by the occupier of the building or land.

Dust-bin carts are placed at the most suitable places for the deposit of refuse.

Any one contravening the provisions of Sections 372 (*e*) will be prosecuted

.....

Executive Health Officer.

Frequently, however, on account of the leniency of the magistrate or want of evidence, or some technical detail, prosecution fails, or the fines imposed are so trivial as to be ludicrous, and the efforts of the public health authorities are in vain. Nothing but constant action and support by the magistrates will ever have any effect.

Any relaxation in the efforts of the officials, and the people relapse into their primitive habits.

Sanitary dust-bins and boxes should be insisted upon for every house, floor and shop for the deposit of refuse, and a basket or bag for waste paper.

Every person found throwing refuse on to the street should be fined, and every person spitting in a public place should be prosecuted ; any one urinating in a place other than a urinal or latrine and any one misusing a latrine severely punished.

In a milch cattle stable, the washing place for the animals is also used by the milkmen for their domestic ablutions, and it is common to see a man wash himself, his clothes and his throat in the same place as he cleans his vessels in, using the waste water, sand and cow-dung, &c., wiping out the vessel with a wisp of litter from the cowshed.

Every milkman or milkseller found cleaning his pots with anything but clean water should have his license taken away.

These are matters which have to be considered when applying practical sanitary methods in the East and the best way to apply them is by steady insistence on the regulations, assisted by instructions from the sanitary staff and male and female health visitors coming in touch with the people and the support of the educated classes.

DISPOSAL BY INCINERATORS OR DESTRUCTORS.

The term "destructor" is applied to a high temperature furnace specially designed for the disposal of town refuse by burning.

Many years of practical experience has led to the design of efficient types of destructors, and has shown what is the true calorific value of average town refuse, so that manufacturers are now able to give definite and reliable guarantees of performance, such as both users and makers may, with a reasonable degree of certainty, expect to realise. The mere disposal of the refuse is not, as a rule, the only consideration kept in view in a modern refuse destructor station. A complete installation for a population of, say, 50,000 persons may cost from £5,000 to £6,000 to erect, accordng to local circumstances, and, in addition to the destructor cells proper, usually includes machinery and plant for the removal and disposal of the residual clinker, for its crushing and manufacture into paving slabs, bricks, mortar, or other saleable products, also steam and engine power for actuating the various plant required at such a station. It will, therefore, be evident that the working expenses, maintenance, and depreciation of a fully equipped installation must necessarily be considerable, and that, with the view of reducing this annual expense to a minimum, it becomes necessary to turn to account any and every by-product or residual material which can be really diverted to profitable use.

POINTS TO BE ENQUIRED INTO WITH REFERENCE TO REFUSE DESTRUCTORS.

(SUGGESTED BY FRANCIS WOOD.)

1. The grate area and the amount of refuse burnt per square foot of grate area.
2. Do the fumes of the burning refuse pass over bright heat to ensure their perfect combustion ?
3. The lowest temperature in the furnace, or in the combustion chamber, should be 1,300° F.
4. The temperature at the chimney flue, and at the combustion chamber.
5. The analysis of the gases at the flue should be procured. There should be less than 1% of CO. The amount of free O and N should approximate the amounts found in the atmosphere near

the flues. CO_2 should be abundant, 6% being frequently got; as much as 15% has been obtained.

6. The amount of water evaporated at 212° F. per pound of refuse per hour.
7. The cost of labour per ton of refuse delivered.
8. Cost of maintenance, together with the number of men required to work.
9. Is skilled labour necessary ?
10. What method is employed to feed the destructor ?
11. The construction of the destructor. Is an inclined road-way necessary ? Height of chimney.
12. Disposal of clinker, and revenue derived from its sale.
13. The number of cells required for every 10,000 inhabitants.

In large towns the destructor will be found to be the best method of disposal.

Destructors are so constructed that the nuisance is reduced to a minimum, and so much so that in large towns in England they are in some instances placed close to dwelling houses, schools, &c.

The best known destructors are :—

Horsefall.	Heenan and Froude.
Beaman and Deas.	Sterling.
Meldrum.	Baker.

One or more large furnaces are used. The refuse is thrown in at the top, and becomes dry as it sinks down, all organic matter is burnt off and at intervals the mineral matter, or "clinker," is raked out below, to be used for road making, filling up hollows, &c. After the furnace is started, the organic matter in the refuse is usually sufficient to maintain the fire without the addition of other fuel. The smoke from a destructor is offensive and should be passed through a second furnace. At Bradford the smoke is rendered inoffensive by forcing a jet of steam, under pressure, beneath the fire bars (Horsefall's Process), and secondly by passing the fumes through a Jones's "Fume Cremator", which consists of a coke furnace provided with several projections or "bafflers."

There are various *types of refuse destructors*, most of which possess the following features in common :—

(1) Furnaces or cells of brick with fire brick lining. (2) Approached by an inclined road way to the top or tipping platform. (3) In the centre of this platform is a series of feeding holes or hoppers into which the refuse is shot and allowed to fall into the cells below. (4) The strokers rake the refuse on to the fire, and after burning, the refuse is reduced to about $\frac{1}{3}$ or $\frac{1}{4}$ of its original weight, the residue consisting of fine ash, hard clinker, &c. (5) By means of forced draught produced by a steam jet or fans, the combustion can be made so complete that temperatures of 1,500° to 2,000° F. are attainable merely from the burning of the refuse. Some destructors are known as *slow combustion* or *low temperature destructors* and in these "fume cremators" should be provided at the foot of the chimney. In the *high temperature* destructors, such cremators are unnecessary.

Low Pressure Destructors-Advantages :—a diminished wear and tear and hence saving in upkeep. *Disadvantage :*—the inlet for refuse and the outlet for gases are at the rear of the cell and hence noxious vapours escape before being burnt and a cremator is necessary ; also more cells are required.

High Temperature Destructors :—(Horsefall and the Beaman and Deas) the outlet for gases is at the front of the cell and the vapours given off pass over the hottest part of the fire to reach the exit ; the foul gases are destroyed within the cell itself ; a large quantity of refuse is burnt per day per cell (10 to 16 tons) and fewer cells are therefore required. These cost more for maintenance. The number of cells depend on the nature and amount of refuse to be destroyed and also upon the type of the cell adopted. If a *high Temperature Destructor*, 10 cells will be required for a

population of 100,000. These cells can be erected in a single row or back to back.

THE HORSEFALL DESTRUCTOR.

The following is a description of the Horsefall Destructor:—

The buildings are laid out in four bays, the destructor furnaces occupying the bay nearest the entrance. This bay is 110 feet long, by 40 feet wide, by 41 feet high. The two centre bays accommodate two sets of boilers for destructors and coal firing respectively, while the last bay (the largest of the four) is the electric power station.

A pump-room, which serves both sets of boilers, adjoins the power station; and the economisers, of which there are two, are housed outside the main building.

The chimney, 150 feet in height by 10 feet internal diameter, is situated at the end of the boiler-house.

A concrete retaining wall and water reservoir are built at the south end of the site, and water is conveyed by an 18 in. pipe from the reservoir into the power station for condensing purposes.

DETAILS OF THE DESTRUCTOR.

The Horsefall Destructor consists of six large cells and combustion chambers, with three water tube boilers, arranged so that each pair of cells with its boiler can be worked independently. This arrangement of independent "units" permits of any section of the plant being shut down for repairs or cleaning, without interfering with the working of any other unit.

By firing the two cells of each unit alternately, a steady steam pressure is maintained in the boiler, while the combustion chamber is also kept at a sufficiently high temperature to cremate thoroughly the noxious gases which escape from the newly-charged refuse.

The furnace grates, which slope from back to front, have each an area of 25 square feet and are constructed to burn

efficiently a full cart-load of refuse at one charge. The grate bars are perforated with a large number of small holes and a high pressure blast is forced through these, by means of electrically driven fans.

It is generally recognised that to ensure complete combustion in destructor furnaces, an air-blast system is the best, but hitherto the blast has been delivered at comparatively low pressure.

The grates and fans are constructed for a specially high pressure, and are fully expected to show a distinct gain in efficiency over the older system.

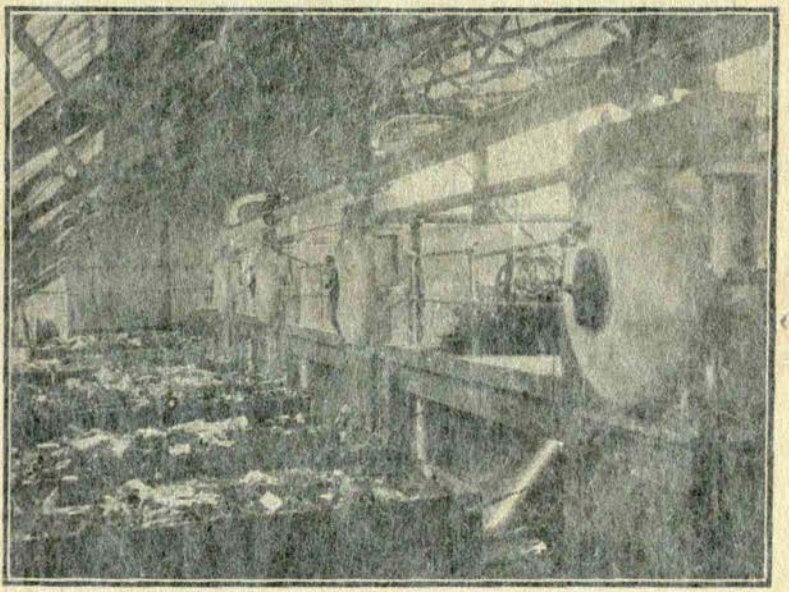
The fans, of which there is one to each furnace, are coupled direct to "Phœnix" variable-speed motors of the totally enclosed type. The starting and regulating switches are fixed conveniently to the furnace doors, and a throw-off switch is actuated in such a way that the opening of the door automatically stops the fan. Incidentally an attempt has been made to improve the unfavourable atmospheric conditions existing in most destructor installations, and ventilation is provided for by carrying the fan inlets to the underside of the storage platform and turning them inwards so that all dust and fumes emitted during the process of "clinkering" are drawn in and delivered back to the fires.

Auxiliary steam jet fittings for steam blast have also been provided, but these are only intended to be used in the event of a breakdown to the fans.

THE SYSTEM OF CHARGING.

The method of storing and charging the refuse into the cells has been specially designed to reduce manual labour to the lowest possible minimum, and forms a striking comparison to some types of destructor still in use, in which the refuse is stored in loose heaps and fed into the furnaces by hand labour.

The refuse is delivered from the carts to the furnaces without handling of any kind, and, while effecting a saving in the cost of labour, ensures a degree of cleanliness which is really remarkable, having regard to the nature of the materials dealt with.



TUBE CHARGED READY FOR INCINERATION.

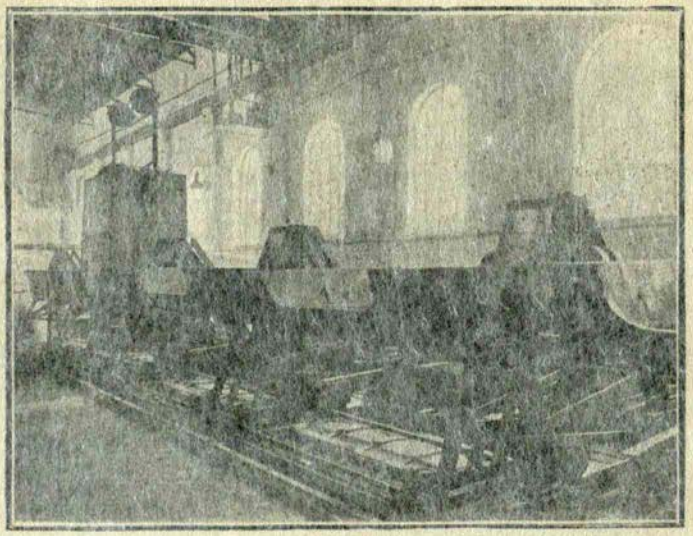
The tipping pit is situated at the north end of the destructor house, and the refuse, which is delivered by carts, is discharged through a specially shaped hopper into a storage tub placed ready in the pit.

The pit has accommodation for four tubs, with two hoppers, the latter being arranged to move on rails across the pit.

When the tub has been loaded, the hopper is moved clear from above it, and an electrically operated over-head crane lifts the tub and deposits it on the storage platform, where it is kept till required. The storage platform extends to the

full length of the furnace blocks, and has accommodation for eighty tubs.

The storage of refuse thus takes place in closed boxes away from the heat of the destructor.



"TUBE FEED DESTRUCTOR" OF THE MERSEY DOCK HARBOUR BOARD AT LIVERPOOL.

CHARGING GEAR.

When ready to charge, a tub-full of refuse is lifted from the storage platform by a crane, and placed on a moveable cradle on the top of a cell. The weight of the tub causes the cradle to descend, and by a system of levers and balance weights, the water-sealed door is lifted from its seat and drawn on rails to one side, permitting the lower edge of the moveable cradle to descend into the mouth of the charging doorway. The storage tub is provided with hinged lids at the bottom which are held shut when the tub is suspended by the crane, but when released these lids open outwards and the whole of the refuse thus falls directly into the furnace and spreads itself over the grate.

The empty tub is then lifted by the crane, and the water-sealed door, actuated by the balance-weight, is mechanically drawn back to its seat. The whole operation of charging the cell and withdrawing the tub occupies less than a minute, and as the furnace door is open for only a few seconds, the inrush of cold air, with consequent reduction of furnace temperature, is reduced to the smallest possible amount.

The crane, which has a lifting capacity of 3 tons at 30 feet per minute, was built by Messrs. Broadbent and Sons, Huddersfield.

The time required to cremate a charge thoroughly varies according to the class of refuse, from one to one and a half hours, and the fire is then cleansed through a large clinkering door at the front of the cell. This door is of specially strong construction, and is provided with two small doors attached to it, so that the fires can be adjusted and managed without opening the main door.

The clinker is withdrawn from the furnace into buckets suspended from an over-head clinker railway, and may either be delivered directly to the clinker crushing and screening mill or deposited in heaps until required.

BOILERS.

A main flue of large area is provided for each pair of cells, from which the hot gases are carried through the combustion chamber of water-tube boilers, and a dust catcher of Messrs. Horsefall's patent type is built in between the combustion chamber and the boilers. All the flues are lined throughout with fire-brick, and in the furnaces specially made fire-clay blocks, set in fire-clay cement, have been employed.

The boilers are of Messrs. Babcock and Wilcox's marine water tube type, constructed for a working pressure of 200 lbs. per square inch, and fitted with super-heaters to raise the temperature of the steam to 500 deg. Fahr.

To meet any special demand for steam, auxiliary grates

have been fitted for coal firing, and a bye-pass is provided direct from the destructor combustion chamber to the main over-head flue, so that in the event of a breakdown to a boiler or an excess of steam being generated, the whole or a portion of the hot gases may be taken by this route instead of through the boilers.

After leaving the boilers, the gases pass by way of the over-head main flue to an economiser, thence to the chimney.

The economiser is of Messrs. Green's type, built into two sections of 120 tubes each.

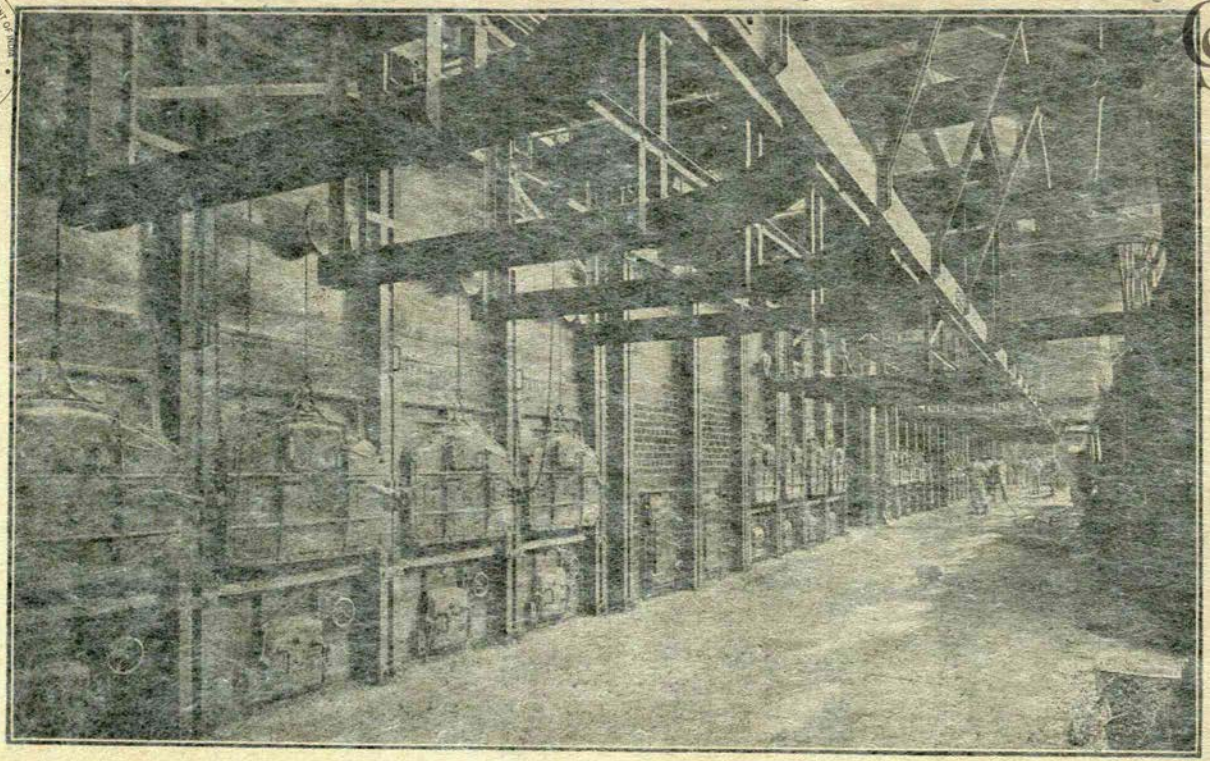
The steam from each boiler is led from the super-heater to a 10-inch main, and carried direct to the main range which supplies the electric generators. The feed piping is connected by a branch pipe to the system supplying the coal-fired boilers, the arrangement being designed so that the destructor boilers can be fed either through their own economiser or from the hot-feed main of the coal-fired boilers.

The pump house contains two triple-throw electrically driven Worthington pumps, and one of Messrs. Weir's double acting steam pumps. A storage tank of 12,000 gallons capacity is placed over the pump room, and a combined water-softening and de-oiling plant is provided to treat the feed-water.

The coal-fired boilers are of Messrs. Babcock and Wilcox's double-drum type, each boiler being capable of evaporating 18,000 lbs. of water per hour. Super-heaters are provided, and the firm's latest type of chain-grate stoker is fitted.

GENERATING PLANT.

Passing into the engine room, a lofty, well-lighted building, there are two Bellis-Westinghouse direct-coupled generating sets, each capable of a normal output of 750 kilowatts when supplied with steam at 200 lb. pressure.



CLINKERING FLOOR OF INCINERATOR.

The engines are of the triple-expansion, quick revolution, enclosed type of 1,140 horse power each, and are fitted with expansion valves to take over-loads up to 50 per cent.

The exhaust steam is taken through an oil separator into a surface condenser, which serves both sets of engines.

A special feature of the works is the use of the electrically driven auxiliaries, and the whole of the auxiliary plant, including pumps, stokers and fans, is driven by electric motors.

The following observations as to the general methods of working the Fryer Destructor apply also, with slight modifications to meet special circumstances, to all hand-fed destructors.

"The cart, on entering the yard in which the destructor is built, is drawn by a horse up an inclined roadway with varying gradients, from 1 in 12 to 1 in 25, and on arriving at the top a platform is provided with tipping curbs, against which the carts are backed, and their contents are tipped on to the top of the cells. Here the material remains for a short time, until one of the cells is ready for a charge, the charging holes being in direct communication with the fire, but so arranged that very little smoke at any time issues from them. When a cell requires to be charged, the material is shovelled or drawn with a two-pronged rake into and on to the top of the charging hole. A second man stands in line with the opening and as the material is delivered on to it he pushes it down the incline on to the drying hearth and continues doing so until the hearth is completely covered. The quantity usually put on at one charge varies from one-third to one-half a cart load, or from 20 cubic feet to 30 cubic feet. From the drying hearth the material is drawn down on the bars as required by the fireman, who stands at a lower level and in front of the furnace. He first clears his fire by pulling the clinker out, spreads the burning material evenly over the fire bars, and then draws down a fresh supply of the partially dried material from the drying

hearth. He usually finishes up by running his bar through the fire, so as to leave as free a passage for the air as possible.

"Too much refuse should not be drawn down at once, or the fire will become dead and blackened. Thin layers may be raked down at intervals of about 20 minutes, but the fires should be undisturbed for at least half an hour before a clinkering. The fire on the bars (which should always be kept covered) should not be more than about 9 inches thick, which is sufficient to secure a clear fire.

"The clinker falls into a barrow provided for the purpose or upon the ground in front of the furnace, where it is cooled by having water from a hose sprinkled upon it. The fine ash drops through the bars into the dust hearth, and it is found that the material in passing through the furnace is reduced to about 25 per cent. of its weight. This residue consists partly of fine ash and partly of clinker, in varying proportions according to the character of the material which has been consumed. Whilst the combustion is proceeding, the hot gases from the furnace or cells escape over the bridge into a central flue 6 feet high by 10 feet 4 inches wide. This is arranged to prevent too great a velocity from carrying pieces of paper and other unconsumed material to the chimney, and also to allow of the deposit of dust within the flue."

THE MELDRUM FURNACE.

The Meldrum patent "Simplex" Destructor is a modern apparatus manufactured by Messrs. Meldrum Bros. of Manchester. In this furnace, it is claimed, ordinary town refuse will give a sufficiently high temperature to utterly decompose all noxious material, nothing but harmless and inoffensive gases passing up the chimney, the solid residue consisting entirely of hard clinker with a little ash. When it is desired to utilize all the available heat for steam-raising, a special internally fired steam generator is employed.

Ordinarily, the furnaces are fed by hand, but hopper feeding may be arranged if required. A forced draught is used in connection with the furnace, but no cremator is considered necessary, owing to the high temperature of the cells.

It will be observed that four grates are placed side by side and separated only by dead plates, the ashpit, however, being divided in four parts, each separately fed with a supply of air under pressure, preferably by steam air blast. The destructor, therefore, is practically a single cell, fed and cleaned in four places at regular intervals, so that an approximately constant temperature may be anticipated.

The escaping gases either pass away from the back of each fire grate into a common flue leading to boilers or the chimney, or are conveyed sideways over the various grates, and thence over a common fire-bridge towards the boilers or chimney. After passing the fire-bridge, it will be seen, there are five rows of baffle pillars arranged to divide and break up the current of hot gases; the pillars remain constantly at a bright red or white heat, and take the place, it is claimed, of the cremator furnace commonly used in the older destructor installations. A by-pass is, of course, provided in order that the furnaces may be used without the boilers. The patentees recommend that four grates be laid down, but fewer or more may be provided to suit circumstances. One or more of the grates may be disused without interfering with the working of the remaining portion of the destructor.

In regard to the question of the number of "Meldrum" cells required proportionately to any given population, if we take the annual production of house refuse per 1,000 inhabitants at 200 tons, then a single "cell," that is, a grate 5 feet by 18 feet, having four ashpits, and burning at an assumed average rate of 40 lb. per square foot per hour, would consume about 38 tons per day of 24 hours or per year of 300 days—say, 10,000 tons. Consequently, if this rate of consumption be uniform and constant throughout the year

such a cell or destructor should suffice for 50,000 people. The heat derived in indicated horse-power per cell would theoretically—assuming a maximum of 2 lb. of water evaporated per lb. of refuse consumed—be equal to

$$\frac{90 \text{ sq. ft.} \times 40 \text{ lb.} \times 2}{20} = 360 \text{ horse-power continuously per cell}$$

at 20 lb. steam per 1 horse-power per hour.

A height of chimney shaft of 40 ft. is said to be ample for the requirements of the "Meldrum" furnace; and the temperature in the cell, if fitted with a regenerator, may be taken as averaging about 2,000 deg. Fah.

THE "HEENAN" PATENT DESTRUCTOR.

The following is a brief description of "The Refuse Destructor at Rotterdam" erected by Heenan and Froude.

The furnace plant consists of five independent units, each consisting of two sets of four cells grouped on either side of a central combustion chamber. The grates of four adjoining cells are separated from one another by low cast-iron transverse dead plates of hollow construction, so that the four grates practically form one continuous furnace chamber. The four ashpits, however, are entirely separated from one another. The furnace chamber is roofed over by fire-brick arches. Each unit has eight cast-iron furnace fronts constructed so as to provide allowance for expansion and fitted with heavy cast-iron mouth rings. The doors are of cast-iron, filled with fire-brick, hung on steel ropes passing over pullies, and counterweighted. The grates are composed of cast-iron grate plates with conical holes, with the smallest diameter on top. The grates are surrounded with hollow cast-iron dead plates, and these, as well as the divisions between the cells, can be replaced with a minimum disturbance of the brickwork.

The combustion chambers of two of the units are each fitted with a grid arch of fire-brick capable of supporting

carcasses and such objects as are too large to be dealt with in the ordinary grates. Charging openings are provided in the covering arches, through which these objects can be lowered on to the grids. A hot forced draught is employed, produced by a separate fan for each unit. The fan takes the air from a ventilating shaft and forces it through a regenerator, and through hot air conduits, to the ashpits under the grates.

Each unit is fitted with a regenerator consisting of a group of vertical boiler tubes expanded at top and bottom into horizontal tube plates. The hot gases from the boilers pass through the tubes and down into dust pits, while the draught air passes over the outside of the tubes.

Each unit supplies heat to one Babcock and Wilcox land type boiler having a surface of 256 m^2 (2,752 sq. ft.), and capable of evaporating 4,000 kilos. (8,800 lbs.) to 5,000 kilos. (11,000 lbs.) of water per hour. Foster's superheaters are fitted to give a steam temperature of from 280 C.° (536 F.) to 325° C. (617° F.)

Two electric and one steam feed pump, each 12m^3 (2,640 gallons) per hour capacity, are installed, and the feed piping is in duplicate. No economisers are installed, but provision is made for their addition if desired. It has been found, however, that the regenerators reduce the temperature of the gases to such an extent that it would not pay to instal economisers.

It is interesting to note that no by-pass flues are provided for diverting the hot gases from the boilers. It is well known that it is almost impossible to keep dampers in such flues tight, and therefore the employment of by-passes leads to an enormous waste of heat.

DESCRIPTION OF SPECIAL FEATURES.

The special features in the Heenan system may be tabu-

lated as follows, but not necessarily in the order of their importance :—

(*a*) Continuous furnace chamber with divided ashpits.
(*b*) Special air heater or regenerator.
(*c*) A rational and effective ventilation system.
(*d*) Simple mechanical means for handling refuse and clinker.
(*e*) Instantaneous charging.
(*f*) A simple mechanical clinkering device applied to each of the main grates.
(*g*) Elimination of all dust.
(*h*) A special furnace design which assures good results both in the dry and in the monsoon periods.
(*i*) Labour saving appliances.
(*j*) Control of the chimney draft.

BEAMAN AND DEAS DESTRUCTORS.

One of the most modern destructors is that of Beaman and Deas.

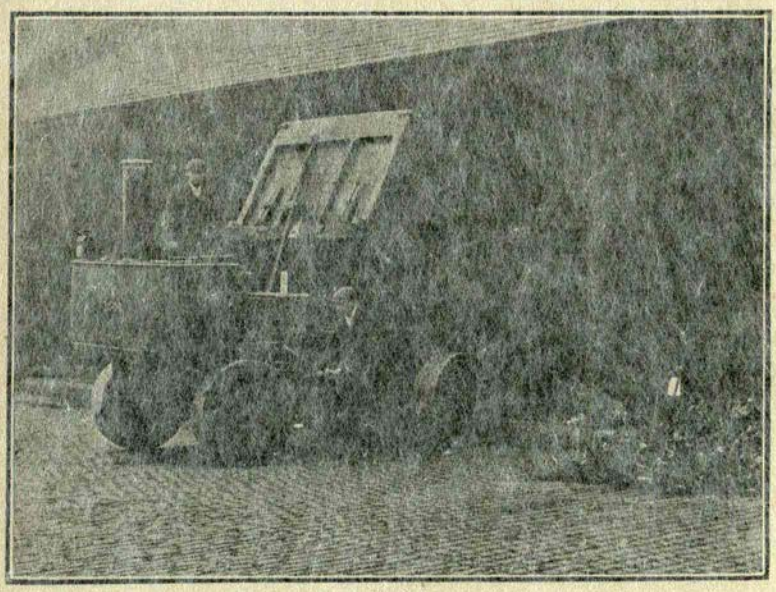
The material to be burnt is carted up a short incline to the top of a platform, which measures only 8 ft. 9 in. from the ground level, and is tipped direct into a hopper mouth about 1 ft. 6 in. square ; after passing which, it falls down a fire-brick hearth supported on T irons, and having an inclination with a horizontal line of about 52 deg. At the bottom of this incline, the refuse is received upon a fire-grate area 5 ft. square, which is fixed level at a height of about 2 ft. 9 in. above the floor of the ashpits. The fire-bars are of the ordinary stationary type, these having been found by experience to give the most satisfactory results. They have spaces between them of only 3—32 inch and the weight of fine ash passing through from a week's work of five days—and burning about 100 tons—only amounts to 3½ cwt.

Vertically under the bridge between the furnace and the combustion chamber is an air culvert, on the top of which

are the air blast pipes, about 12 in. in diameter, and which discharge into a hermetically closed ashpit immediately under the fire-bars. The air is supplied from fans at a pressure of about 2 in. of water, and is controlled by means of baffle valves worked by handles on either side of the furnace handy to the attendant. The forced draught keeps the bars cool, and the wear and tear is found by experience to be very slight.

The process of burning the refuse is briefly as follows :—

The material to be consumed is carted to the tipping platform and, without undergoing any process of screening or selection, is discharged through the hopper, as above referred to, on to the inclined hearth. A charge is meanwhile in course of destruction on the horizontal fire-grate, and when this is consumed the furnace is clinkered, and the charge



TIPPING TO INCINERATOR.

lying on the inclined hearth, which has meanwhile to a considerable extent been dried by the heat deflected from the fire-brick hearth and the general heat of the furnace, is in turn drawn on to the horizontal fire-grate, and another charge takes its place on the inclined hearth. The clinkering and re-charging of the furnace is done alternately, the better to preserve the heat in the combustion chamber, which is stated to be maintained at a temperature of 2,000° Fah. Inasmuch as all the products of combustion have to pass through this chamber, it is impossible for any undecomposed vapours to escape into the main flue beyond, and one of the most important of all questions appertaining to the disposal of refuse, *viz.*, the absolute avoidance of nuisance, is thus provided for.

DESCRIPTION OF THE SMALL INCINERATORS IN USE IN MADRAS.

Dr. W. R. MacDonald, late Health Officer of Madras, thus describes the method of small incinerators in Madras :—

"These were designed and modified to suit local conditions by Mr. C. L. T. Griffith, A.M.I.C.E. (now Professor of Engineering College), while Engineer to the Corporation of Madras. It may be mentioned that his experiments were conducted under monsoon conditions in the latter part of 1910. The structure is a brick masonry one, with three rows of iron bars superimposed and each row placed at right angles to the other ; in the bottom of the furnace, ample draught apertures are allowed for, below and above is an upright masonry chimney on which is usually placed a 12′—16′ iron chimney ; an iron lid with a baffle plate is placed over the furnace, which is opened and closed by means of a wire pulley attached high up on one side of the masonry chimney. The cost of erection is a recommendation also, as the masonry work is of only Rs. 100 and Rs. 25 for the iron chimney.

SEPARATION OF COMBUSTIBLE FROM INCOMBUSTIBLE RUBBISH.

"(1) By drivers and sweepers in the divisions. In the forenoon trips a rough separation is made, so that nearly all combustible material reaches the incinerator in the forenoon. What is left behind for the afternoon trips is nearly ashes, earth sweepings which contain a small quantity of organic matter. This is not usually taken to the incinerator but to the 'screeners' near by, where combustible material is separated out and carried a short distance to the incinerator.

"(2) By hand, rakes and forks, which is the first operation on the arrival of the carts at the incinerators in the forenoon; women and boys do the light work of picking out brick bats, broken earthenware utensils, tins and other incombustibles.

"(3) By screening: after the bulky burning material is separated out from these incombustible materials, a residue of earth, mixed with vegetable matter, smaller pieces of bricks, bottles, etc., is left. This is then conveyed to the 'screeners' for finer separation with the result that we have, when screening operations are complete, a finely powdered earth with a small quantity of organic matter. Night-soil has always been carefully excluded.

"The 'screeners' are double, a large mesh in front, a smaller mesh behind, so that we get double 'screening' with the same operation. The wire work of the 'screener' is of expanded metal, the large mesh being $1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{1}{8}''$ whilst the smaller is $\frac{1}{4}'' \times \frac{1}{4}'' \times \frac{1}{8}''$. The frame work is of wood on which the expanded metal is fixed by bolts. The 'screener' is placed in an upright sloping position and is supported by two supporting wooden legs hinged to the upper part of the wood work frame.

"One is constrained to believe that these small incinerators for the disposal of rubbish in Madras City have proved a sanitary and financial success, and that there is an important place for them in connection with conservancy in mofussil towns and villages in India and Burma, where the rainfall is not excessive.

"I. *Incineration of night-soil mixed with rubbish.*—Experiments were conducted in the disposal of night-soil along with rubbish at Chetput by means of one of these small incinerators, for about one month.

"Night-soil was procured from the two sanded latrines in the paracheries near by. It was free of liquid, but slightly mixed with sand. About 15 cart loads of suburban rubbish were brought in daily. After separation and screening, night-soil was freely mixed with the rubbish and then transferred to the incinerator furnace. So far as the disposal of the night-soil was concerned, the results were eminently satisfactory, as the night-soil of 400 persons (half the population of the paracheri) could be disposed of daily without difficulty. The gases given off from the incinerating night-soil, however, proved such a vile nuisance, that I was compelled to discontinue these experiments. I am of opinion, however, that by using a *dome* incinerator this nuisance can be effectively controlled.

"II. *Incineration during the monsoon.*—It will be seen on reference to the meteorological table that most of the rain for the year in Madras City falls during the months of September, October, November and December. When rain falls continuously for a day or longer, conservancy operations are entirely suspended so far as the removal of rubbish is concerned; but when rain falls during some part of the day or night, incineration operations are retarded on account of the sodden condition of the rubbish brought in. To combat this condition various measures have to be adopted. The

rubbish is separated in the usual way, and spread out to dry in the open when sunshine is available, or under a *kutcha* shed. One's experience in Madras has been that rubbish spread out for a short time in the sunshine and then sprinkled with crude kerosine oil can be disposed of by these small incinerators. Screening operations, however, have to be suspended temporarily until most of the moisture has been removed."

NOTE ON COLOMBO REFUSE DESTRUCTOR,

BY C. L. COX, ESQ.,

City Sanitation Engineer, Colombo.

House rubbish in Colombo is collected in portable sanitary rubbish bins, the use of which is enforced throughout the City, and, together with street refuse, is removed in specially designed self-clearing single-bullock carts.

2. Owing to difficulty in obtaining suitable sites, trouble in securing an efficient transport service and the sanitary objections against refuse dumping in the vicinity of the City, the Municipal Council have established a Refuse Destructor.

3. The following description of the plant and its method of operation is derived from particulars kindly supplied by the Works Engineer.

The plant is of the Horsefall Back Feed continuous grate type with six cells design to dispose of 10 tons each per 24 hours. The hot air blast to the furnaces is supplied by two Roots blowers drawing air through regenerative air heater from the intake over the rubbish delivery hoppers. The plant includes a Babcock and Wilcox boiler, an auxiliary oil engine for the blowers, two beast cremating chambers and a dust catcher of the Accrington Patent type.

A feature of the plant is the additional oil fuel heating apparatus for use with wet rubbish. The oil is atomized by super-heated steam and, mixed with air, is ejected into the furnaces through spraying nozzles.

The refuse delivery hopper has a storage capacity of 30 tons. The back is sloped to deliver the refuse to the feeding floors, and the openings through which the refuse is tipped are closed with balanced doors.

The plant has been in satisfactory operation for nearly a year, and the following notes may be of interest.

The rubbish contains a large proportion of sand and mineral matter. In wet weather it is 25 per cent. heavier than in dry. The capacity of the plant varies from 45 tons per diem in wet weather to 75 tons per diem in dry.

The cost of destruction, including all charges except amortization and the cost of liquid fuel for the auxiliary burners, varies between Rs. 1-30 cents and Rs. 1-50 cents per ton. A saving of 16 per cent. in rubbish transport charges has been effected by the use of the destructor. The furnace residue which consists of broken bricks, tiles, sand, fine ash and friable clinker, amounts to about 40 per cent. by weight of the rubbish burnt. Except as filling the furnance, residue would appear to be useless, but the fine ashes are being tried on cocoanut estates and the dust from the flues and combustion chamber is stated to possess some value as a fertilizer for use on local paddy fields.

In the initial stages some trouble was caused by the accumulation of fine dust in the flues and regenerator, but this has been obviated by providing additional access and clearing openings.

The oil jets are not entirely satisfactory and the benefit derived from their use does not correspond with the heavy expenditure of fuel. The defect is attributed to the fact that the flames do not properly impinge upon the rubbish."

POINTS TO BE REMEMBERED IN CONNECTION WITH THE COLLECTION, REMOVAL AND DISPOSAL OF REFUSE (TOWN SWEEPINGS).

1. The amount of refuse per head is greater in bulk in Indian cities than in European cities.
2. The refuse is lighter in the dry season but decomposes more rapidly.
3. Refuse should be removed twice a day in India.
4. It should be disposed of as quickly as possible.
5. The amount per annum per head of the population in large cities in India is about 7 cwt.
6. The custom is for the people to throw all refuse on to the streets or passages; this should be prevented by notices and prosecutions.
7. Sanitary dust bins should be provided for compounds; and boxes or baskets for each floor of the house occupied by the poorer classes.
8. The refuse when collected should be taken to the place of disposal at once.
9. Each district should be divided up into areas, with Inspector Mukadam and gang of coolies; all carts should have covers.
10. The work should be regularly checked,—trips marked at the depôt.
11. The refuse, if disposed of by reclaiming waste land, should be covered over at once with 6 inches of dry earth.
12. The reclamation ground should be well away from inhabited houses.
13. Sprinkling the refuse with pesterine will prevent the breeding of flies.
14. Land thus reclaimed should be cultivated at a profit.
15. Destruction of refuse by incinerator is the best and cheapest method of disposal.

16. To calculate the number of carts, bullocks and labour staff necessary, the following data will be required:—
The population, amount of refuse to be destroyed, distance to place of disposal.

17. A cart drawn by a pair of bullocks will carry about 10 cwts. of refuse, can make 4 trips of 3 miles each in one working day.

18. One destructor cell will destroy 8—10 tons of refuse in 24 hours.

19. A population of 50,000 persons will produce domestic refuse at the rate of 40 tons a day.

20. A four-cell destructor capable of destroying this amount of refuse will cost £5,000 to £6,000.

Note.—The sanitary disposal of refuse and the waste products of civilization is of the utmost importance as on this the standard of public health largely depends.

Attention has of late however been directed to the utilisation of such material as a fertiliser or a fuel.

House and town refuse is not now regarded as a waste product to be got rid of but is recognised as an article possessing valuable fertilizing properties when suitably treated.

The treatment consists in passing the refuse through what is known as a *lightning crusher* or *lightning dust manipulator* which is a centrifugal-force disintegrator, pulveriser, and mixer combined. The crusher occupies little space, requires relatively small horse-power to drive and works almost noiselessly.

The manipulator consists essentially of a series of steel hammers attached to heavy discs which act as fly wheels and turn at a speed of about 1,000 revolutions per minute. The material to be treated falls through a hopper into the chamber in which the hammers revolve and is at once dashed with great force against a breaking block of special alloy steel, the material receiving about 4,000 strokes from an aggregate weight of over 70 tons per minute, the final disintegration being effected by trituration between the hammers and the grinding plate. When the material is reduced to a proper degree of fineness it drops through a screen on to a chute and thence to a railway wagon when levels permit or is removed by means of a sloping conveyor or an elevator.

Little sorting or picking of the refuse is required. No dust nor nuisance of any kind is developed during the process of transformation from refuse to manure.

The transferred refuse occupies only two-thirds of the space of the crude material.

The new fertiliser has been named "humic." In appearance it is like a fine black powder and has a slightly pleasant smell.

Mr. Mackison, the Chief Engineer of the Bombay Municipality, is now arranging to instal four of these crushers near Carnac Bridge. The cost of 4 dust manipulators complete will be about Rs. 42,000 (pre-war price).

The driving power required is about 20 B. H. P. for each machine.

CHAPTER III.

Collection, Removal and Disposal of Sewage.*

The subject of the collection, removal and disposal of sewage in India is one of the most important the sanitary official has to deal with, as well as the most difficult. No matter whether the place involved is a village or a growing town or a large city, the all-pervading presence of the subject crops up at every turn.

The effect on public health of the present system is enormous, beginning with the persistent smell of fæcal matter, human and animal, in and around the houses, up to the pollution of the food or water supply of a large town, or the transference of disease by "carriers."

To place the collection and disposal of human and animal excrement under proper control is one of the first principles of practical sanitation in India. It means a reduction in the sickness-rate, reduction in the mortality and an improvement in the condition of the people, morally, physically and hygienically.

Badly constructed trenches and want of supervision in mofussil towns mean the propagation of disease by the dissemination of germs and parasites, by flies and dust reaching the person, his food, milk or water; dogs contract and convey intestinal worms to cattle, sheep, goats, pigs and fowls, and thus to the human being, and while the sun has a drying and disinfecting power, the high winds disseminate the germ-laden dust. The majority of towns in India suffer from a form of Dysenteric Diarrhœa due to this pollution of food or water.

Coming to towns which are drained or partially drained, but where only few of the houses are connected, as is the case in the majority of towns in India, the sickness caused by the

* A glossary of technical terms is added at the close of the Chapter.

existing system is impossible to estimate. The open drains receive the contents of the overflowing receptacles, the semi-fluid matter percolates through the soil or lies in the open drain and forms a breeding and feeding ground for flies, rats, mosquitoes and vermin. Even in houses, where the water-closet exists, it is the custom for the same sweeper to attend to many houses either to flush the water-closet or wash the seat and bath. This is done with the same brush or cloth in several houses and it is easy to imagine the possibility of disease being spread in this way.

Any attempt at improving the sanitation of a growing town or city will never succeed unless the collection, removal and disposal of night-soil is dealt with in the strictest and most practical manner: the collection of the excreta at regular intervals in a systematic way and the disposal either by proper trenching, incinerator, or a suitable system of drainage.

In another chapter, the measures to be adopted in camps and fairs are described.

AMOUNT OF EXCRETA AND COLLECTION.

Mr. Fawcus' experiments on Bengali prisoners give an average bowel excretion of 12 ounces or ·75 lb. due to the large bulk of vegetable diet eaten by Hindus. This is confirmed by the observations of Dr. Hewlett in Bombay. The volume is due to the proportion of water it contains. In addition to this there is 40 ounces of urine, and the ablution water in a Hindu population, which must be added, is estimated at 40 ounces.

In Bombay, in those parts where the houses are not on the water-closet system, 2 lbs. per head per day for each adult and 1 lb. for children is the amount of excreta estimated to be actually removed, inclusive of urine and part of the ablution water in the native population; 30 per cent. of the urine and ablution water and fæces passes off into the drain, and

cannot be collected and soaks away owing to defects in the drain and pipes.

Fresh fæcal matter from healthy persons, living on a mixed diet, has an acid re-action when mixed with urine, and this it retains for a considerable time; it then becomes alkaline from ammonia. If free from urine, it usually decomposes slowly and in hot weather often dries on the surface, and subsequently changes but little (in England) for some time. In India, it is reduced to powder by the alternate action of sun and dew, and falls into the ground or is dispersed by the wind.

An adult male, living on a mixed diet of animal and vegetable food, passes 4 ozs., by weight, of solid and 50 ozs. of fluid excreta daily.

A daily average for a mixed population of men and women and children, on a diet of animal and vegetable food, may be taken as 2½ ozs. solid and 40 ozs. urine.

Taking an average of the analyses of the various authorities, we find that the solid and fluid excrements of an average individual, of all nations, sexes and ages, contain the following percentages of ingredients :—

ANALYSIS OF EXCREMENTS (KREPP).

Ingredients.	Fæces.	Urine.
Water	75·0	93·99
Organic substances	12·2	4·15
Nitrogen	1·4	1·42
Phosphoric Acid	1·06	0·24
Potash	0·29	0·20
Insoluble Silica	1·48	..
Oxide of Iron	0·54	..
Lime	1·72	..
Magnesia	1·55	..
Sulphuric Acid	4·27	..
Soda	0·31	..
Chloride of Sodium	0·18	..
TOTAL ..	100·00	100·00

Nitrogen or ammonia in fæces, 1·70; in urine, 1·73; phosphoric acid or phosphate of lime in fæces, 2·30; in urine, 0·52.

In the case of an average individual, the annual produce of the four principal ingredients in the above Table is as follows:—

	Fæces.	Urine.	Total.	Value.
	Pounds.	Pounds.	Pounds.	Shillings.
Ammonia (Nitrogen)	1·49	9·38	10·87	7·3
Phosphate of Lime (Phosphoric Acid)	2·00	2·80	4·80	1·7
Potash	0·25	1·08	1·33	0·7
Organic substances	10·51	22·49	33·10	0·7
TOTAL ..	14·25	35·75	50·00	10·0

The fertilising value of excreta per annum per head of the population living on a mixed diet is stated to be equal to raising as much grain as 75 lbs. of guano, and equal to increasing the yield of grain by 3·21 bushels per acre in addition to what the land would yield without manure.

BOMBAY.

Bombay is the most sewered city in the East, that is to say, it has more sewers and more houses connected to the sewer and more water-closets.

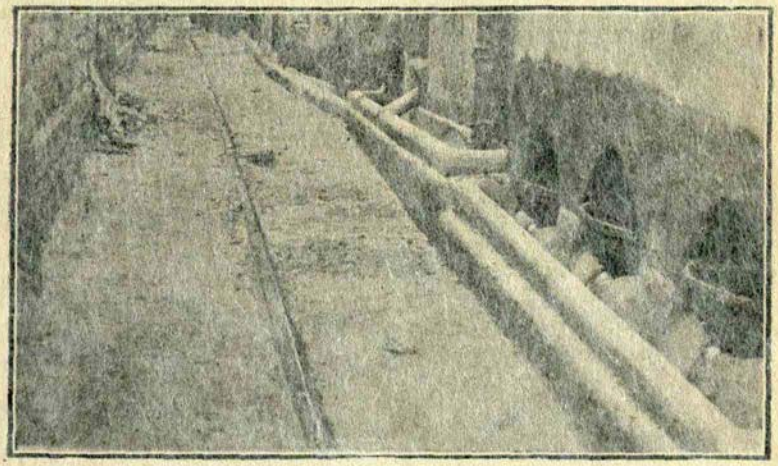
At the same time there are thousands of houses with the old privy basket system; the basket is emptied twice daily and the contents discharged into the sewer at the pail depôt. Between rows of houses a narrow sweeper's passage exists ranging from 1 foot to 5 feet wide. Houses of four and five stories abut on these passages, the living rooms opening on to them. The only ventilation many of the rooms have is from the filthy passages.

In Bombay, for conservancy purposes, 2 lbs. per head per

day is the amount of night-soil and urine estimated to be removed from the houses where privy receptacles are used, inclusive of ablution water and urine, much of the latter escaping into the open drains.

The halalkhor or sweeper or bhangi is an institution of tropical climates.

In sewered towns, where water-closets are not general and where the houses are not all connected with the sewer, the night-soil is collected by the halalkhor man or woman,



SWEEPER'S GULLY WITH BASKET PRIVIES AND OPEN DRAINS.

from the privy receptacle, outside or inside the house, situated chiefly in a passage between two houses; it may be a commode in a bungalow or a public latrine in the street. The privy receptacle is made of basket work or iron and holds about 15 lbs. of excreta.

The halalkhor basket holds roughly about 40 lbs. and when full is carried on the head some distance, varying from a few yards to a mile or more, and there deposited in the depôt connected with the sewers. The number of trips made by the halalkhor varies with the distance he has to travel to the depôt.

In streets, where the houses are close together, one man can collect and convey the contents of 30 privy receptacles; 3 receptacles go to a basket load. One receptacle may have to receive the excreta from 4 or 5 seats, according to the height and nature of the house, as the seats are placed one above the other in buildings of 4 and 5 stories, and 1 seat is considered sufficient for 20 persons. In Bombay it is found that one man can make 8 trips of ½ a mile each way, between 6 and 9 a.m. and 3 and 4 p.m. carrying 40 lbs. of night-soil, the work being estimated thus :—

In a temperate climate an average day's work is calculated to be 300 foot-tons.

A man weighing 150 lbs. and walking 17 miles on a level road at 3 miles an hour does 300 foot-tons.

A halalkhor weighing 120 lbs. carrying 40 lbs. on his head, and making 8 trips in the morning and afternoon of ½ a mile per trip, would do about 150 foot-tons.

Let W = weight of man.
WI = weight carried.
D = the distance walked in feet.
C = co-efficient of traction $\frac{1}{10}$ at 3 miles an hour.

Then $\frac{(W+WI) \times D}{2,240} \times C$ = Foot-tons of work done.

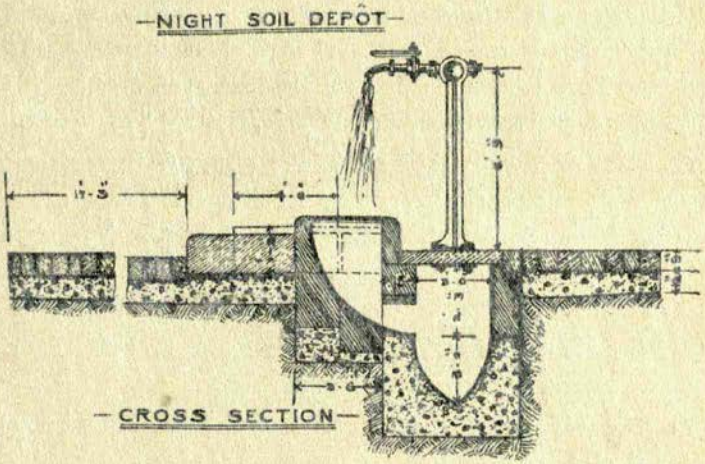
One man can thus remove the contents of 30 receptacles making 8 trips of ½ a mile equal to 320 lbs., or the excreta from 80 persons in 3 hours, or 160 persons in a day's work.

The receptacle is placed on the ground-level, in a trap or compartment. (See figure on preceding page.)

The sweepers or halalkhors number about 2,200 men and women in Bombay City. The labour staff of the Health Department all told number 8,000. They muster at 5-30 a.m. and go round their beats collecting the night-soil, which they convey in baskets on their heads to the various depôts. If their work is not supervised and checked, they will scamp

if either by making false trips or depositing the night-soil in the open drain. That the system is one of the greatest evils in the City cannot be denied. It costs in wages alone about Rs. 11,66,628 per annum without the cost of housing them.

The halalkhor, after 5-30 a.m. muster, takes his basket to his respective beat and loads it from the privy receptacle, which is made of basket-work, or iron in some cases. Immediately after emptying the receptacle, the privy trap is washed down, if water is available, or swept out with a



broom. In the afternoon the same practice is gone through. The loaded basket is taken to the nearest pail depôt, where the contents are discharged into the hopper connected with the sewer and the waste washed out, and another trip made : the trip being marked, in a book kept for the purpose, by the trip-marker. Sulphur is kept burning at these depôts.

In towns and districts which are not sewered, the same procedure is gone through, carts being the receptacles which convey the night-soil to the trenching ground.

(1) The capacity of a cesspool cart is 32 cubic feet. A

cart will hold 200 gallons of cesspool water, or between 17 and 18 cwt.

(2) The average number of trips made by cesspool carts in districts is three for the whole day.

(3) As a rule there is one driver and one cart filler for each cart.

(4) The average distance each cart travels is nine miles a day.

(5) Hours of work are from 5-30 a.m. to 10 a.m., and 2 to 4 p.m. There is a certain number of carts employed at night between 7 and 11 p.m.

(6) On an average there are 25 privy cesspools to each cart and the average capacity of each cesspool is 20 cubic feet, but they vary according to the district.

In actual practice each cesspool is emptied every 3 days.

(7) The cost of repairs and maintenance and cartmen's wages and of bullocks, per mensem, is as follows :—

(*a*) Repairs and maintenance : Rs. 10 per month per cart.

(*b*) Men's wages : driver Rs. 24 and filler Rs. 23-8 each per mensem.

(*c*) Bullocks : feeding and shoeing Rs. 40 and Rs. 5 per pair per mensem, respectively.

In Bombay the Halalkor Tax levied comes under four heads, as follows :—

(*a*) Ordinary Halakhor Tax, based on a 3 per cent. net valuation of the building or property.

(*b*) Special Halalkhor Tax for mills at Re. 1 per head per annum on the number of employés in the mill or factory.

(*c*) Special Halalkhor Tax on Government, Port Trust and Railway properties, also hotels, messes and clubs, as the Commissioner may direct. The tax in these cases is calculated and levied according to the Standing Committee's Resolution No. 3110 of 16th July 1919.

(*d*) Government properties used as residential quarters by their officials are charged the same as (*c*) but 8·6 per cent. reduction is allowed for casual vacancies.

In all the above cases, reference is made to the Health Department in the case of ordinary service, in regard to rendering and discontinuing service. The same is the case with the mills; the proprietors send in a return, every six months, of the number of their employés, and the tax is levied accordingly. In the last two cases, the Health Department gives details of service rendered and charges to be levied. These figures are checked by the Municipal Commissioner and the tax then recovered by the Assessment Department.

In Bombay the following general standard is laid down for the provision of water closets or privies :—

In Dwelling Houses.—One seat of W. C. for every 5 rooms occupied as separate tenements.

In Cinemas.—One seat of W. C. for every 400 persons or less and one seat of urinal for every 200 persons or less.

In Theatres.—One seat of W. C. for every 200 persons or less and one urinal for every 200 persons or less. One seat should be reserved for females.

The requirements in London are :—

In Dwelling Houses.—One W. C. for 12 persons.

In Workshops.—One W. C. for 25 persons upto the first 100 and after that one for every 40. The workshop regulations take into account the fact that workers also use the W. C. in their homes.

THE TRENCHING OF NIGHT-SOIL.

When properly carried out, the conversion of fresh night-soil into manure by burying it in trenches is one of the best systems known in India for small communities. Wherever it is tried, the manure finds a ready sale.

The soil for effective trenching should be loamy and porous

and fairly well drained, and the section and depth of the trench must be of such dimensions as shall allow the process to be carried out without nuisance. Trenches vary from 2 feet deep and 2 feet wide. A mean of the two is preferable, 18 inches wide and 18 inches deep, which allows of cultivation and prevents the breeding of flies and the action of the wind.

The dimensions will vary with the quality of the soil. The temperatures of the air and of the ground are favourable to the changes that take place during the process of conversion, and land that has been used for a period for trenching has its productiveness greatly increased.

Trenching is best suited for localities with a moderate rainfall, as the process of sewage removal will admit of no interruption.

At Nasik, the night-soil of the town (containing 33,463 inhabitants) is trenched in loamy soil in a manner that is both effective and profitable. The trenches are made about 18 inches wide and 18 inches deep, and of any desired length. They receive 12 inches of sewage, and are then covered up with earth. After a period of two or three weeks, the sewage is removed with part of the earth which it has saturated and placed in a depôt for sale. It has now no offensive smell, and is readily purchased and used by cultivators.

THE NASIK SYSTEM.

The Nasik system of pitting night-soil, as described by Lieut.-Col. Marjoribanks, I.M.S., is carried out as follows :—

Briefly, this consists of its disposal in crude and liquid form into a regular system of pits. The pits are covered with a layer of *cutchra* only, which forms an efficient air and fly seal. The method can be applied all the year round. Heavy rain does not interfere with the management of a system which treats night-soil to start with as a liquid.

After a year or so the contents of the pits dried and ripened are very like ordinary earth in appearance and are in demand by cultivators.

At Poona, with a population of 117,256, the night-soil is collected in carts and trenched in the suburbs, in a manner similar to that in vogue at Nasik. During the process of burying, it is mixed with ashes resulting from the burning of *cutchra*.

Trenching as carried on by digging pits is one of the worst methods of disposal of sewage. The urine and fæcal matter from public latrines and from depôts of night-soil, carried by scavengers from private houses, are transported in small tank carts of 12 cubic feet capacity to pits dug in the suburbs of the town on cultivable land. The pits are about 20 feet square and 4 feet deep, and are filled up with the liquid night-soil, which is left to heat up and ferment in the sun. If the ground is of clay, there is very little combination between it and the sewage, which putrefies so freely as to be covered like beer with a head of foam, due to the gas bubbles rising through it.

The stench is indescribable. The residue, when dry, is sold to cultivators as poudrette, the greater part of its fertilising power being lost in the gases of decomposition.

The trenches should not be located to windward of the town, and should not be within 300 yards of dwelling houses, tanks, or wells.

Major Harris, I.M.S., Sanitary Commissioner, United Provinces, gave an excellent description of the various methods of night-soil disposal and its association with fly breeding, at the All-India Sanitary Conference at Madras, 1912.

To choose the best method, much depends on the site, surroundings and soil, the chief object being transforming the night-soil as rapidly as possible into manure or utilising the land so treated for cultivation, with the minimum risk of fly breeding.

The various methods of night-soil disposal are :—

I. By separate septic tank installation for each latrine.
II. By incinerators.
III. The Thornhill system.
IV. The pitting system.
V. The shallow trenching system.
VI. The 2 feet deep trenching system.
VII. The method in small villages of deposition of excreta in the neighbouring fields.
VIII. The absorption or filter trench system, with removal of excreta to trenches.
IX. And, in addition, the methods in vogue at fairs :—
(*a*) The shallow pan system with removal of the solids to trenches.
(*b*) Defecation in open courtyard without pans, but with a removal of the solids to trenches.
(*c*) In firm soil the shallow trench, 9 inches wide, 1 foot 6 inches deep, into which defecation is direct.
(*d*) In sandy, loose soil the deep trench, into which the dejecta fall direct, but in which boards with supporting cross beams are placed to protect the edges of the trench from falling in by the weight of the user.

1. In the first system, the installation is easy to work but the initial expense is large and the effluent is unfit to run into small streams and should be treated on land.
2. In incinerators we have an excellent method of disposal in towns, or parts of towns, where horse litter is obtainable or where the rubbish is of an inflammable character.

The objections to the general use of incinerators are—
(*a*) That the rubbish in civil stations is usually of such a character that it will not burn well.
(*b*) That it is usually damp and in the rains very wet

and requires long storage.

(c) That constant supervision is required.

(d) That no income accrues to the Municipality from the sale of rubbish and night-soil, although the expenses of cartage are diminished.

(e) The smell of incinerators.

3. The Thornhill system is the best method of earth disposal and does not lead to the breeding of flies provided supervision is constant.

4. The pitting system is carried out in several ways. The most successful is by carrying the night-soil to pits in the fields of cultivators outside Municipal limits.

Another pitting method that is used is to fill up large 6 feet deep pits with soild night-soil, which is removed from the private latrines of the towns. When these pits are opened, the stench is unbearable and fly larvæ are found to abound.

5. The shallow trenching system is carried out by placing the night-soil in trenches 9 inches deep and about 9 inches wide.

(1) A common method of disposal of night-soil in Municipalities is by trenching it in suitable trenches, and subsequently disposing of it to cultivators after it has remained a sufficient length of time in the ground. Trenches should be 2 feet broad and not more than 2 feet deep. A depth of 18 inches would be better, but economy generally demands the greater depth, which should however never be exceeded. These trenches should be dug in straight, parallel lines, 2 feet apart from one another. Night-soil to the depth of 1 foot should be placed in them and the trenches then filled in with all earth taken out. They should, therefore, present the appearance of lines of mounds, the elevations indicating the site of the trenches. The earth will in a few months subside to the general ground level. Filth, thus trenched, will usually be resolved into harmless products after some

six months' burial, but inasmuch as the rapidity with which such changes are effected depends largely upon the character of the soil, it is desirable in every case to ascertain, by an experimental excavation, whether the contents of a trench are dry and inodorous before the same are sold to cultivators and others.

The land taken up for trenching should be loamy or alluvial. Sandy soil should not be used for the purpose. A site once trenched should not be used for more than one year, or at the outside two years. After this time there will be no earth left to fill up the trenches over the night-soil deposited in them. The site should then be levelled and a few crops taken off it, when it can again be trenched. Urine is also best disposed of by trenching in a similar way.

(2) A second method is to trench as already described and then take a succession of exhausting crops off the land, such as vegetables, maize, tobacco, etc. Land thus treated can be trenched every year if the cultivation be complete and constant. The method, however, is not one which Municipalities are likely to adopt.

(3) The first object of course is to dispose of all impurities in a sanitary manner, so that the health of the community may be maintained. The various methods of doing this have been described above. In many cases, however, there is no sale for the resulting manure and thus it becomes lost. It should be the endeavour to utilize the manure thus, by taking up land where this is possible, and trenching on the shallow system and cropping with exhausting crops, as potatoes and tobacco. This system was introduced by Col. Thornhill at Bareilly and consists in digging trenches $16' \times 5' \times 1'$ with 6 inches between each trench and 6 inches between each line of trenches. The soil removed is thoroughly pulverized, an essential point, and 2 inches is returned to the trench into which the contents of one or two night-soil carts are tipped. If the night-soil is mixed with earth, the whole

of the remaining earth need not be returned. A depth of 1 foot is necessary, as otherwise flies breed out in large quantities. Land so trenched does not require manuring again, usually till the fourth year.

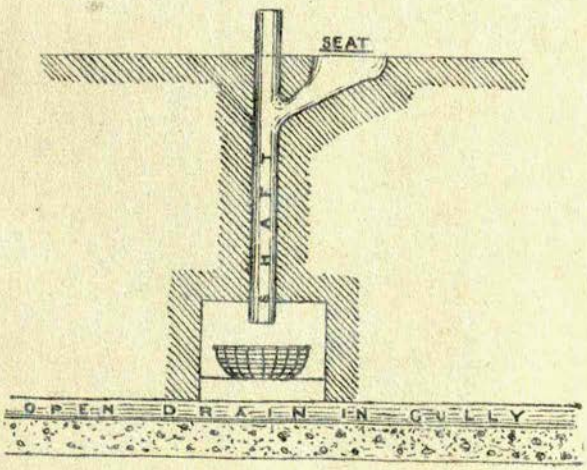
In Cantonments a wet system of treatment has been tried. This consists of adding perchloride of mercury 1 to 500 or cresol, advocated by the late Lt.-Col. W. Morris, R.A.M.C., of Cawnpore; the theory being the killing of the bacilli in the fæces and urine and subsequent disposal by incinerators.

EVOLUTION OF THE WATER-CLOSET.

The forms of privies and latrines commonly used may be classified into dry pattern and water-carriage.

In India there is no dry earth system as known in European cities; it is rare to find outside Military Cantonments any form of privy in which dry earth or ashes are added to the excreta before removal.

In practice this method is found successful in public institutions where there is no sewage system. The important question is the addition of dried earth, 1 lb., each time the pail



IMPROVED FORM OF BASKET PRIVY.

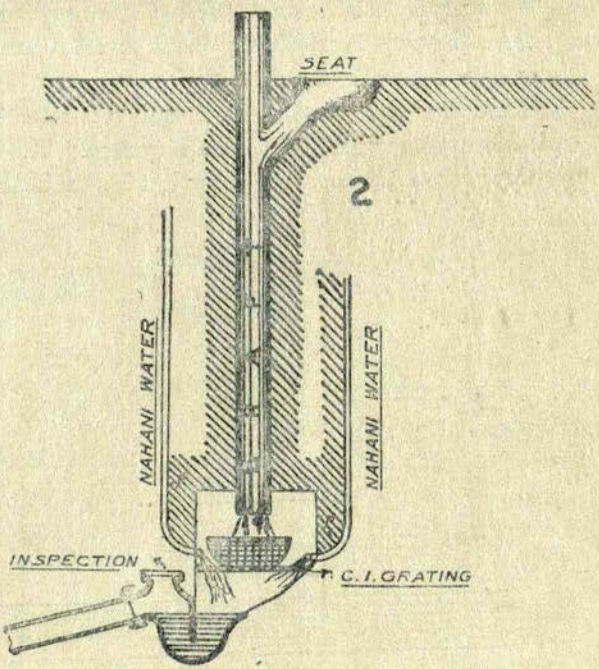
is used. In drying, the earth should not be heated so as to destroy nitrifying organisms which disintegrate the night-soil or humify it. The material must be tolerably dry. The action is ærobic.

The commonest method of getting rid of night-soil is that adopted by the inhabitants of villages and towns, who use the open fields or, at a sea-side place, the sea-shore.

Trenches are cut in the ground into which earth is thrown after use.

The next step is the stone or earthen squat seat with or without a receptacle.

An improvement on this is the cemented platform on which the person squats, the urine and fæces being discharged on to a sloping shoot of iron or cement or glazed earthenware



IMPROVED FORM OF BASKET PRIVY.

into a receptacle. Various patterns of these are on the market and much improvement has been made in them of late.

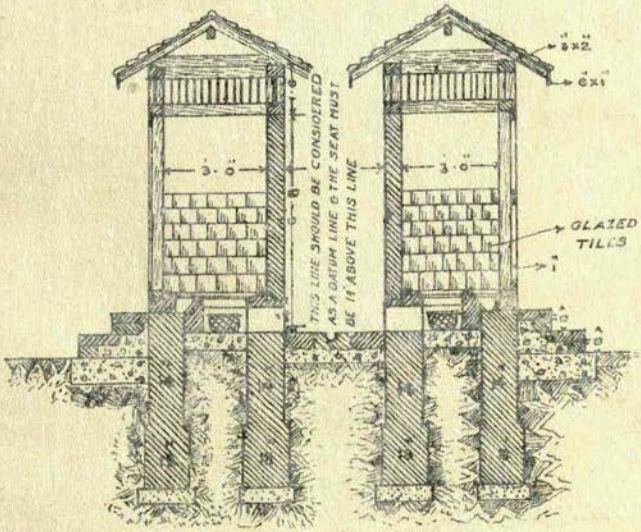
The receptacle may be of basket work, iron or earthenware.

It is the custom for the majority of natives of India to use ablution water and this adds to the quantity of matter to be removed.

Forms of seats and receptacles have been designed to separate the liquid from soild matter; this is desirable but rarely carried out. Fæces and urine combined decompose more readily than when separated.

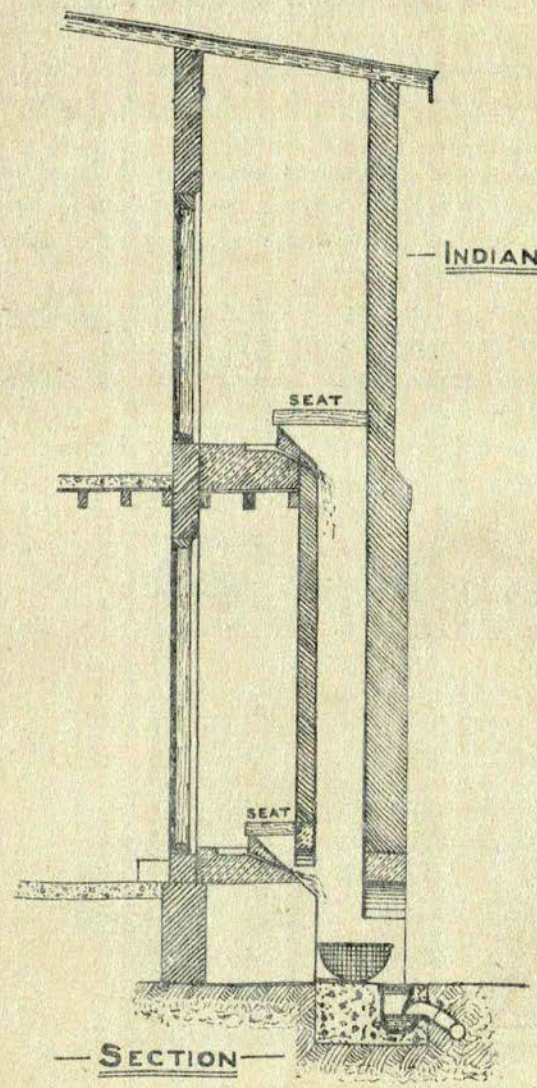
The objects to be attained in providing privy accommodation in places where sewers do not exist are:—

1. Position of latrines should be away from the buildings and to the lee-ward side.
2. Impervious floor and wall and seat on platform of impervious material.



BASKET SYSTEM PRIVY.—CROSS SECTION.

3. Water-tight receptacles capable of holding the daily excreta of the household.
4. Facility of removal of contents once a day at least.



5. Ventilation of the privy.
6. Cleansing and disinfecting of receptacles.

In sewered towns where the latrines are not connected with the sewer, receptacles have to be provided and the contents removed to pail depôts by hand or carts.

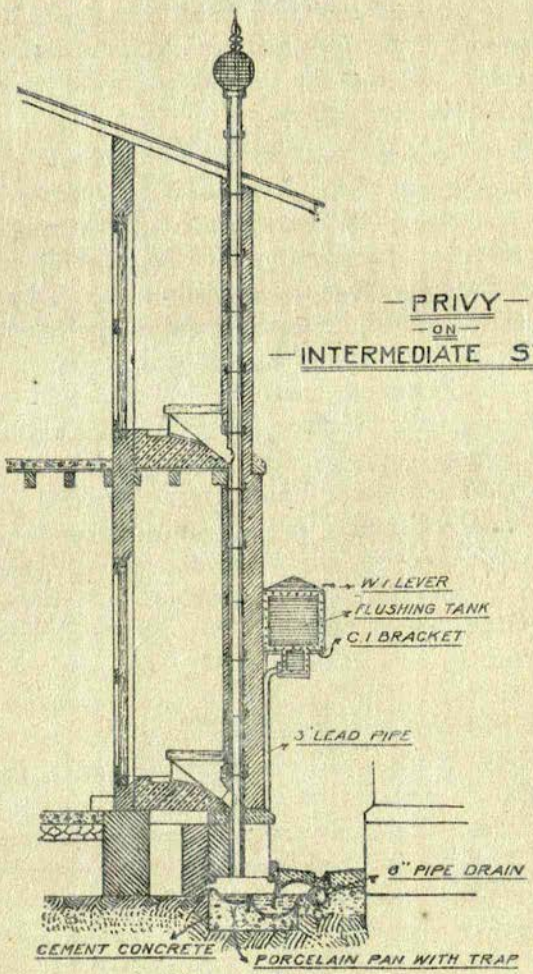
The essence of practical sanitation in all countries is the immediate removal of all waste products. This should be more particularly the case in tropical countries, where decomposition sets in more rapidly.

In towns where the houses are built of two or more stories the privy system is one of the most insanitary features of Indian life. In Bombay there are hundreds of houses in which privy seats are placed one above the other at one end of a dark passage within the building. The platform or seat is made of cement or stone or glazed earthenware discharging into an iron, earthen or stone shaft common to all the privies on the several floors. The excreta of all the tenants, numbering many hundreds of persons in some of the chawls, are discharged into the shaft to drop into a small receptacle 30 to 60 feet below. The receptacle is placed in a small square trap with a door, the contents solid and liquid overflow into the open drain between the rows of houses and are removed twice daily by the halalkhors. (*See* plate.) The shaft becomes coated with filth and the stench from the privy, which is often close to a living or cook room is very objectionable. The presence of the decomposing filth and water attracting flies and mosquitoes is a serious danger to health, apart from the constant foul smell and pollution of the air of the rooms.

To remedy this, when accommodation cannot for some reason be made on the full flushing system, an intermediate water carriage system was designed by Mr. C. C. James, late Drainage Engineer, Bombay Municipality, and improved modifications of this pattern are now being adopted.

The best form of intermediate water carriage closet is

one with the soil pipe of glazed earthenware or iron coated with Barff's material or lead. The seat and basin are of glazed earthenware, marble, tiles, cement or glass with a sharp slope to the soil pipe. The ablution water and fæces and urine are then discharged directly into the soil pipe.



—PRIVY—
—ON—
—INTERMEDIATE SYSTEM—

—SECTION—

The water-closet is placed close to the nahani or bathing place, the waste water from which flows into the basin. The soil pipe is carried up 5 feet above the eaves of the neighbouring houses: it discharges over a receptacle made of cement or glazed earthenware connected with the house drains, at the junction of which an inspection chamber is placed with a trap between the house and sewer. A 10-gallon automatic flushing tank is placed at the head of the house drain. No sewer air can then enter the house. While this is an improvement on the old form of privy, it is not free from objections.

The objectionable custom of removing the excreta by hand from the receptacle below is done away with. No night-soil remains for hours together polluting the air and making a breeding place for flies and vermin, and the sight of the sweeper removing the basket of night-soil is avoided.

The intermediate system is far from perfect and should never be adopted when the full flushing water-closet can be provided.

The next step is the water-closet on the full flushing system.

Much progress has been made in Bombay in this direction, as all new houses and all the newly built chawls for the poorer classes have now such accommodation and the public latrines are for the most part on the water carriage system.

Comparison between a water-closet on the full flushing system and the intermediate water-closet.

In both cases the night-soil is discharged into the sewer.

Full water-closet.	*Intermediate water-closet.*
The soil pipe is carried full bore above the eaves, and ventilates the house drain.	The soil pipe is carried up above the eaves and cut off from the receptacle below.
The house drain is disconnected from the sewer by means of inspection chamber and trap.	The soil pipe is flushed by the ablution water and the waste from the nahanis and bathing places.
At each water-closet seat there is a trap	

Full water-closet.	*Intermediate water-closet.*
Sewer air cannot get into the house if— (1) the traps are sealed; (2) the inspection chamber is in order.	No sewer air can get into the house but the smell from the fæces adhering to the pipe, if sufficient flushing is not adopted, will be a nuisance.
The cisterns are filled at least once a day and the basins are flushed.	The night-soil is discharged into a basin below on the ground level and is periodically flushed into the sewer through the house drain by a 15-gallon flushing tank discharging every 15 minutes; the basin is trapped.
No night-soil remains in the pan and soil pipe if flushed.	
The advantage of this is that the night-soil is carried away immediately.	The advantage of this over the basket privy is that the night-soil is removed by water carriage into the sewer and not by hand, though it is not all carried away at once and requires, in addition to the automatic flushing tank, a sweeper to clean and flush the basins.
The gullies or places between the houses are dry and the open drains do not receive night-soil.	The smell from the decomposing filth of the privy seat and soil pipe is reduced, but unless the flushing is adequate and the soil pipe free from accumulation some smell is bound to remain. (*See* plate.) The advantages are that all the waste water is used to flush the soil pipe and basin and the house drain, while the automatic flushing tank forms an additional flush.

The argument that water-closets get out of order and are not suitable to Indians is over-done. A suitable form of water-closet with automatic flush and proper supervision is practicable in the majority of houses in large Indian towns.

The objections urged against water-closets in Indian towns are owing to :—

(1) the want of constant supply of water, (2) the habits of the people, (3) the inefficiency of the sewers and (4) the cost.

Without a proper supply of water, a water-closet connected with the sewer is undoubtedly not free from danger. But with a supply that is not on full pressure all the twenty-four hours, arrangements can be made to keep the water-closet properly supplied with water by providing suitable tanks and cisterns properly covered and fitted with automatic fittings and not directly connected with the water-closet. The size of the tanks necessary can be estimated by taking the census of the building, allowing for one day's supply and calculating 5 gallons per head per day for water-closet purposes.

Take a building of 100 rooms occupied by 4 persons each, 400 persons require 2,000 gallons per day for water-closet alone.

1 cubic foot of water is equal to 6·25 gallons.

Then 4 cisterns containing 500 gallons each placed on the highest part of the building would be sufficient, as each tank would measure 5′×4′×4′ or 80 cubic feet=500 gallons.

Cisterns.—Cisterns for supplying a water-closet should be separate from the storage tank and so constructed as not to deliver more than three gallons of water at a flush. They should be so made as to make it impossible for water to enter whilst the flush is taking place or whilst the pull is drawn down. They should be supplied with a ball tap and with a half-inch lead overflow or warning pipe.

Every cistern to be used for the storage or reception of water should be made and at all times maintained absolutely water-tight, and supplied with a ball-tap which must remain tight under a pressure of 150 lbs. per square inch; the tap should be fixed so as not to become submerged when the cistern is full. The level of the water in the cistern should be maintained at two inches below the overflow or warning pipe, which must discharge in a prominent position so as to

be easily seen by the Inspectors, and must on no account be connected with a drain. Cisterns should be so covered in as to exclude dust and mosquitoes, and be fitted with a man-hole for cleansing purposes and be easy of access for inspection. The supply pipe should have a draw-off tap, from which drinking water can be drawn before it enters the cistern. Cisterns should be of iron, slate or zinc, placed on the highest position of the building and protected from flies, rats and mosquitoes. No cisterns must be so placed that sewer gas can by any possibility have access to it.

Ball-cocks.—Where ball-cocks are employed, they must be controlled by a stop-tap and must, where a meter is fixed, be of the equilibrium type, similar to Kennedy's No. E-106.

PRACTICAL APPLICATION.

It will be convenient at this point to discuss the application of these rules to the different classes of houses in cities and towns in India.

Reference has already been made to the various forms of privy accommodation, and how the excreta and sullage water are removed to the sewer. In many parts of every city in India there are no sewers available and recourse must be had to cesspits for sullage water. Sullage water may be described as the waste water from cook rooms, bath rooms and nahanis, which does not necessarily contain excreta, though in India it would be difficult to eliminate fæcal matter as an ingredient of sullage.

The classes of houses to be met with are—

1. Those on European style with water-closets and baths and drained and connected with the sewer on the modern system, as already described.

2. Bungalows with gardens occupied by Europeans or Indians. The waste water from baths and stables and kitchens discharges into drains and sewers; the servants' water-closets are connected with the sewer, the tenants of the bungalows using commodes which are emptied by hand.

3. Indian houses with water-closets and bathing accommodation separated from the houses, all connected with the sewer.

4. Indian houses with nahanis inside the house, and the privy receptacle system, the contents being removed by hand; the waste water from bath, kitchen, nahani or mori or overflowing from the privy receptacle discharges into covered pipe drains in the gully or passage between the houses, and into the house drains and sewer.

5. Similar houses but where the sullage and overflow from the privy receptacle pass into an open drain and then into the house drains and sewer.

6. Indian houses on the privy receptacle system with a cesspit, the sullage from the kitchen, nahani and bath discharging also into a cesspit. In this case the sullage water should be kept separate from the privy, and both cesspits should be emptied daily.

The Municipal Act provides that where there is a sewer within 100 feet of the premises, the owner must connect his drain with the sewer. Where there is no sewer within 100 feet, a cesspit must be provided into which the liquid from the privy receptacles and kitchen waste should discharge by means of a 4-inch pipe properly laid.

The capacity of a cesspit for houses of this kind in India should be sufficient to hold 24 hours' flow. The cesspit should be placed as far as possible from the dwellings, and ventilated with a 3-inch pipe, carried well above the highest window. The cesspit for privies should be separate from that for nahanis and should have a capacity of 3 cubic feet per privy seat, with a minimum of 10 cublic feet, and should be regularly emptied after 11 p.m. once in 24 hours. The cesspit should be constructed of brick laid on concrete and internally rendered with a $\frac{1}{2}$ inch layer of cement and sand. Its walls should be brought up 6 inches above the surface of the ground, so that surface water should not be able to

enter it, and covered with an air-tight cover to prevent noxious odour. Cesspits for sullage water from bath rooms should be similarly constructed, and if the water is used in the garden, care should be taken to see that they are regularly emptied and properly covered, so as to prevent the breeding of mosquitoes.

The cleansing of house drains, gullies and waste water pipes in Bombay. —The Health Department undertakes this work, instead of reporting choked drains to the Drainage Department, and a special staff is appointed to carry it out under the control of the House Drain Inspectors. The work falls under the head of conservancy work, while at the same time it is an important part of the Sanitary Inspector's work as it is intimately connected with the sanitary arrangements of houses, a subject which the Sanitary Inspector is daily engaged on. All Sanitary Inspectors are expected to make it their duty to report on any defect in house drainage connections and assist the Drainage Inspectors.

The duties of the House Drainage Inspectors and Sub-Inspectors are to supervise the cleansing of house drains and waste water pipes, and the opening of the same to remove chokes when necessary, and to serve notices on the landlords and recover expenses. Their duties do not cease here, as, in order to prevent daily chokes in drains, gully traps and waste water pipes, constant supervision of all gullies and drains is required and this includes the work of the mukadums, halalkhors, sweepers, begaris, plungermen, and the throwing of kuchra from windows, and for this purpose they can call in the assistance of any of the Conservancy staff. The Sub-Inspectors and mukadams especially, must be made to understand that they are to pay particular attention to the gullies and the way they are cleaned and to report chokes. The Drainage Inspector and Sub-Inspector will have frequent opportunities of noticing how the work of the halalkhors and sweepers is done, as in preventing chokes in drains much depends on the way the work is carried out.

The ordinary daily routine work is to inspect choked drains which have been reported and entered in the book kept at their office and start the work of removing chokes and to proceed on a tour of inspection in their division. If the block cannot be removed at once, notice must be served on the owners. Any drains found choked are to be noted and cleaned and the name of the mukadam of the particular section is to be taken down and entered in a book for reference, and inquiry made as to why the choke was not reported by him. When the house drain is free and the block occurs in the street connection, immediate notice is to be sent to the nearest Drainage Department office and confirmed afterwards by written intimation, copies of which should be kept in the usual way. All reports of choked or defective drains should be sent at once to the Inspec-

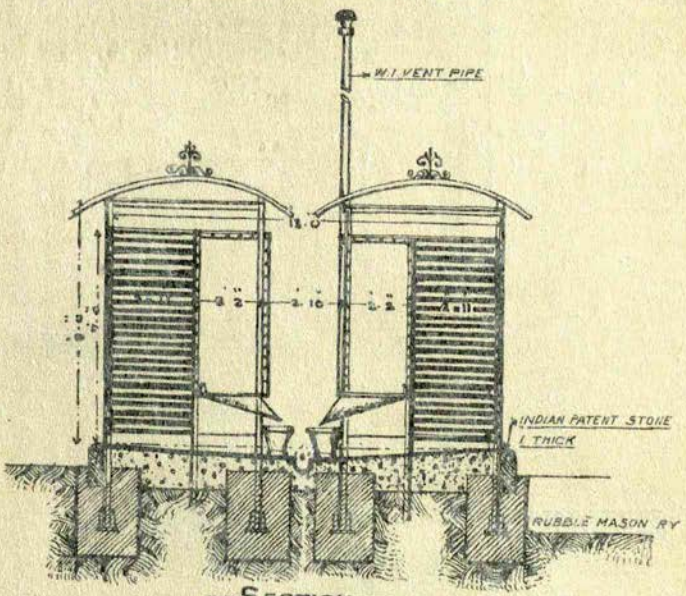
tor's office, entered in a book and attended to daily by the House Drainage Inspector. The Chief Inspector must see this book daily, sign it and send it to the Conservancy Superintendent.

Books of Notices under Sections 260 and 257 are supplied to each Assistant Health Officer and notice under Section 260 must be sent to the Commissioner for signature when required.

PUBLIC LATRINES AND SANITARY CONVENIENCES.

The Municipal Acts in force in India lay down that the sanitary authority (*see* Section 252, Bombay Municipal Act) shall provide and maintain, in convenient situations, and on sites vesting in the Corporation, water-closets, latrines, privies and urinals, and other similar conveniences for public accommodation.

— CRAWFORD SYSTEM LATRINES —



— SECTION —

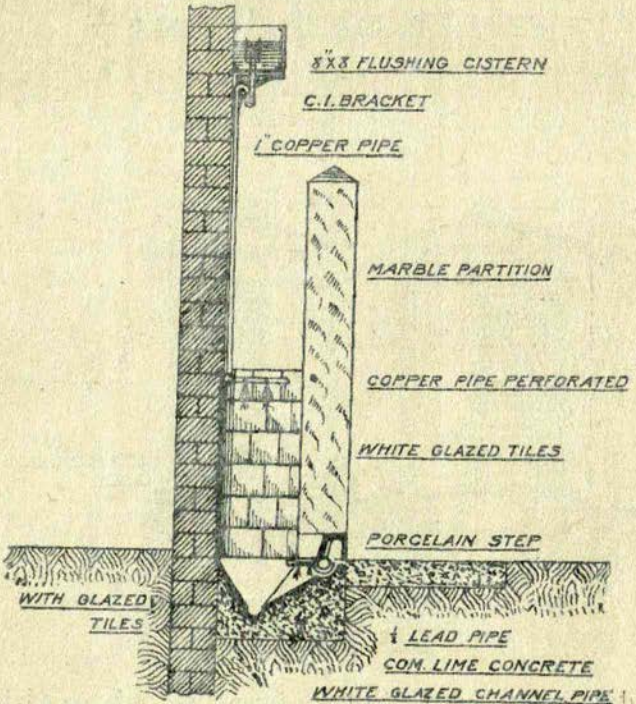
It devolves on the Health Department, as a rule, to advise on the number, site, capacity and form of public conveniences,

and in doing this the following points have to be considered :—

In very few cities in India is it possible to have a latrine for every house.

The Act empowers the sanitary authority to insist on the provision of privy accommodation for each house. The Bombay and Calcutta Municipal Acts do so, and the Public Health Act, England (1875), but with modifications. For example, if the privy accommodation, already provided, is common to several houses and is sufficient, or if there is sufficient Municipal accommodation available in the neighbourhood, the sanitary authority need not insist on separate

—COMBINED CONSTANT FLUSHING URINAL—
—PLACED IN A CORNER—



—VERTICAL SECTION—

accommodation for each house. These circumstances then have to be considered, and to meet the requirements of the people it will be necessary to decide what Municipal public accommodation is required for different localities—

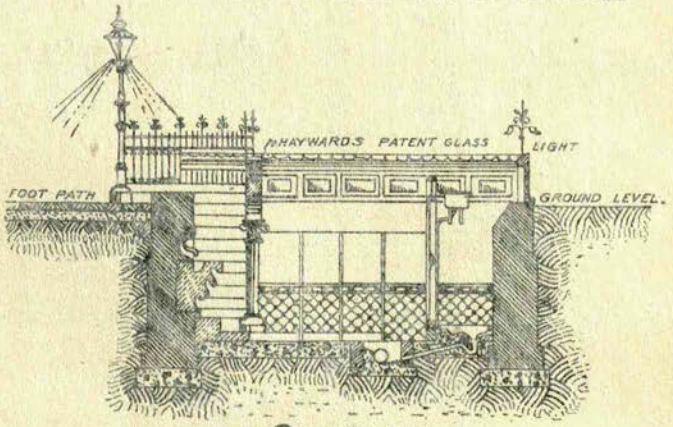
1. Where no drains and sewers are available and the night-soil has to be carried to a trenching ground.

2. Where sewers are available but water is not sufficient for a constant supply at full pressure, and the night-soil has to be carried to the pail depôt.

3. Where the water-closets can be on the full flushing system.

Amongst the poorer classes, in mill districts, docks and localities occupied by daily labourers, the houses are provided with latrines common to two or more. Mills and factories must provide latrines in some form or other.

—COMBINED UNDERGROUND PUBLIC CONVENIENCES—

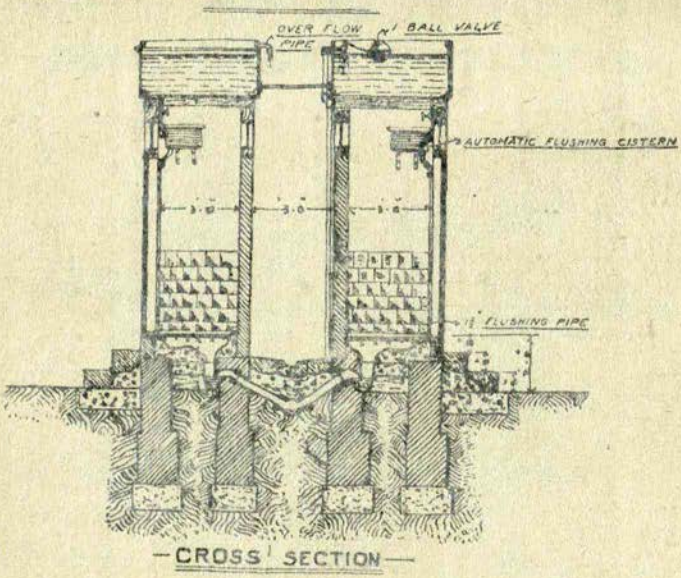


—SECTION—

The early hours of the morning, from 4 to 8, are the time when the latrines are most used, and, as there will be a rush for the latrines in the compounds of the houses, public latrines will be in demand. A visit to a latrine will probably take 4 minutes, therefore 15 persons can use one seat every hour

or 60 in the first 4 hours ; and on this basis, 15 seats will be sufficient for a population of 1,000, because the whole population would not require to use them at the same time, but only those who cannot be accommodated at their houses or works. For large blocks of labourers' dwellings, or mills or factories, more accommodation is required, and in Bombay it is usual to ask for 1 seat for every five rooms, or 20 persons, in a chawl, house or mill, and although there is no bye-law to that effect, it has been so long the custom that it is now recognised by architects and the Magistrates' Courts. In the Factory Act, 1 seat for 50 persons is laid down, but this is not sufficient, unless on the water carriage system, even when separate urinals are provided.

—IMPROVED WATER CARRIAGE LATRINES—

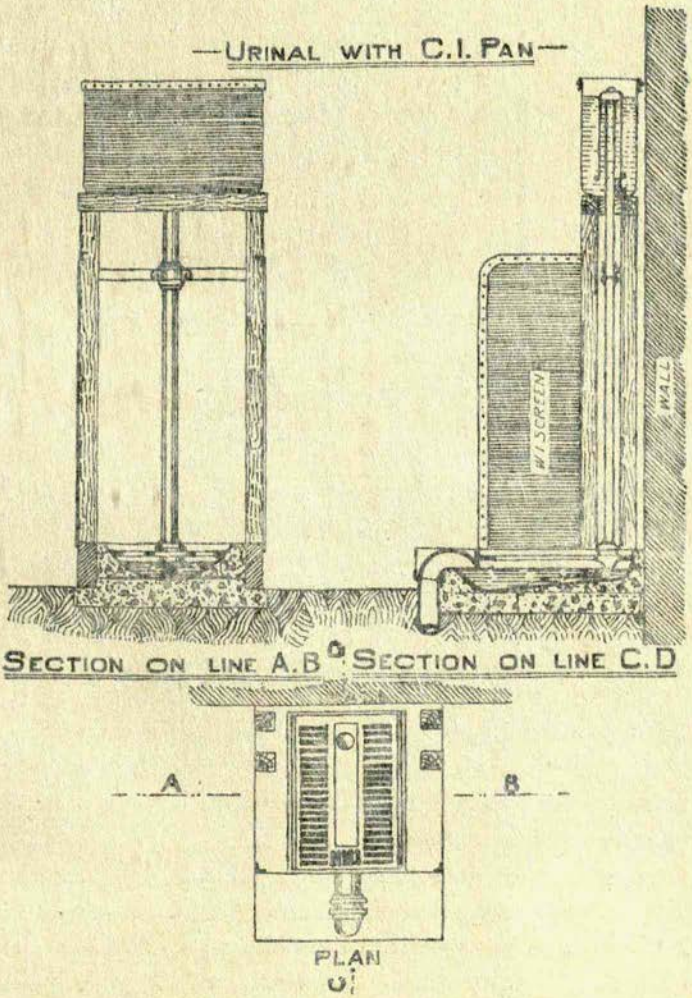


Public latrines and urinals should be provided at suitable places, for example, outside theatres, the neighbourhood of docks and railway stations, tram terminii, burial grounds

and markets, &c., stables and large blocks of dwellings.

Public conveniences on the water carriage system should be tiled inside and paved outside for a distance of 6 feet all round, and provision made for washing the surrounding pavement.

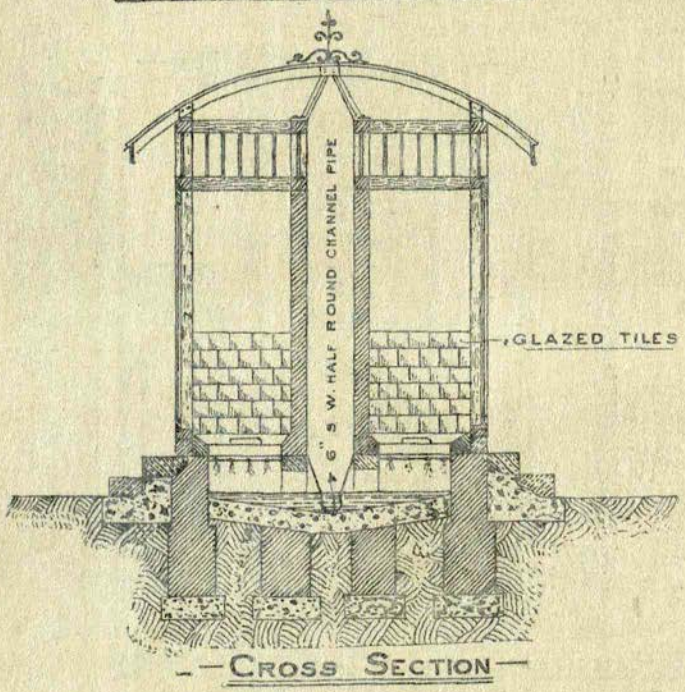
No matter what accommodation is provided, fouling of the roads in the neighbourhood of latrines and urinals always



takes place in India The inside of urinals and latrines is not only misused, but the outside as well.

It is a very common thing to see in all the large cities in India, urinals without any screen in the most thickly populated streets, and although the question of decency

—TROUGH PATTERN LATRINES—

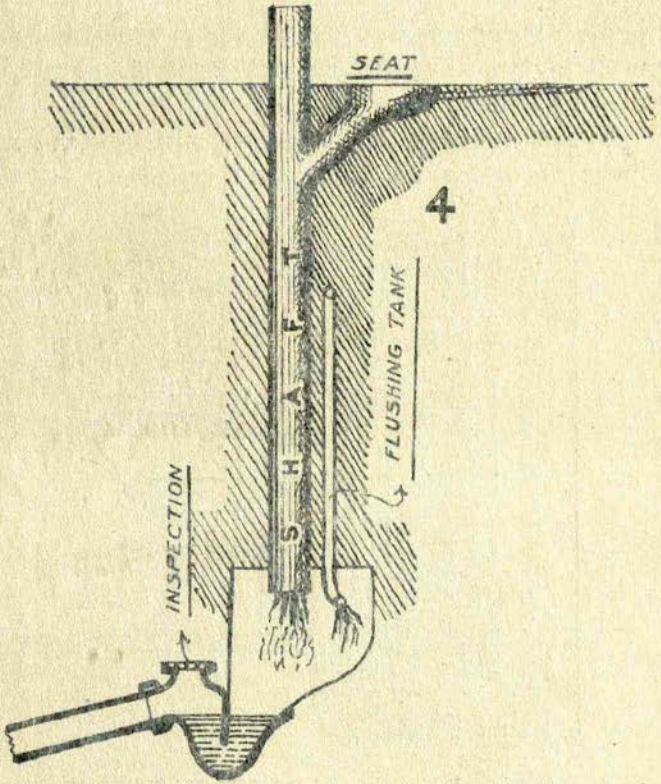


—CROSS SECTION—

may not be so important in the mind of the uneducated Indian, there is no reason why this practice should be allowed. The reason why these screens are omitted is to prevent the convenience being misused.

The principles underlying all regulations for sanitary fittings are the prevention of foul air or liquid escaping from the house drain or sewer into dwellings or open spaces close to dwellings, and the through ventilation of soil pipes, drains

and sewers. For this purpose strict regulations have been drawn up.



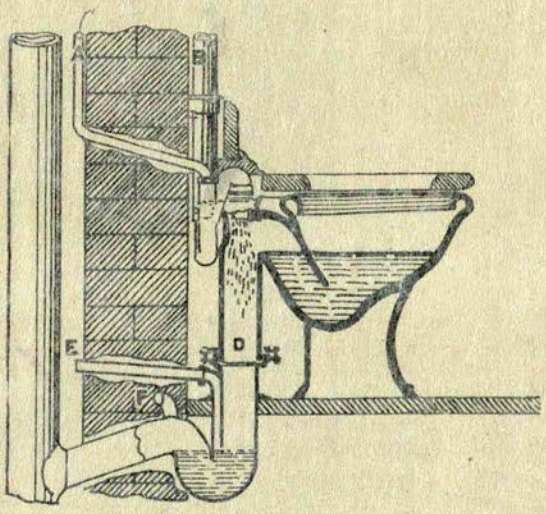
The bye-laws in force in the London County Council and in the Bombay Municipality are given below.

It must be understood that the condition of the two Cities varies greatly. In India the building and drainage regulations are not so complete as in England, though they are gradually becoming so in Bombay and Calcutta. At the same time conditions exist, due to climate and the habits and customs of the people and the water supply, which have to be competed against and a knowledge of these is necessary for the proper understanding of the regulations in force.

The rules as to how the water-closet should be fixed should not vary.

The fittings of a completely fitted water-closet should be the same everywhere and the sketch given is of the most modern type, and the instructions as to connection the most up-to-date.

To meet demands and to prevent nuisance, many modified forms of water-closet are adopted in India.



—JENNINGS PATENT CLOSET OF THE CENTURY—

LONDON COUNTY COUNCIL REQUIREMENTS.

[*Extracts from By-laws made by the London County Council under the Public Health (London) Act*, 1891.]

Water-closets.—Every person who shall hereafter construct a water-closet shall construct it in such a position that one of its sides at the least shall be an external wall which external wall shall abut immediately upon the street, or upon a yard, or garden, or open space of not less than 100 square feet of superficial area, measured horizontally at a point below the level of the floor of such closet. He shall not construct any such water-closet so that it is approached directly from any room used for the purpose of human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop or work-place.

He shall construct such water-closet so that on any side on which it would abut on a room intended for human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop or work-place, it shall be enclosed by a solid wall or partition of brick or other materials extending the entire height from the floor to the ceiling.

He shall provide any such water-closet that is approached from the external air with a floor of hard, smooth, impervious material, sloping to the door half-inch to the foot.

He shall provide such water-closet with proper doors and fastenings.

Every person who shall construct a water-closet in connection with a building, whether the situation of such water-closet be or be not within or partly within such building, shall construct in one of the walls of such water-closet which shall abut upon the public way, yard, garden, or open space, as provided by the preceding by-law, a window, of such dimensions that an area of not less than two square feet, which may be the whole or part of such window, shall open directly into the external air.

He shall, in addition to such window, cause such water-closet to be provided with adequate means of constant ventilation by at least one air brick built in an external wall of such water-closet or by an air shaft or by some other effectual method or appliance.

Every person who shall construct a water-closet in connection with a building shall furnish such water-closet with a cistern, of adequate capacity for the purpose of flushing, which shall be separate and distinct from any cistern used for drinking purposes and shall be so constructed, fitted and placed as to admit of the supply of water for use in such water-closet, so that there shall not be any direct communication between any service pipe upon the premises and any part of the apparatus of such water-closet other than such flushing cistern.

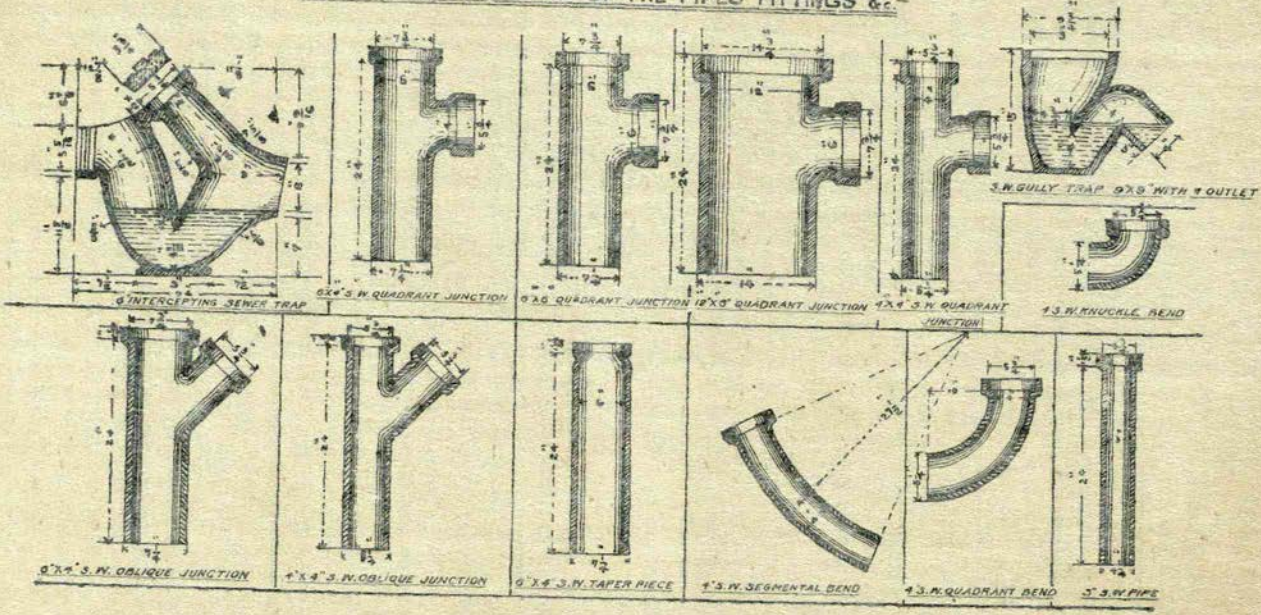
Provided always that the foregoing requirements shall be deemed to be complied with in any case where the apparatus of a water-closet is connected for the purpose of flushing with a cistern of adequate capacity which is used solely for flushing water-closets or urinals.

He shall construct or fix the pipe and union connecting such flushing cistern with the pan, basin or other receptacle with which such water-closet may be provided, so that such pipe and union shall not in any part have an internal diameter of less than one inch and a quarter.

He shall furnish such water-closet with a suitable apparatus for the effectual application of water to the pan, basin or other receptacle with which such apparatus may be connected and used, and for the effectual flushing and cleaning of such pan, basin or other receptacle, and for the prompt and effectual removal therefrom and from the trap connected therewith of any solid or liquid filth which may from time to time be deposited therein.

He shall furnish such water-closet with a pan, basin or other suitable receptacle of non-absorbent material and of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient

DIMENSIONED SKETCHES OF THE PIPES FITTINGS &c.



quantity of water and to allow all filth, which may from time to time be deposited in such pan, basin or receptacle, to fall free of the sides thereof and directly into the water received and contained in such pan, basin or receptacle.

He shall not construct or fix under such pan, basin or receptacle any "container" or other similar fitting.

He shall construct or fix immediately beneath or in connection with such pan, basin or other suitable receptacle an efficient siphon trap, so constructed that it shall at all times maintain a sufficient water seal between such pan, basin or other suitable receptacle and any drain or soil pipe in connection therewith. He shall not construct or fix in or in connection with the water-closet apparatus any D trap or other similar trap.

Any person who shall provide a soil pipe in connection with a new building for the purpose of conveying to a sewer any solid or liquid excremental filth, or shall for that purpose construct a soil pipe in connection with an existing building shall, whenever practicable, cause such soil pipe to be situated outside such building, and shall construct such soil pipe in drawn lead or of heavy cast iron. Provided that in any case where it shall be necessary to construct such soil pipe within such building, he shall construct such soil pipe in drawn lead with proper wiped plumbers' joints, and so as to be easily accessible.

He shall construct such soil pipe, whether inside or outside the building, so that its weight, if the pipe be of lead, and its thickness and weight if the pipe be of iron, in proportion to its length and internal diameter, shall be—

Lead.		*Iron.*	
Diameter.	*Weight per 10 ft. length not less than*	*Thickness of metal not less than*	*Weight per 6 ft. length (including socket and beaded spigot or flanges, the socket not to be less than ¼ in. thick) not less than*
1	2	3	4
3½ inches ..	65 lbs.	3/16 inch.	48 lbs.
4 ,, ..	74 ,,	3/16 ,,	54 ,,
5 ,, ..	92 ,,	¼ ,,	69 ,,
6 ,, ..	110 ,,	¼ ,,	84 ,,

If he shall construct such soil pipe of cast iron with socket joints, he shall cause such joints to be not less than 2½ inches in depth and to be made with molten lead properly caulked, and he shall also cause the annular