

## INCINERATION AND INCINERATORS AS APPLIED TO CANTONMENTS IN INDIA.

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INCINERATION may be defined as the destruction by fire of waste products in such a manner as to prevent injury to the health of human beings and with as little offence as possible.

To fulfil these conditions, the waste materials must, after becoming waste, be burnt within the shortest possible time and with the least handling and transportation. The incinerator must therefore be as close as possible to the place where the materials become "waste."

The materials requiring incineration are organic and highly putrescible, and are either the result of processes necessary to sustain human or animal life or of the manufacture of articles intended for the same purpose.

The principal materials coming under the first category are the resultants of the ingestion of food into the body, i.e., fæces, urine, litter, etc.; while under the second are refuse from food preparation, waste food materials and manufacturing refuse.

In military life, in India, the materials coming under the first category most usually require to be dealt with, those under the second being only encountered as "bazaar refuse." All such materials are liable to contain bacteria which, if they gain access to the human body, may produce disease, and their complete destruction is therefore essential.

In India, two systems are in use for the disposal of such material, i.e., incineration and trenching. Each has, under certain circumstances, advantages or disadvantages which decide the system to be used, and these may be set out as follows:—

### *Incineration.*

Most of the carts are unnecessary.

Waste materials burnt as soon as passed.

Works well in the rains.

All flies' eggs burnt.

### *Trenching.*

All material must be carted to a distance.

Crowley carts have to travel through cantonments. They smell and are apt to spill contents.

Trenching difficult in the rains.

Flies will breed if trenching is not done properly.

<i>Incineration.</i>	<i>Trenching.</i>
A bad or small pattern incinerator is liable to be offensive.	Carts are offensive.
No monetary return.	Monetary return from rent of trenched land.
Necessary litter must be available.	Not applicable.

Where fuel is available incineration is probably the best method and, even where no cavalry or horsed units are stationed, it is the practice, if sheds exist, to collect leaves, etc., in the dry weather and to incinerate in the rains. The extent to which incineration can be employed in a cantonment therefore depends on the amount of litter or leaves available as fuel. Bazaar and bungalow refuse, containing as it does large quantities of inorganic matter, such as stones, bones, tins, etc., is unsuited for burning in the ordinary incinerators, since the fire bars become rapidly clogged. It must therefore be dealt with by separate arrangements, specially designed.

In Jubbulpore, refuse from the slaughter-house is burnt. It would seem hardly credible that entrails, etc., could be disposed of in this manner without the use of coal or wood, but it is done with litter only. This is a great safeguard since, however carefully the material is buried, it is liable to be dug up by jackals, etc.

*Incinerators.*—The ideal incinerator is still in process of evolution and, under varying circumstances, slight changes in type are necessary. Most cantonments record the progress in design by the various patterns still in existence, the older types as they become unserviceable being replaced by newer.

To carry out the principles laid down in the definition the ideal incinerator must fulfil the following conditions:—

(a) It must be capable of burning continuously and completely destroy organic material, in such a manner as to prevent the escape of anything from it deleterious to health.

(b) It must work with a minimum of smoke and smell.

(c) It must be sufficiently simple in action as to enable it to be worked by natives of low intelligence.

The substances which constitute a danger to health are bacteria, etc. Presupposing that waste materials are placed in the incinerator in a cleanly manner, and that they are not allowed to drop through the bars, the only way in which bacteria could escape would be in the ashes or smoke. As both of these in a properly conducted incinerator have been proved to be sterile, a well conducted and well designed incinerator may be said to render innocuous any material for which it is suitable. A certain amount of smoke and smell is

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unavoidable; but it is possible by attention to the design and to the management of the incinerator to lessen the character of the offence and to discharge the smoke in such a way as to ensure its dilution and dispersion.

*Incinerator Design.*—The following points must be considered when designing an incinerator. It must:—

(a) Be simple in construction and not above the intelligence of the sweeper.

(b) Be constructed of materials which will resist heat and yet not make the expense too great.

(c) Be capable of rapidly and completely disposing of the materials for which it is intended.

(d) Be economical in fuel.

(e) Be easily loaded and cleaned.

(a) The intelligence of the sweeper class is small, and they are very conservative. They have an idea that if they are asked to use an implement which they do not understand or disapprove of, they have only to break or block it in order to show the sahib that it is impracticable. Anything which gives a little trouble also is sure to be broken, in the hope that it will not be renewed. The sweeper also is difficult to obtain, owing to the small wages given and to the number of other occupations opening up for him, so it is not possible to put on too much pressure or the individuals run away. There is, however, no need for a complicated apparatus as the simplest works quite well.

(b) The materials available for the construction of an incinerator are brick, stone, iron, reinforced concrete and crude brick. Stone splinters with heat and is also only obtainable in a few places. It is excellent for flooring and foundations, when pointed with cement, and the loading door sill can with advantage be made of it. Iron is not found satisfactory, since it soon rusts or is eaten through. It is also expensive and loses heat rapidly. Reinforced concrete has not been tried on account of the expense, but would probably be the most durable material. Brick is cheap and, in a properly designed incinerator, lasts well. Crude brick can only be used for temporary arrangements in camp.

(c) The complete disposal of material is a question of design and is dealt with further on.

(d) Since fuel must cost nothing, and since only a certain amount is available the greatest economy has to be exercised.

(e) Easy loading and cleaning is essential, but some of the overhead-loading patterns are not easily cleaned. Strength and durability are the first essentials, and must not be sacrificed.

When endeavouring to design an incinerator it is advisable to obtain the advice of the Royal Engineers. Many of the patterns at first devised would have been much improved if this had been done. The first point which limits the design is that latrines must not be too far from barracks and bungalows, or ditches, etc., will be used instead. The latrine and incinerator must therefore be sited within a comparatively short distance and, in the case of bungalows, actually in the centre of the group they are intended to serve. As it is impossible to avoid a certain amount of smoke and smell, chiefly that of burning litter, some method must be adopted to avoid its being blown into the bungalows. During the hot weather and the rains there is usually wind to disperse the smoke which, not being so rapidly cooled, rises higher. In the cold weather the smoke is rapidly chilled, and, as the nights are usually still, it settles down over the surrounding ground. The first desideratum, therefore, is that the smoke and fumes be thrown as high in the air as possible, in the hope that they will diffuse and fall to the ground far from human habitations. Consistent with draught the chimney should therefore be of maximum height. This involves a large amount of weight, so that proper foundations are required. In most of the old pattern incinerators the chimney was placed on the top of the incinerator, an admirable idea from the point of view of the draught but mechanically impossible if a chimney of great weight is required. The chimney should, therefore, be built up from the ground, the size of the foundations being dependent on the character of the soil.

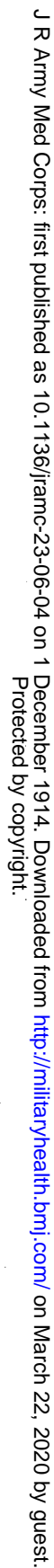
The weights per square foot which can be safely used on foundations are:—

Loamy soil, black cotton, laterite, etc.	..	..	0.8 ton per sq. ft.
In stiff clays	..	..	1 to 1.5 " " "
In rock	..	..	1.5 to 3.5 " " "
On concrete	..	..	Up to 3.6 " " "

—("Military Works Handbook," p. 97.)

The chimney should be of brick with a flue sectional area proportionate to the amount of burnt gas which will be required to pass through it. It may be round or square, the latter for preference from the point of view of cheapness of construction. Too large an internal area spoils the draught by allowing expansion of the gases, while too small an area chokes it. Since the gases cool and contract as they ascend, the sectional area of the flue may be slightly smaller at the top than at the bottom (see pp. 604-5). The internal surface must, of course, be perfectly smooth, as





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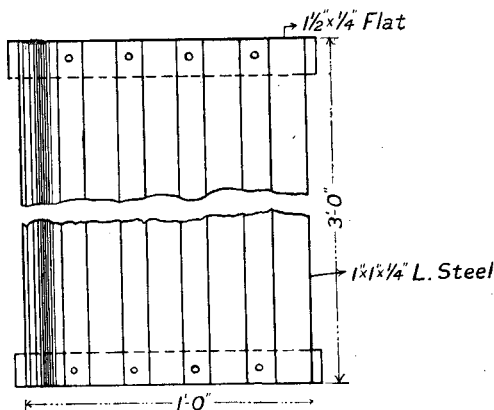
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projections hinder the draught and collect soot. Iron chimneys are inadvisable as they corrode rapidly, and since the metal rapidly conducts away heat, the column of gas is cooled too quickly. A brick chimney retains the heat and thus tends to promote draught

SIXTEEN GRATINGS OF THIS SIZE ARE REQUIRED.

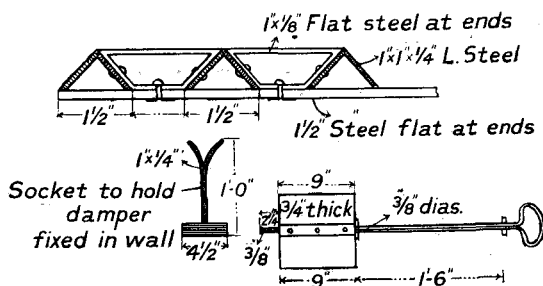
PLAN OF GRATING.

Scale  $1\frac{1}{2}'' = 1'$ .



ENLARGED SECTION OF GRATING.

Scale quarter size.



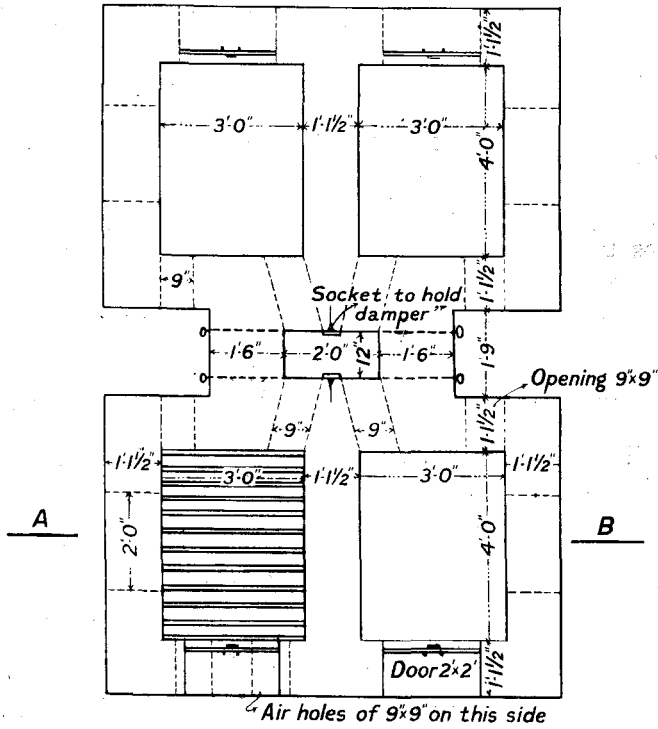
DETAIL OF DAMPER.

Scale  $\frac{1}{2}'' = 1'$ .

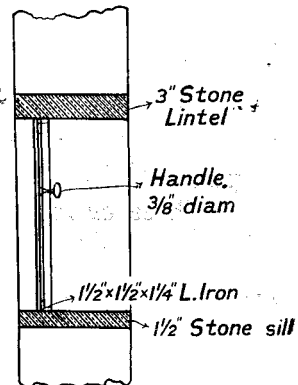
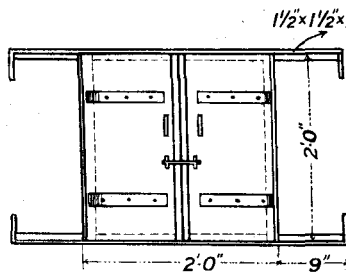
when the external air cools at night. Once the gases are cooled to the temperature of the outside air they will no longer ascend, but have to be pushed up by the warmer air below and the incinerator then tends to smoke from the air inlets below.

PLAN OF INCINERATOR.

Scale  $\frac{3}{8}$ " = 2'.



ELEVATION OF DOOR.  
Scale  $\frac{1}{2}$ " = 1'.





A fierce draught is not desirable as very slow combustion is necessary for successful working, and some device, such as a butterfly valve, should be introduced to check it; the moist material to be burnt should be so added as to permit only slow combustion (see Management). In this way a minimum of smoke and smell is obtained.

The sectional area of the flue can only be determined by experiment, but for the incinerator shown in the plan an area of two square feet below and one square foot above has been found to work very well.

When a large chimney is required provision should be made for cleaning, as tarry matters collect very rapidly. This, as in the plan, can be effected by inserting at the base a narrow iron door, sufficiently large to admit a sweeper. A cap is not necessary for the top of the chimney since rain cannot reach the fire, and a cap would act as a baffle to the ascending smoke. When rain-caps are in use they should be made so that they can be removed in the dry weather.

For a small or single-celled incinerator a length of drain pipe forms a suitable upper section to the chimney, being light and smooth inside. More than one length is apt to be blown down by storms.

The combustion chamber is conveniently made rectangular in shape, as brick lends itself to this form, and square grates are easily made. The floor should be concrete or stone, as otherwise in raking out the ash a hollow is apt to be formed below the grate, which becomes full of water in the rains. The floor should also be continuous with the foundations. The internal dimensions, horizontally, should not exceed four feet by four feet, as larger sizes are difficult to stoke.

The walls, as shown in the diagram, should be eight feet high, and a ledge of brick must be left one and a quarter feet from the ground to take the grates.

Three or four openings must be left in the walls, below the grates, to admit air, and also to enable ash to be raked out.

The shape of the combustion chamber is of importance owing the effect on the draught. The air passes through the grates and the mass of combustible material vertically or with a slight inclination towards the chimney. After passing the fuel it should be directed towards the chimney opening, and hence the roof of the chamber should be sloped as in the drawing. There should also be a slope from the sides, the old pattern incinerator shown in

fig. 1 with a chimney on the top being the ideal arrangement as far as draught goes. This pattern, however, cannot be fitted with a large chimney, as the weight tends to thrust the walls of the incinerator apart. The inclusion of a loading door in the roof also weakens the chimney support. Difficulties in construction

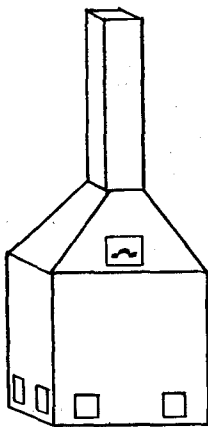


FIG. 1.

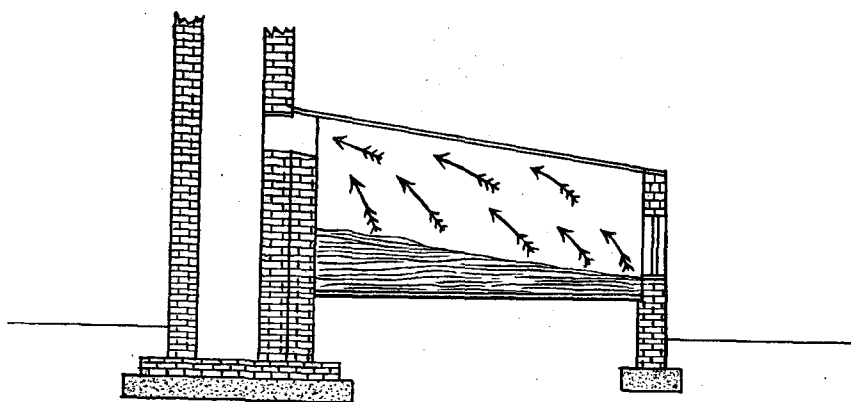


FIG. 2.

render the ideal roof (fig. 2) in brick impossible, so that the roofs of large incinerators are made horizontal. This provides a dead space near the door where whirls of smoke form and, as is well known, a whirl of gas acts like a solid body and tends to check the draught (fig. 3). When, however, four cells are built round a chimney it is possible to limit the dead space, laterally, by combining two cells under one arch (fig. 4). This makes for economy in construction,

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provides a support for the roof and, as there are two walls less than would be required in two cells built separately, saves heat for draught producing purposes.

If two similar cells are added to the other side of the chimney an incinerator is arrived at with as few mechanical disadvantages

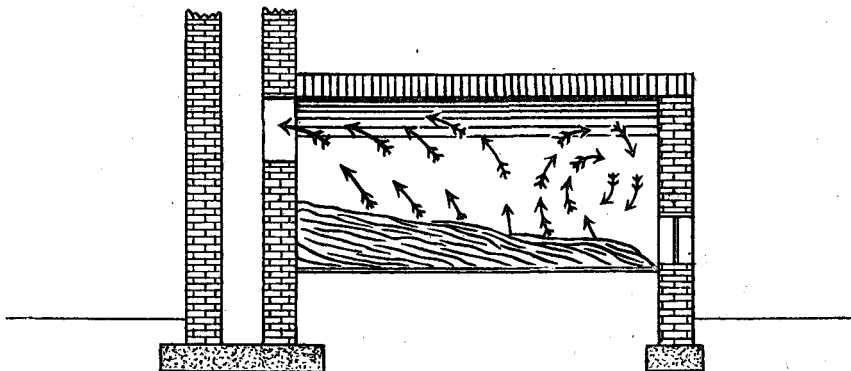


FIG. 3.

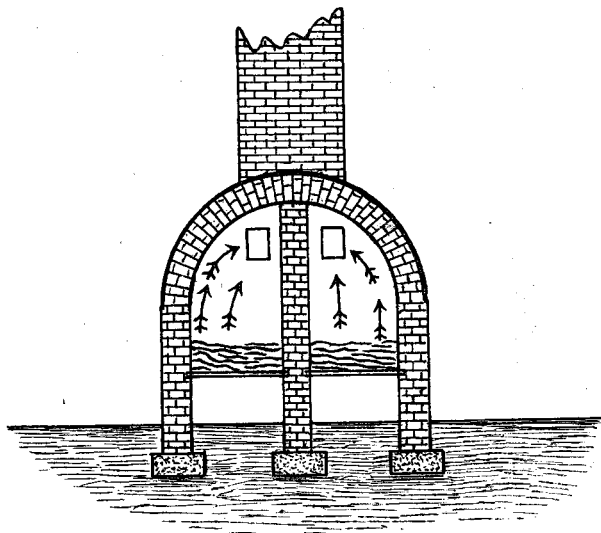


FIG. 4.

as possible, consistent with rigidity and economy. Such an incinerator, with four cells of four feet by four feet internal dimensions each, has been found efficient for one thousand men, to be extremely economical in fuel and to emit little smoke. Details

of such an incinerator are shown on p. 607. The doors are of iron in an iron frame, anchored in the brickwork, the door sill being of stone to take the blows from the pails when they are emptied. Loading from above would be better, but the height is too great and the sweeper invariably shuts the doors with a bang in the overhead-loading pattern, very soon jarring the door frame loose from the bricks. It is also difficult to use the rake, from the top, or the slice for cleaning the fire bars. With the doors vertical there is no reason for their being shut with a bang. The grates should be in sections, of dimensions which will allow of their being passed through the door in case one burns out, though this is of rare occurrence owing to the slowness of combustion. The bars may be round, square or "V" shaped, but care must be taken not to have too long a bar unsupported, as when hot it is liable to bend with the weight of the fuel. It is found, in practice, that the following types of incinerator are required in cantonment:—

*Types of Incinerators.*—(a) The large four-celled type, with high chimney, for the grouped latrines of a battalion or for similar latrines in the bazaar.

(b) The single-celled type, with moderately high chimney, for a latrine serving the native servants in a group of bungalows.

(c) The large incinerator for bazaar and other refuse. The large four-celled incinerator type, being practically smokeless and odourless, and delivering the products of combustion at a good height above the ground, is far preferable to the old pattern small incinerator.

(a) In the native infantry lines, in Mhow, one of these has replaced twelve of the pattern with the central chimney, shown in fig. 1. These incinerators, by the smoke and smell they emitted, made life a burden for the neighbouring bungalow occupants, but no complaints have been received since the substitution of the larger type. It can, and should, be constructed of the best materials, and its cost is approximately Rs. 300 or £20. If properly constructed it should not require repairs for a considerable period, but it must not be brought into use for a month, after construction, to allow the work to set.

(b) The smaller type is occasionally offensive, but this cannot at present be prevented, since losing heat as it does from all walls, and having a small fire body, the chimney cannot be raised to a satisfactory height. These incinerators have to be placed in the middle of groups of bungalows, and hence fumes must occasionally reach those to leeward. Devices for washing or reburning the smoke only check the draught and make smoke come out of the

air holes at the bottom. Pierce combustion would increase the draught, and these incinerators might then be used with success, but this would necessitate the use of coal or some such fuel, at a prohibitive cost. They are, at any rate, not so offensive as the carts necessary for trenching operations.

(c) Refuse destructors, owing to the incombustible nature of the fuel and to the clinker which forms, are difficult to deal with. In Jubbulpore they work fairly successfully, but in most cantonments the refuse is buried or used to fill holes in the ground, a good covering of earth being then added. Since such refuse does not, as a rule, contain faecal matter it is unlikely to become a focus of disease, and flies can be prevented from breeding by a proper covering of earth. In some cantonments the refuse is used for brick burning, but this has to be carefully watched, to prevent accumulations and nuisance.

Attempts have been made to get rid of waste materials in a large central incinerator and there is, at present, a derelict one in Mhow. This involves the nuisance and expense of cartage and has no advantage over the trenching system.

*Management.*—It must be remembered that, when dealing with faecal matter, we have a material containing a large quantity of water. It is, therefore, not possible to treat it as a solid for the purpose of incineration. In preparing an incinerator, before lighting, it is usual to cover the grate with a thick mattress of litter, as dry as possible, and about a foot thick. Less than this would allow the material to fall through when the latrine buckets are emptied. When commencing work the incinerator is lit from below and, when well alight, i.e., smoke rising slightly from all over the fuel, the contents of the latrine buckets are emptied in so as to form a thin layer all over the mattress. More litter is then added, to form a layer, and more faecal material till the material is exhausted or the incinerator is full. Care must be taken that the whole of the grate is covered or air will be drawn through the uncovered part and not through the fuel. The incinerator can then be left, one sweeper keeping his eye on it to damp down with urine or washing water if too much smoke is produced. The merest thread of smoke should be visible if the apparatus is working properly. When thus filled it should burn for about eight hours without attention. Whether this practice is adopted, or whether the sweeper adds all material, as it is passed, depends on the character of the latrine. With a regiment most of the material is available in the morning and evening. A regimental incinerator, therefore, should be loaded at 7 a.m., 3 p.m., and again at 7 to 8 p.m., so as

to keep the fire in all night. If possible, an incinerator should not be allowed to go out, as starting induces considerable smoke and smell. In a bazaar incinerator the attendance on the latrine is constant all day so that the pail contents may be fed in at once. Litter is often placed in the pails for the fæces and this mixes fuel and excreta to a certain extent and also tends to keep the pails cleaner. Ashes are removed, by raking, whenever necessary. If a damper is provided, this should be used at night to limit combustion and keep the fire alight.

The smaller incinerators require a great amount of care (which they usually do not receive) to prevent them becoming a nuisance. If managed as above, the pail contents and some litter being added at once, practically no offence occurs, but it is found, in practice, that the sweeper collects all the material, produced in the bungalow during the day, in a large iron receptacle and carries it to the incinerator as soon as it becomes dark. Since this is done for all bungalows around, the incinerator becomes overloaded and, about dinner time, the smell is disgusting, till the fire has got hold. It seems impossible to induce the sweepers to carry material to the incinerator during the day, and, as has been said before, they are difficult people to put pressure on. An incinerator to each bungalow would fail for want of fuel and would be a source of danger, as a number of small units cannot be so well supervised as a few large ones.

As regards the question of storing the litter, this should be placed in a covered shed, with concrete floors. The shed should be divided into two, by a wall, and the containing walls should be sufficiently high to keep rain out and to prevent litter being blown about by the wind. One day's supply of litter should be kept in each compartment and each should be thoroughly emptied before being refilled. In this way it is impossible for flies to breed, since their eggs are burnt daily, and they cannot penetrate the concrete floors. Wire screening, against flies, is therefore useless and unnecessary.

A sweeper's house should be built near the latrine as, if the sweeper has any excuse to go away, he will neglect his duties.

*Urine.*—As regards urine and washing water it may be said at once that, except for the small amount used for "damping down," it is impossible to get rid of it by incineration. It may be disposed of in covered pits, near the incinerator, if the soil is suitable, otherwise it must be removed and trenched.

*Incineration in Camp and on the Line of March.*—Whether or no incineration can be carried out successfully under active service

or manœuvre conditions depends on the length of time troops are stationary in camp. Numerous forms of incinerators have been devised, to be carried with the troops, but these, from the nature of things, must be unsatisfactory. When a battalion goes into camp for the night the incinerator must be started, material being stored round it till it can be disposed of, since to be portable the capacity of the incinerator cannot be great. It must be kept burning all night, under the supervision of a sweeper who has marched all day, and, when the troops march off in the morning, it must accompany them, so that all material left in the incinerator or pails, has to be buried. The pails and incinerator are bound to be dirty and also add to the regimental transport. Since much of the material has to be buried, the shallow trench system is surely preferable, involving as it does no extra expense or transport.

In a standing camp one of the incinerators shown in the "Manual of Military Hygiene," built of crude brick or turf, will work successfully, provided sufficient fuel is available, and would be far more efficient than any portable pattern. Personally, I am very much against portable incinerators, except, perhaps, for camps where the ground is so rocky as to preclude trench digging. Even where the subsoil water is high there is usually sufficient dry soil to allow shallow trenches to be dug.

*Conclusion.*—The above remarks sum up the position as regards incineration, in India. Not only is incineration possible, but, if properly carried out, waste materials can be got rid of effectually, without danger to health or offence, and at little expense. It is therefore, where fuel is available, preferable to trenching, since the latter, if carelessly done, encourages the breeding of flies. At home very little is known about incineration, either as regards the principles or the limitations, whilst in India, although most officers are familiar with the look of the outsides of the various incinerators about cantonments, and occasionally with the smell, they know little about the practical details. These are left to the cantonment authorities and the sweeper. The object of this paper is to enable anyone to familiarize himself with the principles and working of such apparatus. It is also probable that incinerators might be used with advantage in garrisons in other countries, where removal by the water carriage system is found impracticable. Simplicity is the key-note of the whole system, no complicated apparatus being required and no especial skill in the working. What can be done successfully by a cantonment sweeper should be within the intellectual capacity of men of other races.