Report on filter-carts and barrack-filters / by E. Nicholson.

REPORT

ON

FILTER-CARTS AND BARRACK-FILTERS.

BY

SURGEON-MAJOR E. NICHOLSON,
BRITISH MEDICAL SERVICE.

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REPORT ON FILTER-CARTS.

Proceedings of the Madras Government, Military Department, dated 12th August 1874, No. 2,596.

From Brigadier-General A. HOWLETT, C.B., Quartermaster-General, to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Head-Quarters, Ootacamund, 9th July 1874, No. 167-4,806.

I have the honor, by order, to report that the question of filter-carts for use with troops is now under the consideration of His Excellency the Commander-in-Chief, and that suggestions, with plans and models for these carts, have been called for, and are being received in this office.

2. In letter* from Surgeon E. Nicholson, British Medical Service, (copy annexed), that officer offers his services to test the merits of the several proposals; and Sir Frederick Haines recommends, for favorable consideration, that the papers, &c., on the subject should be transferred to this officer, with a view to his making a thorough investigation of the subject, and reporting on the description of filter-cart best suited for adoption.

* Dated Bangalore, 26th June 1874.

3. I am also instructed to say that His Excellency quite agrees with Surgeon Nicholson that the question of barrack-filters is by no means on a satisfactory footing,† and suggests that this question also may, with advantage to the public service, be reported on by him.

† Order of Government, No. 3,816, 17th November 1873. Order of Government, No. 3,991, 28th November 1873.

From Surgeon E. NICHOLSON, British Medical Service, (on special duty, Public Works Department), to Surgeon W. T. MARTIN, M.D., Secretary to the Surgeon-General, British Medical Service, dated Bangalore, 26th June 1874.

I have the honor to state that the work on which I am now engaged in the Public Works Department will shortly be finished, and to suggest that, before my laboratory is broken up, it would afford a good opportunity for testing the merits of any filter-carts, plans for which were, I understand, recently invited by His Excellency the Commander-in-Chief. My acquaintance with the water-supply of nearly every Military Station in the Presidency, and the disposal of a laboratory originally fitted up for water analysis, would enable me, I submit, to give any assistance which Government might require in deciding on the most efficient plan of filter-cart. At the same time, the question of filters for barracks which, I venture to say, is far from satisfactorily settled, might also be investigated.

2. Should such experiments appear desirable, the inquiry could be conducted without any expense than the continuance of the monthly allowance of Rupees 50 for laboratory rent, which I now draw from the Public Works Department, and the sanction of my actual expenditure (on contingent bill) incurred in the experiment. Such expenditure would probably be amply covered by an additional Rupees 50 monthly. I am quite willing to forego the personal allowance of Rupees 150 per mensem which I draw now as during my former employment as Analyst of Waters.

3. I may add that, hoping to return home during the ensuing relief season, I would use every endeavour to terminate the inquiry as speedily as possible.

No. 178-74.

Submitted.

FORT ST. GEORGE,
1st *July* 1874.

(Signed) H. H. MASSY,
Offg. Surgn.-Genl., B.M.S.

To Brigadier-General A. HOWLETT, C.B.,
Quartermaster-General.

From Brigadier-General A. HOWLETT, C.B., Quartermaster-General (through Controller of Military Accounts), to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Head-Quarters, Ootacamund, 23rd July 1874, No. 189.

With reference to your memorandum of the 19th instant, and the Proceedings of Government referred to, I have the honor to retransmit my letter No. 167-4,806, dated 9th July 1874, and to state that until now it had not been contemplated to employ Surgeon Nicholson in the manner proposed, and consequently no provision could have been made in this year's budget.

2. To postpone the inquiry until provision for the same can be made in the Budget of 1875-76 would probably be to lose this officer's services, he having expressed his intention of going home next cold season.* Such a result the Commander-in-Chief would very much regret; for, with the long experience Surgeon Nicholson has had in testing the water-supply in this Presidency, His Excellency considers it of great importance that the questions of filter water-carts and filters for troops should be taken up at once, while the services of an officer so well fitted for the work are available.

* On completion of tour of foreign service.

3. From paragraph 2 of Surgeon Nicholson's letter, the monthly charge will not exceed 100 Rupees—50 Rupees for laboratory rent, now paid by the Public Works Department, and 50 Rupees for contingent expenses. Dr. Nicholson states his willingness to forego his present personal salary of Rupees 150 per mensem.

4. Under the above circumstances, Sir Frederick P. Haines again submits the matter as a "case of unforeseen and unquestionable urgency," and trusts Government may sanction the arrangement under the provisions of Proceedings of Government, No. 2,243, dated 9th July 1873.

From Colonel T. GILLILAN, Controller of Military Accounts, to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Fort St. George, 30th July 1874, F.

I have the honor to forward letter from the Quartermaster-General, No. 189, dated 23rd July 1874, with enclosures, explaining the advisability of immediately engaging the services of Dr. Nicholson to report upon the question of filter-carts and barrack-filters for use with troops.

2. The proposal is stated to cost Rupees 100 per mensem, *viz.*, Rupees 50 for laboratory rent, now paid by the Public Works Department, and Rupees 50 for contingent expenses, Dr. Nicholson foregoing his present personal salary of Rupees 150 per mensem.

3. Should Government see fit to sanction the arrangement under the circumstances represented, the charge may be met from Grant 9, major head "Miscellaneous," minor head "Allowance for analyzing drinking water."

ORDER THEREON, 12th August 1874, No. 2,596.

The Right Honorable the Governor in Council sanctions the employment of Dr. Nicholson as recommended by His Excellency the Commander-in-Chief in the earlier letter from the Quartermaster-General above recorded.

2. It is observed that funds to meet the cost of the proposed experiments are available from the budget provision for analyzing drinking water.

Grant 9, head "Miscellaneous."

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Proceedings of the Madras Government, Military Department, dated 12th November 1874, No. 3,687.

From Brigadier-General A. HOWLETT, C.B., Quartermaster-General, to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Head-Quarters, Ootacamund, 5th November 1874, No. 539.

Forwarded to Government with reference to Orders of Government, Nos. 2,596 and 2,834, of 12th and 31st August 1874, and No. 3,193, of 28th September 1874.

His Excellency the Commander-in-Chief fully agrees with the Sanitary Commissioner in his recommendation that the filters should be practically tested on the march of the 89th Regiment under the immediate supervision of Surgeon-Major Nicholson. Sir Frederick Haines considers this a very important point; and, as the regiment is under orders to march from Bangalore on 1st February 1875, and the time is short for making up the filter-carts, His Excellency desires to submit this report for early consideration and orders of Government, and trusts that the estimated expense of Rupees 670 may be made available for carrying out the experiment so intimately connected with the health and well-being of our European soldiery.

From Surgeon-Major W. R. CORNISH, F.R.C.S., Sanitary Commissioner for Madras, to Brigadier-General A. HOWLETT, C.B., Quartermaster-General, Fort St. George, dated Ootacamund, 3rd November 1874, No. 7.

I have the honor to forward herewith, for the consideration of His Excellency the Commander-in-Chief and Government, a letter and two reports by Surgeon-Major E. Nicholson on the subject of the construction of cart-filters for use with troops on the line of march.

2. In the "*Report* (No. 1) *on projects and suggestions for a filter-cart*," Mr. Nicholson has, I consider, estimated very fairly the merits of the various schemes already submitted to His Excellency the Commander-in-Chief by various officers. None of these plans really meet the difficulties to be encountered in the construction of a filter for use in marching, and I quite agree with Mr. Nicholson in the conclusion that, for effective filtration in motion, we must discard the use of sand.

3. Mr. Nicholson alludes to the thoughtful and intelligent view of the whole subject by Major Hawkes, of the Commissariat Department, and the useful suggestions of Major Lockhart and Dr. Hyde, although the latter are more adapted for household than moveable filters. I venture to hope that the interest displayed in the subject by these and other officers may meet with the commendation of His Excellency and Government.

4. In the "*Report* (No. 2) *on the best model for a filter-cart*," Surgeon-Major Nicholson has very clearly expressed the conditions which it is desirable to obtain in a cart-filter, and his proposals to meet the several conditions appear to be thoroughly well considered. It will be observed that sponge is proposed as the mechanical filtering agent, and animal charcoal for the further purification of the water from dissolved organic matter. Mr. Nicholson, however, proposes to report further on the efficiency of these filtering media after observation and experiment.

5. Mr. Nicholson is of opinion that one filter-cart will ordinarily suffice for the water-supply of 150 men and the usual proportion of women and children. The filtration would be usually performed during the period the carts were at rest, so that only filtered water would be carried when the carts are in movement.

6. The estimated cost of each cart is Rupees 120, or if iron tanks are used, instead of hogsheads, Rupees 150. Mr. Nicholson proposes to construct six filter-carts on this provisional pattern in order to thoroughly test the use of such carts in the approaching march of H. M.'s 89th Regiment to Madras, and requests sanction for the following arrangements :—

(*a.*) That the Commissary of Ordnance, Bangalore, be requested to build five carts on Mr. Nicholson's plans, the sixth cart being built by Mr. Nicholson as a model for experiment.

(*b.*) That the sum of Rupees 670 be sanctioned as follows :—

	RS.
Building one cart	50
Fitting up six carts with filters, tanks, &c., complete, at Rupees 70 each	420
Experiments on equipment and contingencies	200
Total ...	670

(*c.*) That the District Engineer, Bangalore, be requested to supply twenty brass taps for inch and half-inch pipes.

I have to recommend that contingent bills for all *bonâ fide* expenses to the amount of Mr. Nicholson's estimate be sanctioned.

7. I have further to recommend that Surgeon-Major Nicholson be permitted to accompany the 89th Regiment in marching from Bangalore to Madras, with the view of superintending the working of the water-filters, and noting their action as regards the various sources of water-supply; and that on arrival of the regiment in Madras, the filters be inspected and reported on by a Committee composed of an officer of the Quartermaster-General's Department, a Commissariat Officer, the Heads of the British and Indian Medical Departments, and the Sanitary Commissioner; and that the Committee be instructed to take and record evidence from the officers and men of the regiment, and from Surgeon-Major Nicholson, as to the efficiency of the filters.

8. It affords me much pleasure to bring the clear and practical scheme of Surgeon-Major Nicholson's before His Excellency the Commander-in-Chief and Government, and, as it is of importance that no time should be lost in the construction of the carts, I venture to hope that orders may be passed thereon without delay. It will be observed that Mr. Nicholson proposes two attendants to accompany each cart in addition to the bullock driver, and that these persons will take the place of puckallies.

From Surgeon-Major E. Nicholson, British Medical Service, to Surgeon-Major W. R. Cornish, F.R.C.S., Sanitary Commissioner for Madras, dated Bangalore, 26th October 1874, No. 2.

I have the honor to forward my report on the suggestions and proposals received in answer to the Circular Memorandum from the Quartermaster-General regarding the construction of a filter-cart for troops marching. I also forward the original documents.

2. You will perceive from the report that I cannot recommend any of the seventeen projects as fulfilling even approximately the conditions laid down as capable of adaption without losing their distinctive feature. I have therefore drawn up a supplementary report (also herewith enclosed) embodying the principles to be kept in view in the construction of a cart which shall fulfil the judicious conditions laid down, and deducing from these a pattern of cart capable of such modifications as experience may show to be needful. The cost of this cart I estimate approximately at Rupees 120, complete.

3. I propose, in accordance with your instructions, to construct six filter-carts on this provisional pattern for trial during the approaching march of the 89th Regiment from Bangalore to Madras. These carts will supersede the necessity for engaging puckallies, as they are constructed for general water-supply to camp or quarters, as well as for the filtration and conveyance of drinking water. As some inconvenience would ensue if I were to convert any platform-carts now in use by the Commissariat (as sanctioned), I beg to submit the following measures :—

That the Commissary of Ordnance, Bangalore, be requested to build five carts on my plans. The sixth cart I am building myself as a model for experiment.

That the sum of Rupees 670 be allotted to me for the following purposes :—

	RS.
Building one cart	50
Fitting up six carts with filters, tanks, &c., complete, at Rupees 70 per cart	420
Experiments on equipment and contingencies	200
Total ...	670

That the District Engineer, Bangalore, be requested to supply me with twenty brass taps for inch and inch and a half pipes.

4. I propose, in accordance with your suggestions, to accompany the 89th Regiment on its march for the purpose of working out the details of water-supply to troops marching, and also of examining the sources of water-supply along the route with reference to the system of purification. On arrival at Madras, about the 28th February, I would submit a report of the experience on the march, and of any modifications required in the fittings of the carts or in the system of filtration.

I would suggest the appointment of a Committee to examine the carts immediately on their arrival in Madras and to report on the trial. In the interval between my arrival at Madras and my departure for Bombay (to embark by the troopship of March 28th), I could assist the Ordnance Department with regard to the establishment of a pattern and the details of making up the portable filters.

REPORT ON SUGGESTIONS AND PROJECTS FOR A FILTER-CART.

Contributed in accordance with Circular Memorandum from the Quartermaster-General, Fort St. George, No. 1,787, of 9th March 1874.

Twenty-five suggestions and projects.

THE documents forwarded to me by the Quartermaster-General include replies from twenty-six members of the Military Service and Public Works Department. Of these, two merely state that they have no suggestions to offer, the twenty-four others give suggestions and projects; one of them gives an alternative project, so that twenty-five is the total number of replies to be considered. These may be thus classified:—

A.—Remarks generally adverse to change.
Five replies.

B.—Independent projects.
Fifteen projects give plans (in three cases accompanied by a model) for various filter-carts; with one exception, there is a common feature that sand is the filtering medium used; charcoal, gravel, &c., being also used either to aid the action of the sand or to keep it in place.

C.—Adaptations of well-known filters to the purposes required. Two are projects for the adaptation of these to water-carts, the three others merely point out certain household-filters as good, and suggest their adaptation.

Suggestions classed A.

2. In the replies classed A certain objections are made to the proposed system, and it may be well to consider how far these objections carry weight either in deprecation of change or in modifying the basis of change.

For my own part I have no reason to consider that the carriage of water in leathern bags is of itself bad. Under proper supervision the water would be just as clean as if it were conveyed in vessels of metal, wood, or earthenware.

Advantages of the puckally system on the march.

3. Puckally bags used indiscriminately for water of various qualities attract any suspended matters, and become foul just as iron pipes or vessels, other than of leather, would become; and wherever the ordinary Indian system of looking as little as possible at disagreeable things is in force, there the evils of the system will be exemplified in water-supply as in other departments of conservancy. Mussucks and puckals require cleaning like other vessels; but the experience of most persons who live much in camp is in favor of leathern vessels as light for their capacity, portable, and not likely to suffer damage, besides allowing the water to cool by evaporation through the porous leather. It is especially on the march that these advantages are shown.

4. But while the puckally system can show the advantage of supplying fairly cool water in a manner long established in the country, it has drawbacks. It appears to be a mistake to think that puckallies keep up well with troops.

Defects of the puckally system.

A laden puckally bullock moves much more slowly than a cart, and it is only by sending on some of their number in advance that the puckallies supply troops while actually on the march. In this case there is no certainty as to the source of the water, for the puckally is very unlikely to make his bullock carry water for eight or ten miles when he can go on empty and fill from a road-side well just before the troops come up.

5. If it be desirable that the source of all water drunk by white troops should be known, the only plan is to have, as proposed, water-carts accompanying the column. This does not prejudice the point as to whether a small number of puckallies or, better still, of bheesties might not still be employed to distribute the water to troops on field service, or whether the water might not be kept in *chaguls* or *mussucks* in order to become cool pending consumption. There is no doubt that a water-cart could carry as much water as two puckally bullocks* lightly laden; that it could keep up well with the troops; that if judiciously constructed it could go over any ground practicable to guns; and that, with the assistance of a bheesty, it could afford refreshment to troops in action at least as well as a puckally. A bheesty who can fill his mussuck at a water-cart hard by would be a far more useful attendant on troops than a slow-moving puckally, whose bullock is tired with a long march laden. Bheesties, or watermen who would do nearly as well, are always available, while puckallies are difficult to obtain when urgently required.

Advantages of water-carts over puckallies.

6. The proposed cart would not only supply water, but would filter it; so that, instead of depending on an uncertain supply of water taken, no one knows whence troops would march accompanied by water either of known good quality or at least purified as far as is possible. The importance of filtration in the case of cantonment waters has never been overlooked (however much it may have been neglected), and if it be desirable in cantonments where the water is constantly drawn from sources with which the sanitary authorities are well acquainted, how much more important must it be when the water is of unknown quality (except as far as can be ascertained by appearance), and from a source of which little or nothing is known. I have no doubt that in some cantonments where the water is constantly drawn from good sources, filtration in barracks is really superfluous, indeed it need be, considering the inefficiency of the primitive apparatus in use; but if it be desirable at all, this must certainly be the case on the march. And in the present state of our knowledge regarding the cause of those bowel diseases to which troops on the march are especially liable, it is but a reasonable precaution to subject all drinking water to the best purification possible.

Advantages of filtering carts.

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* In cantonments a puckally bullock carries on the average 33 gallons of water, but it can only do this for a short distance, say four miles in the day. On the march it would not carry more than 20 gallons, perhaps much less, and then would be unfit to work in camp.

7. The processes available for purification may be divided into boiling, the addition of a disinfected fluid, clearing by subsidence with alum, and filtration.

Processes of purification available.

The first is too inconvenient for use except under extraordinary circumstances, such as would justify the prohibition of all beverages except malt liquor and tea or coffee, a measure which might, however, be worth trial when troops are compelled to march through a country in which cholera is very prevalent. The second process is troublesome, as the addition of more than the exact quantity required of Condy's fluid or other form of alkaline permanganate gives the water a disagreeable taste, and it will nearly always make it discolored and turbid. It may be said that filtration is necessary after this process of purification. The third process, clearing by alum, is most valuable in every case where the water is very turbid, as in the case of many tank and river waters; the more turbid the water, the quicker the clearing; but in waters which are soft and but slightly turbid, the process is slow, and it is always much more troublesome than filtration. Where the water is decidedly turbid, it may with advantage be used as a preliminary to filtration. The last process, filtration, is the most convenient when large quantities of water are operated on, and when it is not excessively turbid; it is very efficient if properly applied, and has the great advantage of working almost automatically. But, however easy filtration may be in a cantonment, its application by means of an apparatus fixed to a cart which is jolted over rough roads presents many difficulties.

8. These have been well appreciated by Major Hawkes, the Executive Commissariat Officer at Secunderabad, from whose letter (No. 4) I quote the following passage as the best introduction to the projects about to be considered:— "The problem is one of no ordinary difficulty. The term 'filtering' is generally used in a very indefinite sense, and many who write on the subject appear to have the crudest notions as to what they propose to themselves when recommending patterns of filters. The case of a camp-filter presents additional difficulties, owing to the fact that, from its being required to be in constant motion, the element of rest which is so essential to efficient filtering is altogether absent."

Difficulty of devising a camp-filter.

9. Although several of the projects forwarded show much ingenuity, the majority are very crude, and I cannot bring forward a single one of them in mitigation of the opinion given by Major Hawkes.

Projects classed B.

Passing over those obviously unsuitable (an abstract of all is appended to this report) from the unfitness of their construction to the purpose required, I will take the best of them in order to examine in it their common feature—the action of the filter. This can be well seen in No. 19, inasmuch as it is the type of most of them, while its simplicity makes it avoid the defects so obvious in the majority.

10. The project is for a cylindrical iron vessel, 3 feet high, $1\frac{1}{2}$ foot diameter, with a tap near the bottom, a cylindrical bucket, $1\frac{3}{4}$ foot deep, fits into the main cylinder, its

The best project No. 19.

rim supported by the edge of the latter. The whole is closed by a cover. The bottom of the cylindrical bucket is perforated with numerous small holes; it is intended to carry three inches depth of charcoal (bone charcoal if possible), and above this three inches of sand, each covered by a perforated plate. A pair of these cylindrical filters are lashed on to a platform-cart. The apparatus is simple, light, and portable; it might appear to be a little top-heavy when returning from the well to camp, but this will be seen not to be the case. There can be no leakage between the tray and the cylinder, as would be the case in most of the other projects; there is no need of an air-vent, a detail forgotten in some of them; and the apparatus might be kept in store indefinitely without injury. There is only one fault, the common fault of fourteen out of seventeen projects, that the filtration would be worse than useless.

Inefficiency of the filtration in Class B.

11. On following the cart fitted with its filtering cylinders at its first trip to the well, the following would be the certain results observed:— The waterman raises a bucket of water and pours it into one of the cylinders, a bubbling takes place, and before he can raise the next bucketful the first has disappeared; he continues, with the same rapid results. By the time he has poured in about ten buckets the water has filled the lower receptacle and covers the sand. Shall he go on? As he was told to fill, he fills. Both cylinders full, the cart jolts back to camp, and by the time he arrives there the washing of the sand suspended half way in three feet of water has made the latter rather more turbid than it might have been when drawn from the well. If, at the second trip, the waterman stops directly he sees the water no longer passes through the sand, the effect will be the same, as every jolt of the cart will wash the water up through the sand, and any suspended matters which might have been separated by the latter are shaken out of it into the water at each jolt of the cart. On this one point alone the whole of the projects are unsuitable. In eight of them the water would pour through as I have described, merely strained through the sand; in two others (Nos. 13 and 14) the filtration would be much slower, from the small surface of the filter, but just as inefficient, especially as the filters remain constantly immersed in the filtered water. In four others the filtered water is balanced by an equal amount of unfiltered water, which is supposed to filter through the sand on the march. In the remaining project of this class the water is simply digested with bone-charcoal until drawn off.

Experiment on the filters of the Class B.

12. The description given above of the filtration in the best of the projects is based on the following experiment:— The bottom of a large galvanized iron bucket was cut out and replaced by perforated zinc (holes $\frac{1}{8}$ inch diameter) soldered down. On this was placed 1 inch of coarse gravel, then 1 inch of fine gravel, then 4 inches of well-washed sand; this was covered by a plate of perforated zinc fitting to the circumference at the level of the sand. The filtering surface was 86 square inches, as nearly as possible one-fourth of that in project No. 19. The bucket being suspended over a tub, water was poured on by successive bucketfuls. It passed through at the rate of $2\frac{1}{2}$ gallons per

minute, and showed no traces of any purifying action. The water poured in was perceptibly turbid from organic matter produced by keeping it in an open tub for a day, and after filtration no difference could be perceived. The experiment was repeated daily with similar results. It was rather more favorable to the water than the filtration in project No. 19, as the sand was one-third deeper, so that it may fairly be taken as comparable. The rate of filtration was $4\frac{1}{4}$ gallons per square foot in one minute, or upwards of 6,000 gallons per square foot in twenty-four hours. When I mention that 70 gallons per square foot in twenty-four hours is about the maximum rate at which water can be purified in English water-works, some idea will be formed of the total impossibility of any purification being effected by filtration of the description proposed. No filter in which the mechanical purification is effected by means of sand can be suitable for the purpose required.

1*st*.—Because, in order to be effectual, it must be in far thicker layers than the space available will permit.

2*nd*.—Because rest is an essential element of the action of such a mobile substance as sand saturated with water.

13. There remain two projects for adapting complete filters to water-carts, and three suggestions to a similar effect. In the two projects the filters are two syphon-filters known as Danchell's and "Macnamara's;" their value will be considered presently after examining the adaptations proposed. The first project (No. 21) is simply to place a Danchell filter in an ordinary water-barrel, the long arm of the syphon passing out at the usual tap-hole. The project could hardly be entertained if it were really necessary, as its auther states that the waterman should "suck the air out" of the syphon in order to prime it each time that the cask is refilled. Fortunately the author does not understand the principle of the syphon; when, as in his drawing, the bend of the syphon is below (2 feet below) the level of the filled cistern, the syphon does not require priming by suction or otherwise. The second proposition of this class (No. 22) is to adapt the "Macnamara" syphon-filter to a cistern. This filter, invented ten years after the Danchell filter, presents remarkable coincidences of principle with the latter; the only notable point of difference is that Dr. Macnamara placed a tray of sand above and below the animal charcoal. For reasons already given, the presence of sand renders the project inadmissible; besides, the author misapprehends the principle of the syphon, and by cutting off the long arm destroys the action of the filter. The remaining suggestions (Nos. 23, 24, 25,) advocate the adaptation of household-filters—Danchell's, Dahlke's, Atkins'—to the purposes required. It may be as well to examine the action of these.

Projects and suggestions classed C.

14. There are, and have been for the last twelve or fifteen years to my knowledge, five rival filters in the English market.

Household-filters.

Danchell's (The London and General Water Purifying Company).—Animal (bone) charcoal packed in an earthenware vessel joined on to the short arm of a syphon.

Lipscombe's (Animal charcoal packed in a hollow diaphragm situated midway in an earthenware cylindrical vessel).—A piece of sponge closes the upper opening of the diaphragm.

Dahlke's (The silicated carbon filter).—Coke obtained from a siliceous coal or schist (the Torbanehill mineral). A diaphragm of this substance is cemented midway in an earthenware cylindrical vessel.

Atkins and Co. (The moulded carbon filter).—A block of porous but highly condensed composition, made with animal and vegetable charcoal. A tube is inserted into the centre of the block and collects the water filtering into it from outside. The tube is fixed into the outlet of the vessel used.

Spencer's (The magnetic carbide filter).—A mixture of oxide of iron and sawdust is burnt and compressed, forming a diaphragm in a cylindrical earthenware vessel.

The first four of these consist of the same class of carbonaceous substance, and the respective action of each appears to have been adopted by the inventor more with a view to keeping clear of his rivals' patents than from any intrinsic merits. The evidence regarding their purifying action on water is most conflicting, and not uninfluenced by partisanship; the testimony as to the superiority of each is most convincing until that of the others is read. One point is certain, that animal charcoal alone makes a very poor filter; water that is already fairly clear, naturally or from previous filtration, is purified from dissolved organic matters by being slowly strained through it; but this is not filtration in the ordinary sense of the term. Until it can be shown that the deleterious matters likely to be found in water are entirely dissolved and not suspended, straining through animal charcoal cannot be admitted as the best action for a general filter. The most perfect filtration should combine efficient mechanical filtration with the action of energetic animal charcoal.

Fallacy of the syphon filters.

15. In the Danchell filter (and also in Dr. Macnamara's adaptation of it) much stress is laid on the upward action of the syphon as preventing the suspended matters of the water from falling on the surface of the filter and choking its pores. But any one who has seen a glass syphon at work must have observed that not only light suspended substances, but particles of sand, even of gravel, are sucked in most vigorously; and, as the pressure of water acts equally in all directions, it is absolutely immaterial whether the filtering surface be directed upwards or downwards; in either case suspended matters are carried into the pores of the filter with equal force. Any beneficial effect produced by the Danchell filter would be obtained just as well by making the outlet pipe of a cistern or barrel expand (between the barrel and the tap) into a cylinder packed with animal charcoal. But, as I have before said, this is not filtration; a turbid water swarming with organisms would pass out little, if at all, improved. The only real filter amongst those suggested, and at the same time the only one adaptable to a water-cart, is that of Atkins and Co., the moulded carbon filter. It really filters very well, but it works slowly, and soon becomes clogged when used with turbid water.

Conclusions.

16. After careful consideration of the seventeen more or less complete projects, I regret to say that I cannot recommend any as fulfilling even approximately the conditions laid down. In the fourteen projects in which sand is used, the filtration would be positively prejudicial; in the three which use animal charcoal, filtration would not be obtained, and the charcoal is not used in a manner suitable to the requirements. I could not contrive any effective adaptation of these projects without depriving them of any features of originality they may possess. The suggestion made by Major Lockhart, Commanding 107th Regiment, to adapt a moulded carbon filter to a water-cart, is the best of the suggestions made. The thoughtful letter of Major Hawkes contains valuable advice on the principles of camp water-supply and filtration.

BANGALORE,
26*th October* 1874.

EDWARD NICHOLSON, Surgeon-Major,
British Medical Service.

APPENDIX.

Abstract of Suggestions and Projects for a Filter-cart.

Abstract.	Remarks.
1. *Regimental Committee, 15th N.I.* Suggests for Native troops a water-cart containing a bag of charcoal for filtering purposes.	It is probable that no efficient system of filtration would be acceptable to Native troops.
2. *Lieut.-Colonel Preston, Commanding Wellington.* Knows of no filter that would stand the jolting. Thinks the plan would not answer. Suggests that water be subjected to the action of charcoal and carried on for use at the next camp. Also suggests the use of alum to clear water.	Charcoal has very little purifying power and no filtering power. Alum acts very slowly unless the water is decidedly turbid.
3. *Colonel Hackett, Commanding 76th Regiment.* Cannot suggest any better system than that at present used. Care should be taken that the bags are cleaned daily. 4. *Major Hawkes, Executive Commissariat Officer, Secunderabad.* Considers that the plan is one of no ordinary difficulty; does not feel in a position to offer a suggestion, and deprecates change in the present system, which he considers well suited to the march or to field service.	There is a good deal to be said for the present system, and great caution is necessary before making a change. There are few subjects on which circumspection is more imperative than in questions affecting the purity or purification of water.
5. *Officer Commanding 21st Regiment Native Infantry.* Considers that puckallies have answered well. Does not think that a bullock-cart could keep up with troops; suggests ponies or mules. Also suggests a sketch of a pyramidal water-tank. The filter to be a horse bucket placed on top of the tank, and only used when the cart is stationary.	A water-cart, if light, could keep up with troops just as the sick carts do. No details regarding the filter part of the arrangement.

20. *Major Caine, B/C Royal Horse Artillery.* Suggests that experienced officers should adapt the filter described in the Soldier's Pocket-book.	This is the camp filter described in Galton's Art of Travel. See next project, which is an adaptation of it.
6. *Major Swanston, Deputy Assistant Quartermaster-General, Nagpore Force.* A hogshead enclosing a small kilderkin with the bottom knocked out. The interval filled with sand, charcoal, gravel. The kilderkin communicates with another one outside. The whole mounted on a cart.	1*st.*—The filter is inefficient. 2*nd.*—Filtration must go on during the march.
7. *Mr. MacGeorge, Executive Engineer, Kamptee.* An iron tank cart, divided vertically, axle passing through a tunnel in it. Water passes from the front compartment, through sand, gravel, and charcoal, to the back.	1*st.*—The filter is inefficient. 2*nd.*—Filtration must go on during the march. 3*rd.*—Heavy and difficult iron work.
8. *Colonel Greenaway, Commanding 13th Native Infantry.* An iron tank cart, divided vertically. Water passes from the front compartment, through gravel and bone charcoal, to the back.	1*st.*—The filter is inefficient. 2*nd.*—Filtration must go on during the march.
9. *Colonel Tweedie, Commanding 10th Native Infantry.* Recommends a filter invented by the late Captain Spry. It consists of a wooden box divided into five vertical compartments, three of which are filters charged with sand and charcoal.	Not fit for carriage.
10. *Captain Miller, 37th Native Infantry.* An iron tank cart on springs, divided diagonally. The water passes from the compartment, above and in front, descends, then ascends through charcoal and sand, and finally overflows into the rear compartment.	1*st.*—The filter is inefficient. 2*nd.*—The load is badly distributed, 80 gallons of filtered water being balanced by an equal load of water and wet sand. 3*rd.*—A heavy and complex piece of iron work.

11. *Captain Vibart, R.E., District Engineer, Bangalore.* A hogshead divided on the plan of the 2-chatty filter. Water passes through sand, charcoal, and road metal. Slung in a cart with crank axle.	1*st.*—The filter is inefficient. 2*nd.*—Capacity too small. 3*rd.*—Axle only 12 inches from the ground.
12. *Captain Whyte, 14th Regiment Native Infantry.* A zinc-lined wooden box containing two large trays of sand and charcoal, one above the other. Very little space for water. The model represents a box stated to weigh 1,083 lbs. without any water in it, and 1,524 lbs. when containing filtered water.	1*st.*—The filter is inefficient. There is no reason why the water should pass through the trays when it can pass along side of them or even through the flap side of the box. 2*nd.*—Dead weight too great.
13. *Major Forster, R.A., Brigade-Major, S.D. (A.)* A wooden tank mounted on a cart with crank axle. Divided horizontally into two compartments. The filters are two cylinders which remain immersed in the water of the lower compartments. Filtering medium sand and bone charcoal; sizes and arrangement as in the "Macnamara" filter.	1*st*—Neither the wooden tank nor the partition will remain watertight unless constantly used. 2*nd.*—The filtration is inefficient. 3*rd*.—The immersion of the filters in the filtered water is very objectionable.
14. *Captain Nangle, M.S.C.* Only differs from Major Forster's by the filters being of wood and inclined instead of perpendicular. Filtering medium sand and charcoal.	The objections to it are the same as those to Major Forster's.
15. *Officer Commanding 48th Regiment.* A cask 6 feet in length, $5\frac{1}{2}$ feet diameter at the bung, $4\frac{1}{2}$ feet at the head; containing a smaller cask, the orifices of both corresponding. The smaller cask contains sand and charcoal, and has a perforated bottom. Water is poured into it, and passes through the filtering material into the main cask.	1*st.*—The dimensions of the cask gives a capacity of 700 gallons; 7,000 lbs. of water is too much for a pair of bullocks. 2*nd.*—The filtration is inefficient. 3*rd.*—There would be some difficulty in the construction of these casks.

16. *Major Whigham, Commanding 16th Lancers.* Three puncheons of sizes arranged on the plan of the 3-chatty filter; the whole slung in a cart with crank axle.	There are some coopering difficulties. The middle cask is $2\frac{1}{2}$ feet high and 3 feet diameter. When the lower cask is half full of water, a weight of about 2,000 lbs. would be supported by one of the upper hoops of the cask.
17. *Private Pickersgill, 67th Regiment.* A wooden zinc-lined tank divided horizontally by a tray containing charcoal, sand, and sponge.	1*st.*—The tray would not fit watertight. 2*nd.*—The filtration would be inefficient 3*rd.*—The weight is far too great.
18. *Major Jennings, M.S.C.* Two hogsheads, each divided on the plan of the 2-chatty filter. Water passes through bone-charcoal and sand. Placed in a cart, the floor of which they fit.	The filtration would be inefficient.
19. *Surgeon-Major Hyde, B.M.S.* Two iron cylinders, divided on the plan of the 2-chatty filter. Each has a deep tray containing sand and (animal) charcoal. Placed on a platform cart.	The inefficiency of the filtration is shown in the report. It is the simplest of the various projects.
21. *Surgeon-Major Corbett, R.A.* A barrel containing a Danchell syphon-filter. Prefers this to the Macnamara filter as being on the same principle and simpler.	The filtration would be inefficient. As good results would be obtained by simply attaching a box of bone-charcoal to the tap of the barrel.
22. *Major Forster, R.A. (B.)* A pair of "Macnamara" filters, each in a wooden tank, and filtering into a smaller tank. The cart has a crank axle.	1*st.*—The filtration would be inefficient. 2*nd.*—The syphon being cut off, water would soon cease to flow. 3*rd.*—The filtered water is all back weight. 4*th.*—Wooden tanks would not be watertight when wanted.
23. *Officer Commanding 4th Light Cavalry.* Recommends the Danchell filter.	See remarks to project No. 21.

24. *Major Lockhart, Commanding 107th Regiment.* Suggests that Atkins & Co.'s moulded carbon-filter be adapted.	This filter is about the best mechanical filter extant, and that most capable of adaptation.
25. *Colonel Waterman, Commanding 17th Native Infantry.* Suggests the use of the silicated carbon-filter (in wicker cases).	A household-filter, not capable of adaptation.

Report on the best Model for a Filter-cart.

1. To work out the principles on which the filter-cart should be constructed, it is necessary to consider the conditions laid down in the Circular Memorandum on the subject. They may be thus stated :—

Conditions to be fulfilled.

(*a.*) The cart to be an average load for a pair of bullocks when returning from the well or tank to camp. When on the march the load to be diminished, so that the cart can keep up with troops.

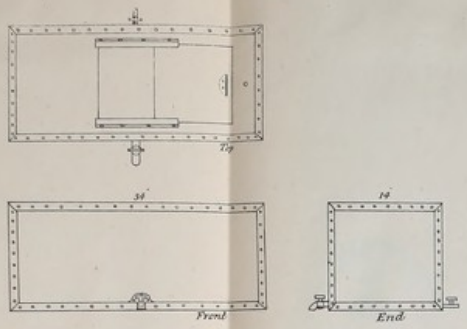
Remarks.—One of the reasons for the proposed change of system is the difficulty of procuring puckallies for the march, especially in stations where improved modes of water-supply have been introduced. It will therefore be desirable that the carts should do the whole water service of the camp. And, as the bullocks have already done a morning's march when beginning the day's work in camp, their load should not exceed the average one of 800 lbs. On the march it might be as much as 600 lbs. at starting, as the water would be gradually consumed. Accommodation might be given for that quantity as a *maximum*, though it need not be carried in ordinary cases, unless for special reasons.

(*b.*) Strength, combined with lightness and a judicious distribution of weight, will be required in the cart.

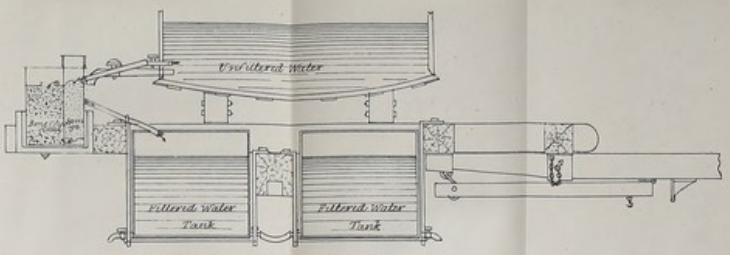
Remarks.—It is important that the carts should be able to follow troops in any country practicable to Artillery, so as to avoid entirely any necessity for puckallies. To secure this advantage, the cart, when on the march, should have its centre of gravity as low as possible. At the same time the lowest part of the apparatus must be sufficiently high from the ground to be free from all risk of damage by ruts, &c. It should not project much, if at all, below the naves of the wheels, a distance of 22 inches from the ground in the ordinary pattern of wheels for Government bullock carts.

(*c.*) Filtered water only to be carried on the march.

Remarks.—It would be injudicious to rely on extemporaneous filtration. To be efficient, a certain speed cannot be exceeded; and I doubt if more than 10 gallons per hour could be obtained as an average rate from a portable apparatus. Now this rate could never be sufficient when a crowd of thirsty men are eager for water. It would require an hour to give 100 men less



One of the filtered water Tanks (capacity) 20 gallons)

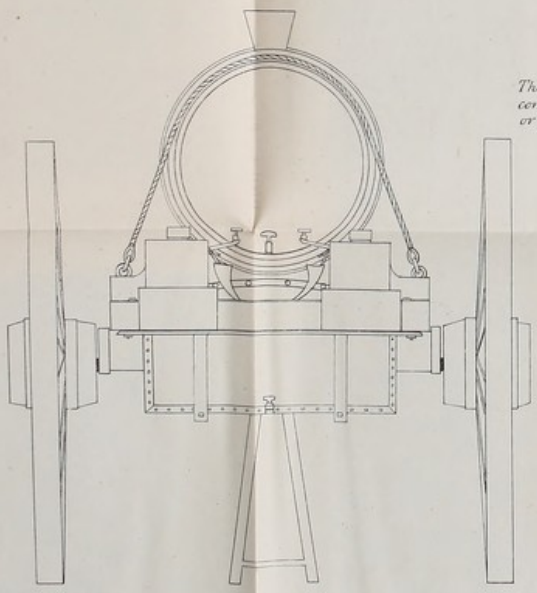


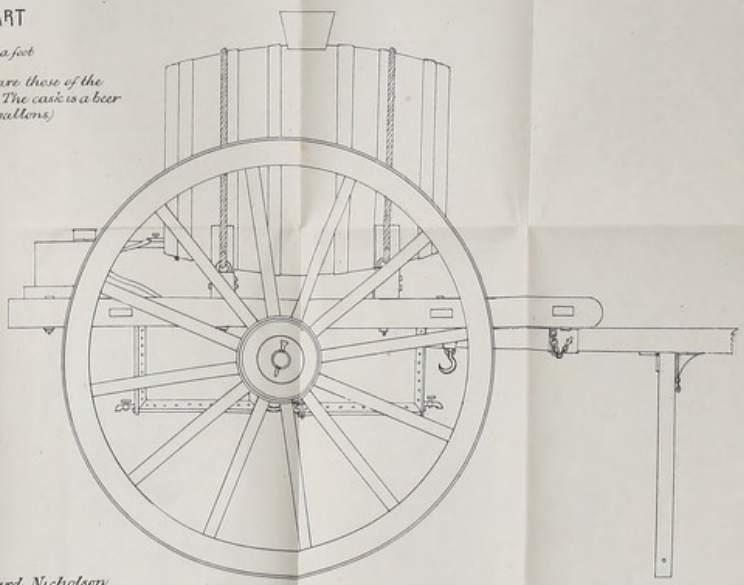
Longitudinal Section of the Filter-cart

Sketch
of a
FILTER-CART

Scale 1 inch to a foot

The axletree and Wheels are those of the common plat-form cart. The cask is a beer or arrack hogshead (54 gallons)





(Signed) Edward Nicholson
Surgeon Major BMS.

Bangalore 23rd October 1874.

Govt Lithographic Press
Fort St George May 1875

than a pint each. I am strongly of opinion that the condition laid down should be adhered to; no unfiltered water to be carried except under extraordinary circumstances, such as a march in the hot weather, when extra water might be required for medical purposes, or when the water at the next camp is known to be very bad.

(*d.*) The filter to be of simple construction, not likely to get out of order by jolting along a road.

Remarks.—This essential condition could hardly be fulfilled when the filter is a part of the receptacle for unfiltered water. Although a fixture in the cart, the filter should be separable, so that it can be always under supervision, and that in case of choking or other disarrangement, it can be, if necessary, disconnected and repaired. It would be desirable that there should be two filters, so that, in case of accident or disarrangement, one filter might still be in working order. Also that a few spare filters could be carried with the Commissariat Stores in case of accident. The filter should, if possible, be made in India, or at all events be capable of repair in the Commissariat Stores of any station.

Principles of construction.

2. From these conditions the following principles of construction may be deduced :— The apparatus attached to the cart should be composed of three separate parts—the unfiltered-water receptacle, the filters, and the filtered-water receptacle: the flow of water through the filters to be regulated by stop-cocks. The filtered-water receptacle must occupy the space between the upper part of the platform of the cart and the lowest part of the naves of the wheels. The weight of the cart should not exceed that of the common platform pattern. The weight of the apparatus (apart from the cart) should not exceed 200 lbs., thus allowing 600 lbs. or 60 gallons as the load of unfiltered water, and 400 lbs. or 40 gallons as the maximum load of filtered water.

Application of the principles.

3. Applying these principles, I arrive at the following pattern of filter-cart and apparatus :— I take the axletree and wheels of a common platform-cart, the wheels of which are 54 inches apart; after fixing on the axletree-bed the two side pieces of the framework, each $3\frac{1}{2}$ inches square, I find that the available tank space is 34 inches on the breadth of the cart and 14 inches in depth, divided in 2, as to length, by the axletree-bed. The filtered water receptacle would then be formed by two tanks, their length may be fixed at 32 inches, their depth at 13 inches; their breadth will be determined by the quantity of filtered water required, and may be fixed at 14 inches each; $\frac{32 \text{ in.} \times 13 \text{ in.} \times 28 \text{ in.}}{277 \text{ c. in.}} = 42$ gallons. Deduction made for thickness of metal, 40 gallons of water will be contained in the two tanks, each 32 in. × 13 in. × 14 in., placed one in front of, one behind, the axletree. They can be connected, below the axletree, by a piece of flexible tubing.* These tanks will be supported by two pairs of iron-

* Any adaptation of a single tank would necessitate the cart having a crank axle, which is objectionable. The double-tank system has also the following advantages :—

1*st.*—By shutting one of the connecting stop-cocks, the water is prevented from shifting when the cart is going up or down steep ground.

stirrups fixed in the intervals between the axletree and the nearest thwarts of the framework. The cross bar of each stirrup is moveable; it passes through two slots, and has a head at one end and a linch-pin at the other.

The breadth of each tank being 14 inches, a thwart would be fixed at 16 inches in front of, and another at the same distance behind, the axletree. A third thwart would be required 18 inches further in front to support the pole of the cart. The framework will be quite open; on it will be fixed two cross pieces of wood, strengthened with arched iron, on which the unfiltered-water receptacle will be secured. Some minor fittings will provide a support for the filters behind the unfiltered-water receptacle, and a pair of small-store boxes between the two front thwarts. Having thus fixed the principles of construction and the form of the cart, the details of the filtering apparatus may now be considered.

The unfiltered-water receptacle.

4. The unfiltered-water receptacle may be either a common beer hogshead of 54 gallons, or an iron tank of 60 gallons; in either case the gross weight will be about the same, and there will be little practical difference in capacity. The quantity of unfiltered water will supply the 40 gallons of filtered water required to fill the tanks, and leave either 14 or 20 gallons surplus for general camp purposes. In favor of the hogshead are its merely nominal cost, its ability to stand rough usage, its easy replacement on the march. The only objections to it are its somewhat greater weight (though probably only by 20 to 40 lbs.) and its liability to decompose some brackish waters if they are left in it for a night. I do not think that this would be any drawback in practice, for the water in excess of that necessary to fill the tanks during the night would be run off from the cask in the morning before leaving camp. Experience will show any real defects from the employment of hogshead; and if iron or galvanized iron tanks be preferred, these can be substituted without any alteration in the cart beyond levelling the cheeks from the cross pieces which supported the hogshead. Water will be drawn off by three taps; the middle tap as a sluice-cock, and to give unfiltered water for general camp purposes; the side taps will communicate, by flexible tubing, with the filters.

The filtered-water tanks.

5. The filtered-water tanks should be either of iron or of galvanized iron; each would have two taps, one in front for the supply of water, and a small one behind for connexion with its fellow; the two tanks being back to back, separated by the axletree. Iron tanks can be made in Bangalore for about Rupees 12 each; galvanized iron tanks, imported, would hardly cost less. Experience will show whether locally-made iron tanks will not answer the purpose.

2nd.—In case of accident to one tank, the other remains good.

3rd.—Each tank, containing 20 gallons of water, weighs 230 lbs., and can, if necessary, be carried by two bearers; while a single tank, weighing 460 lbs., would be much less portable.

4th.—The tanks can be taken out for cleaning, &c., by drawing out the cross bars of the stirrups; with a crank axle and single tank the unfiltered-water receptacle would have to be removed in order to get at the tank from above.

The filters.

6. The filter must be compact, of cylindrical form, not exceeding 12 inches in height; thick tin plate, japanned, answers well as a material. The filtering media which will work well on the march are confined to three—sponge, Bohemian felted glass, and moulded carbon blocks. The second of these I have quoted merely nominally, as it is a recent invention, comparatively unknown, of which I have no experience; I understand that it was manufactured in view of the filtration of water in the Austro-Hungarian Army. Experience alone can decide between the first and third of the filtering materials mentioned; but without prejudicing the results of actual trial, I am inclined to consider sponge as best suited for the circumstances; it is easily procured, and, if clogged, the dirt can be removed at once by washing. I have never been enthusiastic on the subject of animal charcoal; but I think that if there is any occasion in which its undoubted property of removing (when fresh) dissolved organic matters from water is valuable, it is on the march. It should of course be used as supplementary to filtration, the water being passed slowly through animal charcoal after the best mechanical filtration possible under the circumstances. I propose, provisionally, filtration downwards through sponge, upwards through animal (bone) charcoal. But experiments will be made on the various methods of filtration available, and full details given in a subsequent report.

Allotment.

7. On the basis of filtration at 10 gallons per hour (with two filters) each cart could furnish 100 gallons of filtered water between 8 A.M. and 6 P.M., besides 50 gallons more filtered during the night, if necessary. Allowing as a maximum 1 gallon of filtered water daily (2 pints on the march, 6 pints in camp), one cart would suffice for a strength of 150 men. Under ordinary circumstances, the above allowance would give a surplus sufficient for the usual proportion of women and children. A moderate quantity of unfiltered water, 50 or 100 gallons, could also be supplied for general camp purposes and the use of the hospital. I have little doubt that, in ordinary marching, one cart would be found sufficient for the whole water-supply of 150 men besides women and children. I would suggest, as a provisional allotment, one cart for the first 100 men, and one for each subsequent 150 men or fraction of that number. Thus, small detachments, not exceeding 100 men, would have one cart; a strength of two companies of a Field Battery or Royal Horse Artillery Battery would have two carts, a wing of an Infantry Regiment three carts, a Cavalry Regiment four carts, an Infantry Regiment either five or six carts.

Attendants.

8. Each cart proceeding with troops will probably require two attendants (besides the bullock driver); one should be, if possible, a bheesty by trade, capable of carrying the mussuck if the troops went on service; the other may be a common cooly. At the end of a march the filtered water-tanks and the filters would be removed and taken into store for cleaning; the cart would remain a water-cart for cantonment work. The bheesty should be retained, if possible, as a barrack waterman.

9. The cart, dismantled of its filters and tanks, would replace puckallies in cantonment, and when required for the march, or for use at a cholera camp, it can be fitted up again at an hour's notice. For service in hill countries impracticable to wheeled carriage, the filtering apparatus would be as efficient as for ordinary service. Each of the filtered-water tanks would be carried by two bearers, and two others would carry each a half-cask tub and a filter; the apparatus would be set up at a well or spring, and when the troops moved the filter water-tanks would accompany them.

Puckallies supersede.

10. I am not yet in a position to estimate the cost of the filter-cart otherwise than approximately.

Estimate of cost.

The following is a provisional estimate :—

	RS.
Cart	50
Hogshead	Nominal.
Two filtered-water tanks (complete with taps)	30
Two filters complete	20
Taps, minor fittings, buckets, &c.	20
Total Cost ...	120

With an iron tank instead of a hogshead, the cost would be about Rupees 150.

11. The number of carts required for the whole Presidency (including Burmah) might be taken (in the proportion of one for 150 men) at 75, or, allowing for contingencies, at 100.

Estimate of number for the Presidency.

EDWARD NICHOLSON, Surgeon-Major,
British Medical Service.

ORDER THEREON, 12th November 1874, No. 3,687.

The Right Honorable the Governor in Council concurs with His Excellency the Commander-in-Chief in the opinion that it is very desirable that the experimental filter-carts should be tested, under the direct supervision of Surgeon-Major Nicholson, during the march of the 89th Regiment from Bangalore to Madras, and accordingly sanctions the immediate construction of the proposed number (six) of carts.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Proceedings of the Madras Government, Military Department, 3rd March 1875, No. 1,008.

From Brigadier-General A. HOWLETT, C.B., Quartermaster-General, to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Fort St. George, 26th February 1875, No. 1,341.

With reference to Order of Government, No. 3,687, of the 12th November last, I have the honor to report that the filter water-carts in Surgeon-Major Nicholson's charge arrived in Madras this morning with the 89th Regiment, and to state that, with the approval of Government, His Excellency the Commander-in-Chief proposes to convene a Committee as per margin to inspect and report on them as recommended by the Sanitary Commissioner in paragraph 7 of his letter in the above quoted Government Order.

President :
Surgeon-General Gordon.

Members :
A Surgeon, British Medical Service.
An Officer, Commissariat Department.
An Officer, Quartermaster-General'sDepartment.

2. With reference to Order of Government, Public Department, No. 64, 16th January 1875, instructions are requested relative to the Sanitary Commissioner being associated with the Committee as member.

ORDER THEREON, 3rd March 1875, No. 1,008.

Approved. The Sanitary Commissioner will be a member of the Committee.

(True Extract.)

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Proceedings of the Madras Government, Military Department, dated 31st May 1875, No. 2,593.

From Surgeon-Major W. R. CORNISH, F.R.C.S., Sanitary Commissioner for Madras, to Colonel A. C. SILVER, Secretary to Government, Military Department, Fort St. George, dated Madras, 15th March 1875, No. 270-A.

I have the honor to report, for the information of Government, that, as the labors of Surgeon-Major Nicholson in connexion with the construction of water-cart filters have come to an end, I have reported to the Surgeon-General, British Medical Service, that Dr. Nicholson's services will not be required in this department after the conclusion of

the Proceedings of the Committee appointed in G. O. No. 1,008, of 3rd March 1875.

2. I have to express my best thanks to Dr. Nicholson for the care and attention he has given to the experiments on the best form of filter for troops in movement. The reports to be submitted with the Proceedings of the Committee will show the nature of Dr. Nicholson's proposals, both for water-carts and barrack-filters, and I trust that the recommendations of the Committee may meet with approval.

3. I would also venture to suggest, for the consideration of Government, that some remuneration should be accorded to Dr. Nicholson for the special duty on which he has been engaged, since November last, in connexion with these experiments.

4. The papers in connexion with these experiments will be collected, and an abstract of them printed in the Annual Sanitary Report for 1874.

From Brigadier-General A. HOWLETT, C.B., Quartermaster-General, to Colonel A. C. SILVER, Secretary to Government, Military Department, dated Fort St. George, 25th March 1875, No. 2,078.

With reference to G. O., 12th November 1874, No. 3,687, I have the honor, by order, to forward, for submission to Government, Proceedings of Committees to report on Surgeon-Major Nicholson's filter water-carts and his barrack-filters, together with the accompaniments named in the margin.

I.—Proceedings of Committee on Surgeon-Major Nicholson's filter water-carts, with the following accompaniments:—
1.—Letter from the Officer Commanding 89th Regiment, No. 308, dated 15th March 1875.
2.—Report by Surgeon-Major M. L. White, in medical charge 89th Regiment, dated 15th March 1875.
3.—Report by Surgeon-Major Nicholson, dated 10th March 1875.
4.—Plan of filter-cart.
5.—Enlarged plan of filters for water-carts.

II.—Proceedings of Committee on Surgeon-Major Nicholson's barrack-filter, with the following accompaniments:—
1.—Report on Surgeon-Major Nicholson's barrack-filter, by Deputy Surgeon-General Massy, C.B.
2.—Letter from Medical Officer in charge of Royal Artillery, Bangalore, on Surgeon-Major Nicholson's barrack-filters.
3.—Report on the filtration of water in barracks and hospitals by Surgeon-Major Nicholson.
4.—Plans of the Macnamara, Madras Railway and Lamprey filters.
5.—Plan of Surgeon-Major Nicholson's barrack-filter.

2. In forwarding these documents, it affords His Excellency the Commander-in-Chief much satisfaction to report that the experiment with these filter-carts has been attended with great success. The health of Her Majesty's 89th Regiment during its recent march from Bangalore to Madras, and its immunity from bowel-complaints, so common during the marches of troops, is remarkable, and may fairly be attributed in a great measure to the good drinking-water provided for the men from these filter-carts.

3. The favorable reports of the Commanding Officer and the Surgeon-Major of Her Majesty's 89th Regiment sufficiently establish the soundness of the principle on which these filter-carts are constructed. His Excellency the Commander-in-Chief recommends that fifty filter-carts of the best material and workmanship be made up and distributed to two or three of our large stations for use and further trial. They would be very useful to take out with troops on route marches, to rifle practice, &c., and would be available for both ordinary marches and on any sudden demand for troops to take the field. In many of our large stations, where systems of water-supply are being introduced, puckallies are dispensed with, and, in the course of a few years, will, like dooly-bearers, be most difficult to obtain on an emergency. Some substitute for puckallies must be devised, and these filter-carts, which have stood the test of trial so well, seem to be exactly what is needed.

4. Surgeon-Major Nicholson has left for England. The Commander-in-Chief would suggest that application be made to the authorities at home for his services there to superintend the construction of metal casks and filters for fifty carts. When these are sent out to this country, carts for them could be constructed here. The casks, filters, and fittings had better be made in England, and accuracy and excellence of workmanship would be attained by having them constructed under the superintendence of the designer, whose practical experience of the working of the filters would enable him to ensure strength where it is most needed, and perfection of finish throughout.

5. With regard to Surgeon-Major Nicholson's barrack-filters, they appear to combine the properties particularly required, *viz.*, simplicity of construction, quick and efficient action, and cheapness. The water, being in porous vessels, is also kept cool. At present, the general introduction of these barrack-filters is not practicable, as Government has recently incurred considerable expense in the construction of Macnamara filters.

6. Surgeon-Major Nicholson has been engaged for seven months in investigations and experiments on the subject of the best kind of filter-cart for military use and the general question of the supply of pure drinking-water for troops. He has brought to bear on these subjects not only his well-known scientific attainments as a chemist, but also much patient inquiry into the best mechanical construction for both carts and filters. During his employment on this duty he has received no special salary for it. His Excellency the Commander-in-Chief is of opinion that some recognition of his services should be granted, and would take the liberty to recommend that the thanks of Government and an *honorarium* of Rupees 2,000 be accorded to him for his past services, and that further remuneration, if he is employed as recommended in England, be left to the decision of the home authorities.

7. For convenience of reference and the advantage of general circulation, it is recommended that all the documents now submitted be printed and the plans lithographed, one hundred copies being struck off; also that Surgeon-Major Nicholson's former reports, submitted to Government by Dr. Cornish, be also printed with the above.

Proceedings of a Committee assembled by order of His Excellency the Commander-in-Chief (G. O. C. C., dated Fort St. George, 6th March 1875,) to inspect and report on Surgeon-Major Nicholson's Filter Water-carts.

President:

Surgeon-General C. A. Gordon, C.B., Surgeon-General, B.M.S.

Members:

Colonel R. Benson, Assistant Commissary-General.
Do. H. O'Connell, Deputy Quartermaster-General.
The Sanitary Commissioner.
Surgeon-Major M. L. White, 89th Foot.

The Committee having assembled at 11 A.M., 11th March 1875, at the Office of the Surgeon-General, British Medical Service, read a report by Surgeon-Major Nicholson, giving a description of the construction and working, during the recent march of Head-Quarters, 89th Regiment, from Bangalore to Madras, of a filtering cart and apparatus invented by him.

The Committee then proceeded to inspect six of the carts in question. The workmanship of the filtering apparatus is rough, owing to hasty construction and to the difficulty of obtaining suitable materials at Bangalore. The principle of the whole, however, seems simple and well adapted for military use.

The report by Surgeon-Major Nicholson, together with those of the Officer Commanding and Medical Officer in charge, 89th Regiment, are annexed to these Proceedings.

The Committee recommend that fittings for twelve filtering carts, as described by Dr. Nicholson, be made up in England, the proper material and workmanship not being procurable in India.

As Surgeon-Major Nicholson is about to proceed to England on the expiration of a tour of foreign service, the Committee would further suggest that his services might be made available to superintend their construction.

From Lieutenant-Colonel E. Thorp, Commanding 89th Regiment, to Surgeon-General C. A. Gordon, C.B., British Medical Service, President of Committee to report on Water-cart Filters, dated Fort St. George, 15th March 1875, No. 308.

In reply to your letter, dated 10th March 1875, I have the honor to express much satisfaction at being able to report most favorably upon the

working of Dr. Nicholson's carts during the recent march of the regiment under my command from Bangalore to Madras.

2. There were six of these carts in use producing jointly 300 gallons of filtered water for drinking purposes during the actual marching of the regiment each day, which was amply sufficient for the six companies (about 500 men); and there was not the slightest difficulty in getting this water at any stage of the march, the carts being always close in rear of the column.

3. In order, however, to ensure a plentiful supply for the "halt" (coffee, and to avoid the risk of getting bad water for this purpose in the dark, I think that, with the same number of men, an additional cart should be provided, and that the camp colormen and others (who have to march in the heat of the day), preceding the regiment to each camp-ground, should also be provided with one cart.

4. These carts, which, in the case of my regiment, were admirably and industriously worked, are, undoubtedly, a great improvement for *ordinary road marches* on the old puckally system, insomuch as the carts (containing filtered water, a fact of the first importance) being filled before starting, and able to keep up with the regiment—which the puckallies cannot do—water is always at hand; but, in anticipation of any proposed abolition of puckallies, I consider that in the case of a camp-ground where the water-supply is unavoidably at a distance, and the road to it bad for the carts, it is a great advantage to have, say, three or four puckallies at hand, who have been sent on the day before, to fill the carts immediately on the arrival of the troops at each stage and at such other times as may be necessary during the day, besides supplying water for washing purposes.

5. In conclusion, I have no hesitation in placing before the Committee my own favorable opinion of these carts, as compared with the old puckally system, for the use of troops moving by ordinary road marches, and in this I am supported by the opinions of the officers and others under my command who have given the subject their attention.

Report on the Working of the Nicholson Filter-carts on the march of the 89th Regiment from Bangalore to Madras.

The supply of water to the 89th Regiment on the march from Bangalore to Madras by means of the filtering carts built and arranged by Dr. Nicholson was decidedly successful. There were some defects in matters of detail to be allowed for in a first experiment, but no practical inconvenience arose. Four carts delivered filtered water all day long, and at the rate of about ten gallons per hour for each cart—a quantity amply sufficient for the wants of the regiment. The quality of the water supplied in camp was much better than that usually obtained under the puckally system, and there was no comparison between the efficiency of the two methods. As a rule, two carts were sent on in the evenings for the use of the coffee-shop; this insured a supply of good wholesome water to make the coffee, and it also permitted the Serjeant in charge to take up his position at the proper

distance on the road (half-way). Under the puckally system, the coffee halt from necessity depended on the presence or absence of water, and it not unfrequently happened that in the early dawn foul water from some stagnant pool was, in the hurry of the moment and from necessity, used. The other two carts came along in rear of the column, and at each halt came up along the line, and the men had an ample supply of filtered water in a moment; in fact, they were able to dispense with the water-bottle almost entirely, and I think all medical officers will appreciate the benefit of a system which insures that their attention to the quality of the water-supply in camp is not counteracted by the supply of impure water on the line of march. The filtering apparatus worked very well, suspended matters were removed in a manner which, if not quite perfect, would still have been very creditable to a household filter working under the most favorable conditions, and may, therefore, be considered excellent in an apparatus subject to the rough usage of marching. From first to last they worked well, and their great simplicity is one of their strongest recommendations. During a march in which the greatest attention was directed to the subject of water-supply, it was impossible to determine what share of sanitary benefit was respectively attributable to the selection of the water, to its protection from pollution by camp-followers, or to its filtration, but the fact remains that the regiment enjoyed splendid health. Without a single case of bowel-complaint so common to troops marching, and usually ascribed by sanitary authorities to the use of impure drinking-water. In conclusion, I think the filter water-carts a decided success, and feel sure that they only require to be more generally known to be fully appreciated.

MADRAS, 15*th March* 1875.

(Signed) M. L. WHITE, Surgeon-Major,
In Medical charge, 89th Regt.

Report on the Experimental Water-supply, by means of Filter-carts, of the 89th Regiment on its march from Bangalore to Madras.

Six water-carts were begun immediately on receipt of the sanction given in G.O., 12th Novemher 1874, No. 3,687. I had little more than two and a half months to build and equip the carts, and at the same time to make the experiments necessary before I could fix on the form of filter most suitable for the purpose. The carts were, however, completed and equipped by the end of January, and on the 1st February they accompanied the six companies of the 89th Regiment on their march from Bangalore to Madras.

2. The twelve regimental puckallies belonging to these companies had been ordered to march also in case of any failure in the water-cart experiment; their services did not prove necessary, but they were utilized for the conveyance of washing and cooking water, and were occasionally required to furnish six bullock-loads of water in the morning, so as to enable the empty carts to begin filtering immediately on arrival in camp. The puckallies were let off duty early in the day and allowed to proceed at leisure to the next camp.

3. On arriving at the new camping-ground my first care was to inspect the available sources of water-supply. These were of various kinds, and one was sometimes expressly selected in order to test the capabilities of the water-carts. Of the sources used there were five wells, six tank-wells (small tanks containing subsoil water), four tanks (surface water), four rivers or streams; a detailed description of these is given in another report. The greatest care was taken to guard the selected water-source against pollution or even use by camp-followers, and to effect this the most vigilant supervision was required. Sometimes the water-source was apparently inaccessible to carts, seeming to necessitate the aid of the puckallies; but I found that the water-cart attendants were able to make in a very short time a road practicable to carts, a rough road, but hence all the better test of the ability to stand rough usage possessed by the carts and their fittings.

4. The strength of the regiment was 545 of all ranks, and the quantity of drinking-water used (including wastage and consumption by servants) was not less than twelve casks, of 54 gallons each, daily; on halt days as little as ten casks might be used, while on marching days as many as fifteen casks were used. Of the latter quantity, 750 gallons, two-thirds was filtered for use in camp, the remaining third being sent forward to the coffee-shop at the half-way halting place, or carried for consumption on the march. This latter third was not always filtered, as some of the filtered-water tanks were found to be leaky (from the difficulty of getting good iron and rivetters in Bangalore), and only capable of being made water-tight by means of red lead and other substances detrimental to good water. The mode of closing the tanks had also been found to be defective before leaving Bangalore, but there had been no time available for change. Therefore, when the water was of good quality, it was usually filtered only for camp use, but if there was the slightest doubt as to its quality, 100 or 150 gallons of it were filtered and carried in the cask receptacles previously well cleaned.

5. I regret that I was not able to carry out the system in its entirety, but I was able to test the principle of carrying water in the iron tanks, and found it quite satisfactory. Little practical inconvenience occurred from the failure of one part of the equipment, and the defects will not appear when the tanks are made up, at home, of galvanized iron. The same defect of leakiness appeared in the two unfiltered-water tanks which I had made of iron; one of these was replaced, on the march, by an arrack cask, so that there were five carts still available; these were amply sufficient, and the substitution of an arrack cask for a damaged iron tank afforded a useful trial of the possibility of making such repairs in case of accident.

6. I found the hogshead receptacles strong, but open to some objections, especially on a point which I had anticipated in my previous report, *viz.*, their liability to decompose the sulphated] waters common in Southern India if these be left in the casks for many hours. This defect showed itself on the arrival of the regiment within a few marches of the coast. The casks also collect the matters suspended in the water, and these form

sediments difficult of removal except by scouring the inside. I would prefer cylindrical receptacles made of galvanized iron; they would be much cleaner, without effect on the readily decomposable waters, rather lighter, and capable of replacement by arrack casks in case of necessity.

7. Apart from the advantages of the system of filtration, the carts, even deprived as they were of the use of the filtered-water tanks, showed a decided superiority over puckallies in the water-supply of the troops while marching. The men stepped out well, often at four miles an hour; yet the carts laden with the maximum quantity of water, 54 gallons, kept up without the slightest difficulty, and, at any moment the Commanding Officer considered proper, the men were supplied with water without a minute's delay. When the halt sounded, as soon as the men had made way by forming front along the side of the road, the carts moved quickly up to suitable positions along the line (one to each two companies) and were ready to supply water by the time the men had piled arms and broken off. Before five minutes had elapsed, every man who required water had obtained it, and in the usual halt of ten minutes the foremost cart had time to trot up to the advanced guard, a quarter of a mile ahead, and give water there also. Water-bottles were entirely disused during this march.

8. Under the puckally system the troops are not accompanied by the water, as no laden bullock could keep up with the column. They depend entirely on their water-bottles and on the appearance of puckallies who have stationed themselves at various points of the road. The puckallies leave camp in the evening, their bullocks laden, not with water, but with families and baggage. They halt at different points of the road, necessarily close to some tank, well or ditch, and in the morning, at the approach of the column, they fill their bags with water, the quality of which is undetectable in the darkness, and the coolness of which is owing not to the porosity of the leathern bag, but simply to exposure at night. No remedy to this system is practicable; firstly, because a bullock laden with even a half-load of water (200 lbs. for 16 gallons) could not possibly keep up with troops; secondly, because a bullock cannot stand laden all night, and it cannot be relieved of its load except by letting the water out of the bags. The exertions of the medical officer in selecting and conserving the water-supply of the camp are evidently thrown away so long as the men, while marching, must drink water the quality of which is unknown, and the source often most objectionable.

9. In my previous report I mentioned that the equipment of the cart could be carried separately by coolies for hill service. The only point on which the puckallies have an apparent advantage is in the case of the water source being inaccessible to carts; but even here, as I have already shown, there is simply a slight delay, if the advance party or the local civil authorities have not already made a road. When the filter-cart system is properly organized, and each cart has two bheesties as attendants, there will be no point remaining on which the puckallies would have even an apparent advantage.

10. With five carts available for duty it was found possible to send on

two of them in advance in order to supply the coffee-shop with good water, thus rendering it able to choose its position independently of tanks, &c. The coffee-shop party were thus able to sleep in camp, starting one hour in advance of the column. The carts having supplied whatever water was required for the coffee, proceeded on to camp, and, had no puckallies been present, would have supplied water to the cooks for the men's breakfast. As it was, they filled up with fresh water and began filtering ready for the men as they marched into camp.

11. During the march the carts had to pass some bad pieces of road notably the bed of the Palar river in the eighteen-mile march from Vellore to Ranipett (by Arcot) and the bed of the river half-way between Stripermatoor and Poonamallee. They did this much more easily than the sick-carts, they were able to rejoin the column immediately afterwards, and the bullocks did the day's work in camp just as usual.

12. The system of filtration adopted was that which I mentioned in the previous report, *viz.*, filtration downwards through sponge, and then upwards through bone-charcoal. This was found to give very satisfactory results; it was not perfect, but it gave constantly good results which, from my knowledge of other filters, would not have been obtained by other extant systems without sacrifice of simplicity. Each of the two filters attached to a cart had to deliver 50 gallons daily, making a total of 1,200 gallons during the twenty-five days' march. The water was sometimes very turbid, so that the casks required scouring every day and the sponges to be cleaned twice daily from the accumulated sediment. Nevertheless, the filters still work very satisfactorily. The results are in remarkable contrast with those given by filters in which the suspended matters are retained in solid substances difficult to clean. Experiments made on silicated carbon filters (a kind highly commended by competent authorities), presenting four times the filtering area of the cart-filter, and working on fairly clean well-water, showed that these filters gave very good results as long as they were only filtering for half an hour or so daily, but that, when kept at work for ten hours daily, they clogged past remedy before 100 gallons of water had passed through, and had to be cast aside as useless.

13. The cart-filter will not render white water colorless; the most perfect filter will only do so for a very short time, and they clog very rapidly in the attempt. But it removes all distinguishable suspended matter (such as visible organisms, vegetable *debris*, &c.,) while the turbidity produced by finely-divided clay is considerably diminished. More than this no filter adapted to the rough usage of a march can be expected to do, and few, if any, of the more perfect stationary filters will do it for any length of time.

14. The action of the filters was simple enough to admit of their being entrusted nearly entirely to the attendants after a few days. These men were common barrack-followers, horse-keepers, and cook-boys out of place, yet they soon understood the management of the filters.

15. The filters were made of thin tin plate (the only suitable material procurable at Bangalore), and therefore are to be regarded, like the rest of the equipment, merely as models to be improved upon in the definite pattern;

yet they lasted very well, and would have been serviceable for a three-months' march.

16. I have appended a memorandum of the modifications to be made in the provisional pattern of the equipment before the next trial with troops on the march. When this takes place, it would be quite safe to dispense with puckallies, allowing a somewhat greater number of carts than I had at first considered sufficient. An allotment of one cart per company, troop or half-battery of mounted artillery, with one extra for the hospital, but available for general duty, would be sufficient, and would admit of the following liberal distribution of carts on the march :—

—	Regiment of Infantry.	Wing of Infantry.	Company of Infantry or Garrison Battery.	Regiment of Cavalry.	Royal Horse Artillery or Field Battery.
With Quartermaster's party to supply water at the new camp	1	1	...	1	1
With coffee-shop party go on afterwards to camp ...	2	1	1	2	1
With the column	5	2	1	3	1
With the rear guard (if they can be spared from the column)	1	1	...	1	...
Total ...	9	5	2	7	3

This allotment would be ample for cantonment as well as for camp water-supply.

Memorandum on the definitive Pattern of a Filter-cart for use with Troops on the march.

17. The following definitive pattern includes the modifications which experience on the march of the 89th Regiment has shown to be necessary.

18. The cart remains the same as in the provisional pattern.

19. The receptacle for unfiltered water should be of galvanized iron, placed like the cask in the provisional pattern. It should be, like a hogshead, 36 inches long; if 25 inches diameter, this size will yield a capacity of 63 gallons, and will permit of replacement, in case of accident, by a common arrack-cask. It may with advantage be of elliptical form; flattened above and below. There will be a $\frac{3}{4}$-inch tap behind and two $\frac{1}{4}$ or $\frac{5}{16}$ taps in front. These will be adapted for junction with a tightening screw. The cylinder will have three hoops; two of them arranged for the attachment of stays; the middle one bears a pin fitting into a hole in the thwart, thus preventing the cask from shifting. It will be supported at each end on a curved iron thwart; in the middle by a wooden arched thwart fixed to the axletree bed.

20. The filter will be double. Each will consist of a cylinder 7 inches diameter and 7½ inches high, with a half-flap lid and a false canister top 1½ inch below the lid. In the part with a fixed lid is an inner cylinder 2½ inches diameter, not reaching quite ($\frac{1}{10}$th inch short) to the bottom of the main cylinder, and 1 inch higher than the latter. In this fits loosely another cylinder, ½ inch shorter, open at the bottom, closed at the top, with a tube in the top and fitting by a bayonet-catch to the cylinder in which it fits. The tube is directed horizontally and ends in a union screw fitting on to the tap of the unfiltered-water receptacle. Near the top of this inner cylinder there is a perforated diaphragm and in the top an air-cock. At the bottom of the filter is a purge-cock. The filter should be made, if possible, of enamelled iron, otherwise of galvanized iron; some brass fittings will be required.

21. The filters are supported in a box which fits between the two front cross-pieces of the cart frame; it rests on the pole in the middle, on two ledges at the ends. This box forms a driver's seat, in it at each end is a small-store box.

22. The filtered-water receptacles consist of two rectangular tanks; the long edges should be rounded to avoid weakness at these parts; they communicate by a flexible tube under the axle, and have a ½-inch tap front and rear. Each is supported by a pair of ¾-inch iron bars passing through two pairs of lugs rivetted to the tank; these bars are bolted to the frame-work, but can be removed. Each tank has the man-hole covered so as to be water-tight against splashing; water and air pass in by a tubular orifice 1 inch diameter covered by a loose cap.

23. The cart is also equipped with the following stores:—

Two zinc buckets, beneath the front cross-piece.
One leather bucket with rope, slung on the receptacle.
One mamooty or pickaxe.
One date-mat cover.
One funnel,
One sponge rammer,
One sponge extractor,
One pint, tin,
Four sponges,
One spanner.
} In the small-store box.

24. The above description necessarily omits many details which would be necessary for a complete specification and working plan. These would require superintendence while the permanent pattern was under construction.

Instructions for working the Filter of the Water-carts.

25. The main cylinder should be filled with bone-charcoal about the size of peas, not smaller, especially at the bottom. The charcoal should be well shaken down, so as to fill the cylinder perfectly up to the canister lid of the false top; charcoal which is overburnt, and thereby contains some quicklime, should be well washed and dried before use.

26. Take out the inner moveable cylinders and pack them with sponge. Round pieces of honey-comb sponge, the size of the fist, weighing about two ounces new, one ounce washed, should be well cleaned of sand. Two pieces are required for each cylinder. Take one piece wet and wring it, then introduce it into the cylinder so that the upper part shall be smooth, the folds being below. Press it gently up to the diaphragm by means of the rammer, then introduce the second sponge in the same way. Place the sponge-cylinder in position, connect it with the cask tap by means of the union screw; turn on the tap and open the vent-cock until air is expelled.

27. The water now descends through the sponge and rises through the bone-charcoal, overflowing by the perforated canister top. Both filters being at work, place the funnel in the mouth of the filtered-water tank; see that the taps of the latter are all right, and moderate the flow of water to about 10 gallons per hour (one pint in 45 seconds) from the pair of filters.

28. The sponges will require cleaning at intervals of from five to ten hours according to the turbidity of the water. They should be removed at night, or when filtration is suspended for some time; and opportunity should be taken to air and dry them, in the sun if possible. The sponges are removed by a long extracting tongs. Filtration goes on very well when the cart is in motion, but it is better to disconnect the filter then, in order to avoid strain on the joints.

29. When the sponges are taken out, their cylinder can be replaced empty; in the case of tin filters it is better to leave water in the filter, as corrosion takes place much less rapidly than when the metal is in contact with wet charcoal and air. This water should, however, be run off by the sluice-cock when the filter is again set at work.

30. The filtered-water tanks act as reservoirs; the rear tap should, as a rule, be used for drawing off water; the pair contain forty gallons of water.

31. The filter contains about 6 lbs. of bone-charcoal; this may, if convenient, be aired and dried in the sun once a week, and changed every month if fresh charcoal be available.

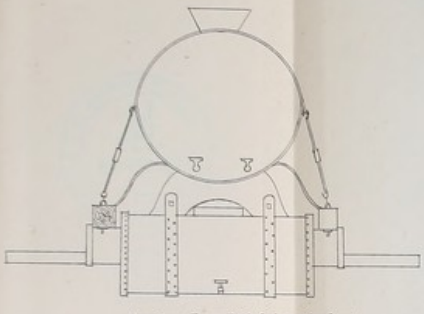
32. The unfiltered-water receptacle should be scoured out as often as possible, at least once a week. The stem of a palm leaf with one end beaten soft makes a good scrubber for the tanks. The filtered-water tanks should be also scoured at suitable intervals. The top of the man-hole must be removed for the purpose.

33. Should water be observed to well up between the moveable sponge-cylinder and the cylinder into which it fits, this shows that the communication with the main cylinder is obstructed, generally by fine charcoal having accumulated there. The charcoal must be taken out, dried and winnowed free of fine particles.

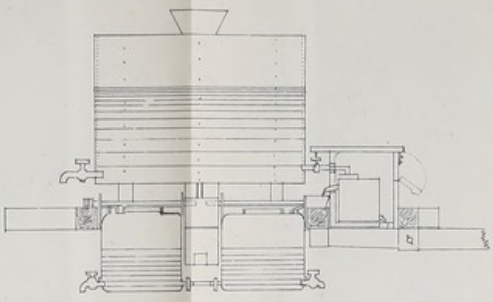
(Signed) E. NICHOLSON, Surgeon-Major,
British Medical Service.

MADRAS,
10*th March* 1875.

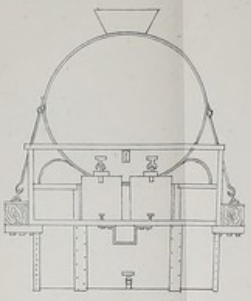
FILTER WATERCART FOR TROOPS MARCHING



Section through C.D from the front



Section through E.F



Section through A.B.
front of the driver's box removed

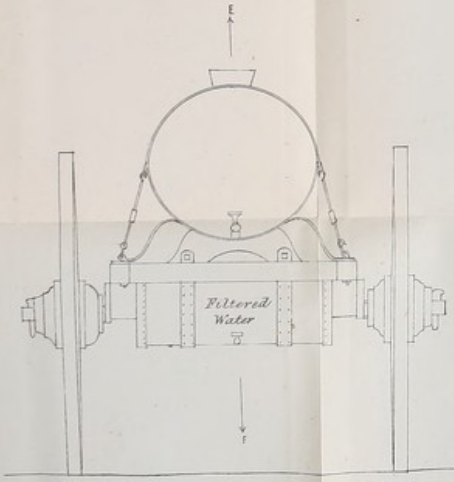


Fig 2
Rear Elevation
the filtering apparatus removed from the front

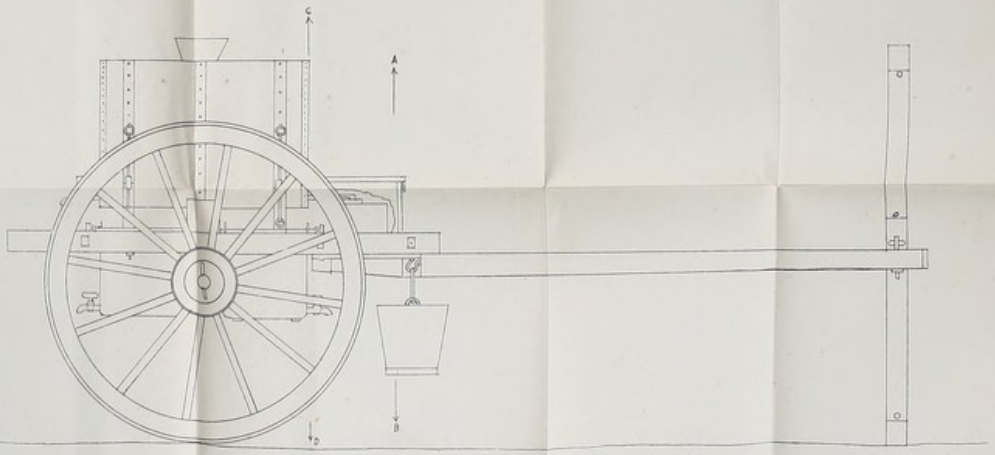


Fig 1
Side Elevation

(Signed) Edward Nicholson
Surgeon Major B.M.S
Madras 3rd March 1875

(True Copy)
(Signed) H. O'Connell Colonel
Dy Qr. Mr. General

Qr. Mr. General's Office
30th March 1875

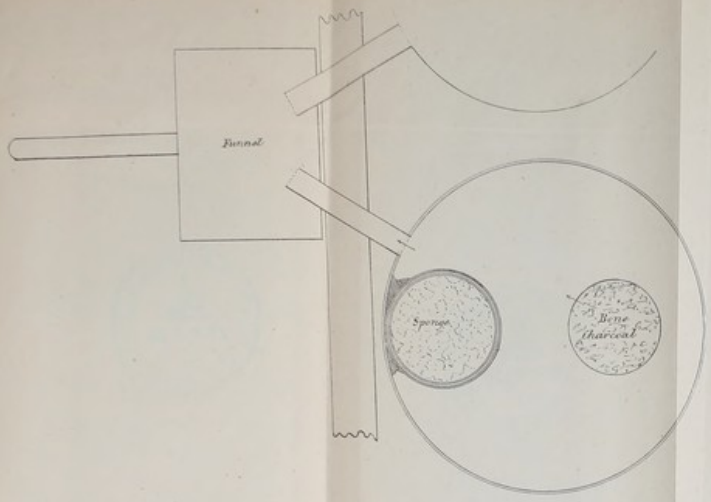
Govt. Lith. Depart. Fort St. George
Madras " May 1875

Scale One — Sixteenth
INCHES 1 2 3 FEET

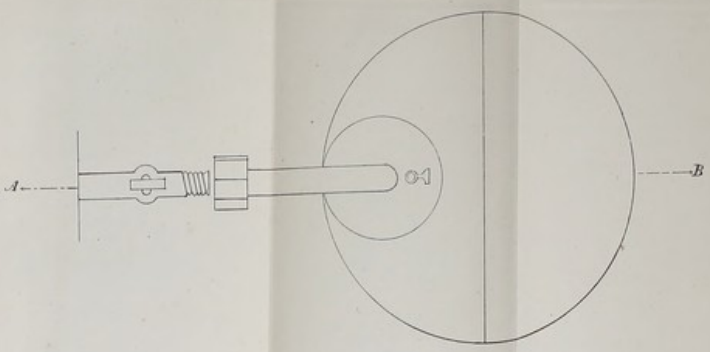
TRANSFER BY T. THAGARAJOO AND LITH BY J. BALDRY GOVT. LITH. PRESS FORT ST. GEORGE MADRAS 1875

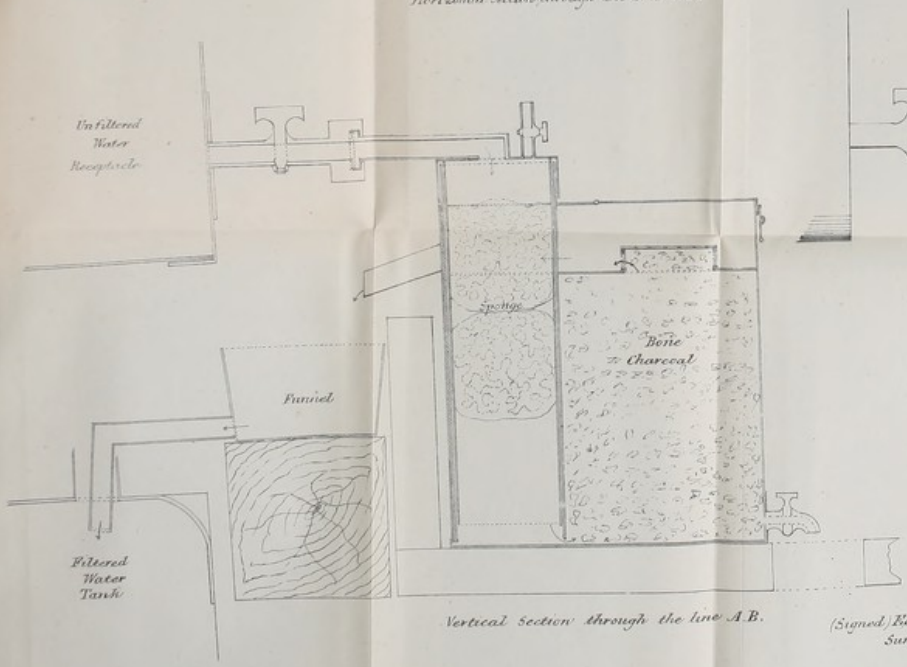
Filters for a Water cart

Scale One Half

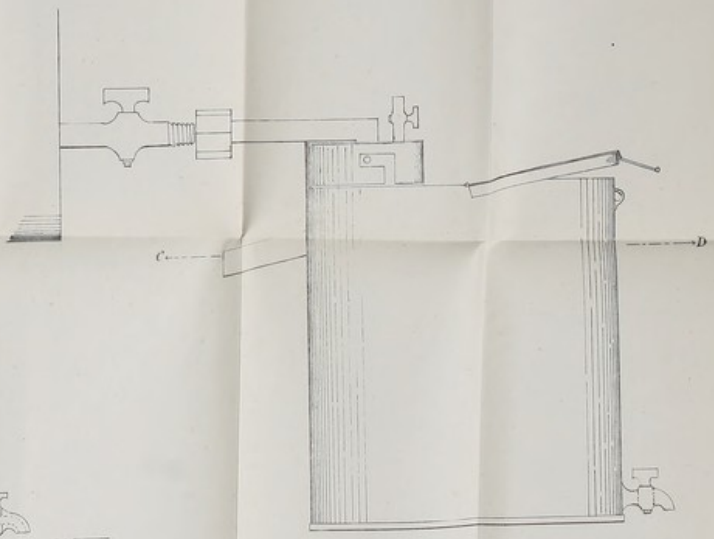


Horizontal Section through the line C. D.





Vertical Section through the line A.B.



(Signed) Edward Nicholson
Surgeon Major B. M. S.

(True Copy)
(Signed) H. O'Connell Colonel
Dy Qr. Mr. General

Qr. Mr. General's Office
15th March 1875

Govt. Litho. Depart.
Fort Saint George
May 1875. Madras

TRANSFER BY S. PARTHASARATHY & LITH. BY R.A. BALDREY GOVT. LITHO. PRESS FORT ST. GEORGE MADRAS 1875

Proceedings of a Committee assembled by order of His Excellency the Commander-in-Chief (G. O. C. C., dated Fort St. George, 6th March 1875,) to inspect and report on Surgeon-Major Nicholson's Barrack-filter.

President :

Surgeon-General C. A. Gordon, C.B., Surgeon-General, B.M.S.

Members :

Colonel R. Benson, Assistant Commissary-General.
Colonel H. O'Connell, Deputy Quartermaster-General.
The Sanitary Commissioner.
Surgeon-Major M. L. White, 89th Regiment.

The Committee having assembled at the office of the Surgeon-General, British Medical Service, on 11th March 1875, proceeded to inspect Dr. Nicholson's barrack-filter. It is fully described in his report with plans attached. The filter is a modification of the old three-chatty barrack-filter, on which it is a decided improvement. The simplicity of this filter, its efficiency, small cost, and suitability for barrack use make it, in the opinion of the Committee, an excellent one for general adoption.

A report from Bangalore on some of Dr. Nicholson's barrack-filters that have been in use there is attached.

Report on the Working of the Filters as improved by Surgeon-Major Nicholson.

I presume it is not necessary to enter into a minute description of these filters, as no doubt they are known to the Committee.

No. 1.—A cylinder, three parts filled with sand and gravel, placed in a large earthenware jar, the space between containing sand, wood-charcoal placed on the cover. The supply of water for them flows from the stand-pipes direct into the filter.

No. 2.—A chatty with a sponge placed in a cylindrical hole in the bottom rests on a stand; under this a small tray of animal-charcoal. The water is placed in the chatty, and passes through the sponge and animal-charcoal into a jar underneath, for which the tray of charcoal forms the cover. The jar has a brass cock for drawing off water as required.

No. 1 is the filter supplied to the men's barrack-rooms and hospital.

No. 2 is supplied to families.

The jars with brass cock, the receptacles for the filtered water of No. 2 filters, are used also as receptacles placed in various parts of the barracks, and are filled by puckallies from No. 1 large barrack-filter several times in the day.

The men prefer No. 1 to the old chatty-filter. They seem durable; none of the filters have been broken since their adoption.

A few of the receptacles have been broken by men falling against them, usually at night. The cocks have in a few instances been knocked off, but have been readily replaced with cement.

They are more easily filled than the old chatty-filter, and, unlike the latter, no pollution not originally contained in the water can enter any part of them.

They are easily cleaned.

They have a greater depth of sand than the old chatty-filter, but the filtration is much more rapid.

I approve of the simplicity of these filters, and, if they are found to remove impurities from water adequate to other ordinary filters, would certainly seem a valuable improvement upon the old chatty-filter.

To ascertain their filtering power, however, it would, I apprehend, be necessary to pass through them water of ascertained impurity, and examine it after filtration, as was done by Dr. Parkes at Netley by direction of the Army Sanitary Commission.

Dr. Parkes showed that the power of sponge in removing sediment from water is most remarkable. A small sponge of 255 grains weight removed 257 grains of sediment.

I cannot help thinking that if sponge were introduced into the construction of the No. 1 barrack-filter, it would be an advantage, and I believe Dr. Nicholson's well-known ingenuity could easily provide this.

(Signed) H. H. MASSY,
Deputy Surgeon-Genl., B.M.S.,
Mysore Circle.

From Surgeon-Major B. TYDD, Medical Officer in charge, Royal Artillery, Bangalore, to Deputy Surgeon-General H. H. MASSY, M.D., C.B., Deputy Surgeon-General, British Medical Service, Mysore Circle, dated Bangalore, 18th March 1875, No. 35.

With reference to Surgeon-General's letter, dated Fort St. George, March 11th, 1875, and your endorsement thereon, I have the honor to report that Surgeon-Major Nicholson's filters were introduced into the barracks of C Battery, C Brigade, Royal Horse Artillery, and the hospital of the Royal Artillery, about the middle of January last.

2. The filters employed in barracks are of two kinds, one of which is for the use of the unmarried soldiers, and the other for the married men and their families.

3. That used by the unmarried soldiers differs little in principle from the old three-chatty filter, being composed of vegetable-charcoal, fine sand, and gravel. The essential distinction, however, is that there is less charcoal and a greater depth of sand, while from the nature of its construction the filtration is accomplished both by descent and ascent. Indeed, the quantity of charcoal is so trifling that it is scarcely worthy of being taken into account, while the depth of sand is much increased. The result of my

observation is that on the whole it is a decided improvement on the old method, and its advantages may be thus summarized—1st, the water appears better filtered; 2nd, the number of filters and chatties required is much reduced; 3rd, the filters being few in number, admit of easier supervision; 4th, the water after filtration is preserved clean, as it is transferred into covered vessels; 5th, as these vessels are provided with taps, it is drawn with facility and comfort; 6th, the system gives greater satisfaction to the men, who express themselves pleased with it.

4. There are two of these filters in barracks, each capable of supplying fifteen gallons per hour.

5. The filters supplied to the married soldiers simply consist of sponge and animal-charcoal, the sponge being fixed in a funnel-shaped receptacle at the bottom of a jar, through which the water drips into a perforated saucer filled with animal-charcoal resting on the narrow neck of a second jar, from which it is drawn off by means of a tap.

6. I am using this filter in my own house and observed it in barracks, and find it also very efficacious and well suited for families.

Report on the Filtration of Water in Barracks and Hospitals.

The system of filtration employed in the barracks and hospitals of European troops is that of the well-known three-chatty filter. There are two slightly different arrangements of the filtering materials; sometimes the upper chatty contains sand and the middle one charcoal, at other times the upper chatty is merely a reservoir, while the sand and charcoal are placed together in the middle chatty. The water trickles through holes bored in the bottom of these two pots, the flow being regulated by straws or shreds of rag stuffed into the holes. Whichever arrangement be in use, the following defects constantly occur:—

1*st*.—The three chatties are generally left open, the lower one containing the filtered water is always left so, to the manifest risk of pollution by the excreta of birds, by dust, by fragments of rotting straw, &c. There is also a natural temptation for the waterman to fill the lower chatty direct instead of raising the water to the upper one.

2*nd*.—Water can only be taken by dipping some vessel, generally a tin-pot, into the filtered water—a practice necessary, but evidently objectionable.

3*rd*.—The filtering materials are nearly invariably inefficient (from the small depth of sand and the disturbance of it when water is poured on), and they are generally dirty, and rather worse than useless. So frequently is this the case that when the water in the lower chatty is found to be fairly clear, it may be very safely inferred that the waterman has filled this chatty direct, and that the water has thus escaped being fouled by the process of filtration.

2. So obvious were the defects of this filter that the Government of India was induced to sanction the adoption of a filter brought forward by

Dr. Macnamara of the Bengal Medical Department, but there are such difficulties in making it, and such grave doubts have arisen with regard to its value, that, in this Presidency at least, the old-pattern filter still remains in use.

3. In my former report I explained how the principle of this syphon-filter really possesses none of the advantage claimed for it, and which it might at first sight appear to have, and there is no doubt that any other arrangement by which water would be made to pass through 6 inches of sand and 12 inches of bone-charcoal would be equally effective, while it could with difficulty combine so many faults of action and construction. I have shown in my former report that sand must be in very thick layer (1 to 4 feet), and pass the water very slowly in order to be efficacious as a filter; in the present case a 6-inch layer of sand placed in a 10-inch cylinder has to retain the dirt separated from about 50 gallons of water daily for two months. I have no hesitation in saying, as the result of experiment, that, if effective, the sand would be choked in less than a week. The bone-charcoal has little or no effect in rendering water clear.

4. Not only the efficiency of this filter is most questionable and its distinctive principle erroneous, but the fact of its containing, according to its inventor's description, about 6 yards of bondage cloth necessarily in a state of incipient putridity is hardly consistent with its pretensions as an apparatus for freeing water from organic matters. There are also details of construction which are quite incompatible with the simplicity required in a barrack-filter, and which would be certain to make it break down even if it were otherwise efficient. For instance, it contains an earthenware dish and a zinc tray both perforated with 400 holes to the square inch. The first would be rather difficult to produce in India, the latter would be clogged with carbonate of zinc in less than a week; even if varnish could be applied as suggested, it would be of little avail. The filter is also placed in a wooden tub and fastened so that the cleaning of the tub would be a difficult task, and it is well known how foul a tub becomes if not thoroughly scrubbed daily. I have mentioned some of the leading defects; there are many more hardly less important.

5. I have, at the request of the Sanitary Commissioner, examined a filter devised by Mr. Winter, Telegraph Engineer to the Madras Railway Company, and used at the stations on the line. It consists mainly of three pots, of rather superior earthenware. The upper is a receptacle for unfiltered water; this passes out through a hole into a flat pan lined by a shallow zinc funnel. The long stem of the funnel reaches to the bottom of a tube placed in a filtering cylinder (9 inches high 4 inches diameter), which is contained in the third pot or filtered-water receptacle. The water should pass down to the bottom of the cylinder, rise through the mixture of sand and charcoal which it contains, and overflows into the filtered-water pot, whence it is drawn off by a tap.

6. The filter is certainly compact, and cannot be well meddled with, but this very feature is a disadvantage, as it is impossible to know what is going on inside. Were this not the case, uselessness of the filter would have

been perceived long ago. I may give the following instances which have come under observation :—

At the Bangalore station I found both the filters yielding very dirty water. In one of them the stem of the funnel was broken off, so that the water did not pass near the filtering material. It had been in this condition for three months to my knowledge.

At the Madras Central Station I found the water very dirty, and on examining the filters, in presence of the Station Master, I found in both of them that the water, instead of passing through the sand, simply regurgitated up the central tube of the filtering cylinder and overflowed directly into the filtered-water receptacle; in one of them a resistance equal to ½ inch of water was sufficient to produce this effect, and the funnel overflowed as well as the central tube. Even the small resistance offered by about a half-pint of sand mixed with a pint of charcoal in lumps was sufficient to make the water take the easier road into the filtered-water jar.

7. I have also examined the "cylindrical syphon-filter" devised by Surgeon-Major Lamprey, 67th Regiment. The principle of it presents much analogy with that of the one just described. A large pot, in the bottom of which is a large hole, has fixed in it, by a water-tight joint, a zinc cylinder with a glass grating at the bottom, this corresponding with the hole in the large pot. The cylinder is filled with filtering material and covered by a zinc cylindrical shade, the upper part of which has a vent-hole closed by a cork, while the lower part is perforated.

The two cylinders form a syphon, of which the inner one is the long leg and the outer one the short leg. When the large pot is filled with water above the vent, the syphon becomes primed and the vent is then corked. Water now ascends the outer cylinder and passess down the inner cylinder through the filtering material into a lower pot provided with a tap.

8. There are some obvious defects in the construction of this filter. Firstly, the syphon has to be reprimed by removing and replacing the cork each time the filter has become empty and is refilled. And if by any chance the cork has not been fixed in perfectly air-tight, the syphon will stop work in a short time. The action of the filter being concealed, there is nothing to tell that this has happened except the failure of water in the lower pot. Before the filter can be again in action, the supply must be reprimed by filling the filter up to the brim, taking out the cork and fixing it in again firmly. Secondly, the slightest leak in the luting of the cylinder to the bottom of the pot would cause unfiltered water to pass out; a leak is very likely to occur from accident in cleaning, and if it did happen, would escape notice from the action of the filter being concealed.

9. Supposing these defects—great drawbacks in a barrack filter—to be remediable, the action of the filter remains to be investigated. This is explained as follows :—

"The water being made to pass through sand and charcoal before it reaches reservoir, insures the removal of all suspended matter, ova and larva of insects, &c.

"It is not likely to get clogged, as it is so constructed that nearly all the

impurities held in suspension fall to the bottom of the jar, and do not reach the surface of the filtering medium, which is nearly on a level with the top of the jar, and such as do collect on the surface of the filtering medium are easily removed without disturbing the filter in the least.

"When there is an accumulation of impurities on the upper surface of the sand sufficient to retard the action of the filter, it can be easily removed by lifting the small perforated cap from the top of the inner cylinder, emptying it of its dirty sand, refilling it with clean sand and replacing it as before."

10. The first point which attracts observation is that common to all descriptions of syphon-filters—the assumption that the suspended matters, on arriving at the inner orifice of the syphon, will stop there and "fall to the bottom of the jar." I have shown in my former report that there is not the slightest foundation in fact for this assumption; water exercises pressure equally in all directions, and matters suspended in water pass as freely up a syphon as they would out of a tap. Hardly more correct is the assumption that filtration through 16 inches depth of charcoal and sand (8 inches of each) *insures* the removal of all suspended matter, and that the renewal of the top half inch of sand will set the filter all right when the sand is clogged.

11. Great mistakes are made in the employment of sand. This substance is an excellent filtering medium when in layer of 4 to 6 feet thick, and the rapidity of flow can be regulated, as in water-works, but in layer of less than 2 feet it loses its efficiency, and if less than 1 foot in depth, it is inferior to an inch or two of compressed sponge. I might almost say that the filtering effect of sand is in the ratio of the square of its depth, and that for household filtration its effects can never be obtained, owing to the small depth available.

12. The two filters I have described are examples of the different ingenious combinations which can be made with three or four vessels of various sizes and shapes, by putting one side the other, by inverting the filtration, by varying the disposition of filtering medium, &c. A dozen other arrangements might be made answering the same purpose, but without any real advantage over more simple apparatus, and accumulating defects with each departure from the ordinary principle.

13. It may be safely said that the essential qualification of a barrack-filter is simplicity—in action, in construction, in capability of cleaning and repair. A filter possessing these essential qualifications in every respect, and also improving the water even slightly, is better than a filter of perfect action which fails in one of the essential points, and hence will certainly become unserviceable sooner or later.

14. I do not consider that any of the filters in the English market fulfil the requirements of Indian barracks. The moulded carbon blocks of Atkins and Co. might, perhaps, be adapted for use; their action is the most perfect I know, but there are some details of fitting which render them rather unsuitable for filters scattered about barracks, and the very perfection of their filtering powers renders them liable to clog.

15. On the whole I am of opinion that the simplicity of the three-chatty

filter renders it the type of construction for an Indian barrack-filter—for the present at least. If it could only be made, without notable detriment to its simplicity, to render water better, not worse, than before filtration, its simple principle would render it decidedly the best filter for general use. This object is, I believe, attained in the improved form of the filter about to be described.

Description of a Filter for Barracks.

16. This is an adaptation of the common three-chatty filter, the inefficiency of which is removed by the following modifications.

17. The upper chatty has at its lowest part a tubular orifice rather more than an inch long and nearly 1 inch in bore (admitting the forefinger entirely). In this a piece of sponge is packed, sand being dispensed with. The chatty has a wide mouth (8 or 10 inches) and a cover.

18. The middle chatty is small and flat, holding about one pint; it contains animal-charcoal in rather fine grain. It rests on the lower chatty, so as to cover the latter and prevent any access of light or of dust to the filtered water. It has a saucer cover, and both chatty and cover are perforated below by a few fine holes.

19. The lower chatty is in the form of a flat-bottomed jar, with a tubular orifice about an inch above the bottom; in this a tap is fixed by some Portland or other cement. No water can enter the jar except through the bone-charcoal in the middle chatty, which forms its cover; and none can be taken out except through the tap. Its mouth is about 5 inches diameter. Both the upper and lower chatties are about 12 inches high, and contain each 3 gallons.

20. The stand is of such a shape as to combine stability with protection to the chatties. It is pyramidal, with four legs 24 inches apart at each base, 14 inches apart at the top, and is 40 inches high. At the top is a seat for the upper chatty, while the lower chatty stands on a double cross-bar, the end of which rests on two side tie-bars placed half way up the stand. There is no tie-bar in front; this would interfere with the tap.

21. The filtering media are sponge and bone-charcoal; together, these effect unexceptionable filtration. Water as dirty as it can be when intended for drinking comes out free from all distinguishable suspended matters, and with ordinary care the action lasts indefinitely. Of course, the whole apparatus must be cleaned at suitable intervals, in order to remove the dirt separated from the water and to keep the chatties in the porous condition which enables them to cool the water. Beyond this no care is required. The chatties can be renewed when accident at last breaks them, the sponge can be replaced when worn out, and the bone-charcoal should be changed every three months.

22. The rate of filtration depends on the head of water above the sponge. It is as much as 2 gallons an hour when the upper chatty is full, and may be taken as an average at 1 gallon an hour. If the upper chatty be filled four times a day, 12 gallons of filtered water will easily be obtained daily. This is enough for twenty-five men at the maximum rate of consumption.

23. There is one possible defect in the apparatus, that if the waterman

spills water on the outside of the upper chatty, some of the water will trickle down on to the middle chatty; however, though it escapes the sponge, it cannot escape the charcoal, and its quantity is trivial compared to the bulk of perfectly filtered water with which it becomes mixed. If the upper chatty be wide-mouthed, this risk is reduced to a minimum, and I have not thought it necessary to complicate the apparatus by providing specially against a trifling defect.

24. The cost of the filter does not exceed that of the common chatty-filter, and all its parts are procurable locally. The set of chatties costs 8 Annas in Bangalore, or 10 Annas including a flat pan at the foot of the stand to receive drippings and for the use of domestic animals.

The stand costs Rupees $2\frac{1}{2}$ in Bangalore, where wood and labor are rather dear.

Brass taps cost Rupees $1\frac{1}{4}$ in Bangalore; pewter taps would be preferable for barracks, being less liable to disappearance, and they would cost not more than 8 Annas.

A piece of sponge cut of the size and shape of a plantain, or of a pear, and weighing about half ounce new, costs in Bangalore from 3 to 4 Annas. Common honey-comb sponge, costing about 8 shillings per pound at home, answers as well as the more expensive toilet sponge.

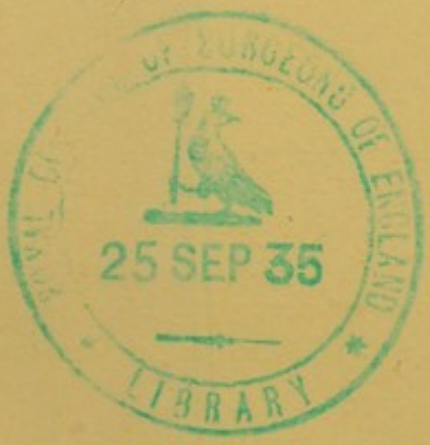
Bone-charcoal can be made at any station by the Commissariat at a cost not exceeding 1 Anna per pound. A memorandum on its manufacture is appended.

Portland cement for fixing the tap is procurable in Presidency towns (and elsewhere) for about Rupees 8 the cask of two cwt. It should be repacked in metal canister, and issued, thus packed, at the rate of 1 lb. for each filter annually. Allowing for wastage, &c., the cost would not exceed 1 Anna per pound. If not procurable, dammer cement may be used.

25. In the above data the first cost and annual maintenance charge of the filter may be estimated at the following rates :—

	First Cost.		Maintenance (Maximum).	
	No.	Price.	No.	Price.
		Rs. A. P.		
Stand	1	2 8 0	..	Barrack fixture.
Tap	1	0 8 0	..	Do.
Chatties .. .. set	1	0 10 0	2	Rs. 1 4 0
Sponge .. .. oz.	½	0 4 0	1	„ 0 8 0
Bone-charcoal .. .. .. lbs.	1	0 1 0	4	„ 0 4 0
Portland cement .. .. lbs.	½	0 0 6	1	„ 0 1 0
Total ..	..	3 15 6	..	Rs. 2 1 0

I here estimated quantities and prices liberally, and it may be taken that the cost of the filter will not exceed that now allowed for the common chatty-filter, *viz.*, Rupees $4\frac{1}{2}$. 1 Rupee extra might be allowed when brass taps are alone procurable. The allotment may be the same as that now in force.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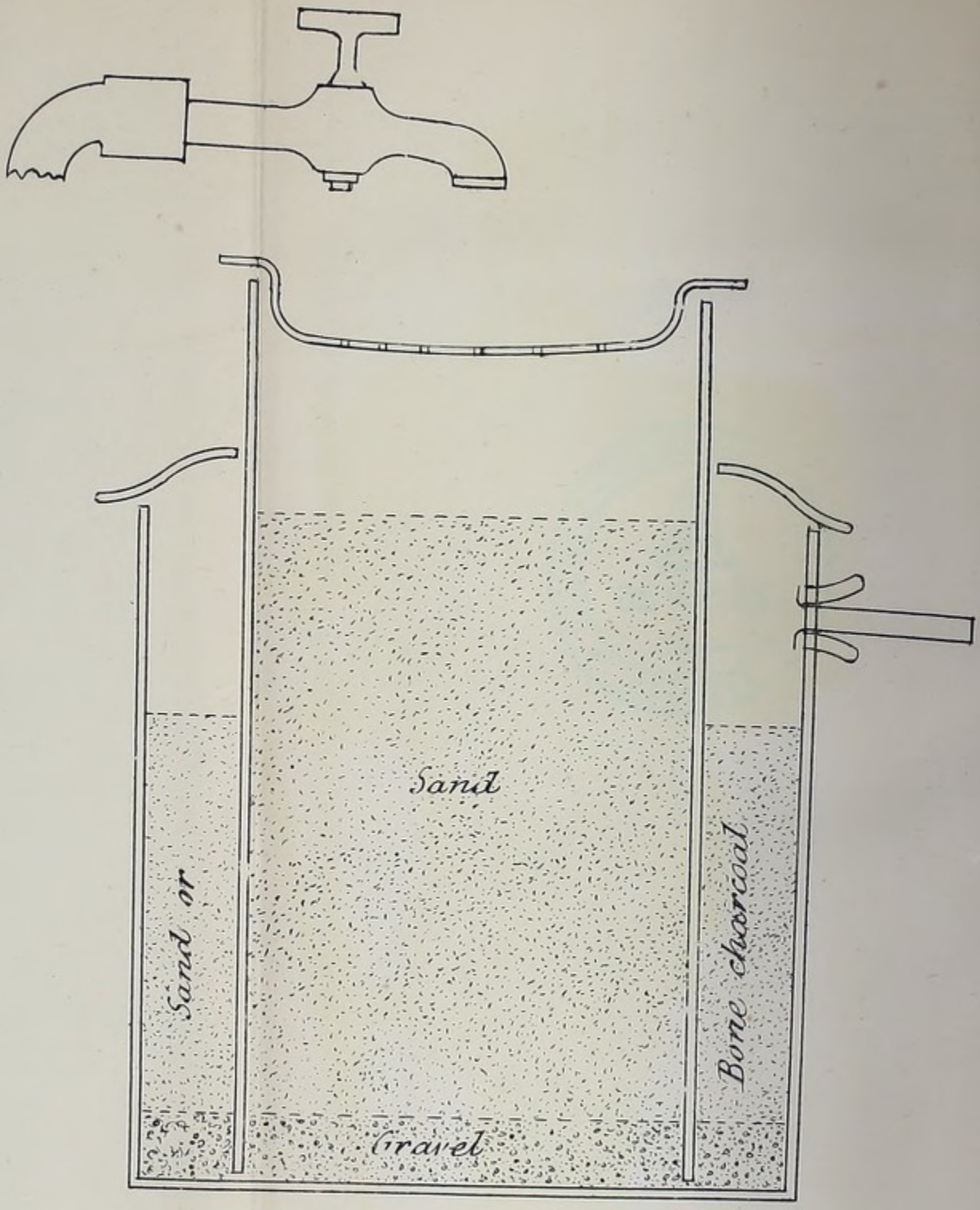


Scale one-fourth

Description of a Sand Filter for Barrack use.

In conclusion, I would mention that I tried at the Royal Horse Artillery Hospital, Bangalore, a sand filter of the following description :—

The filter is composed of two cylindrical pots, an inner one 20 inches high and 10 inches diameter, which may be either without bottom or perforated close to the lower end, an outer one 15 inches high and 15 inches diameter with a spout about 2 inches below the top. The inner one had a concave perforated cover, the outer one a convex ring-cover. In the inner one was about 15 inches of sand, in the outer one about 10 inches of either sand, gravel, or bone-charcoal, according to the quality of the water to be filtered. This filter was placed on some brick under the tap of a stand-pipe or of a half-cask tub, and water allowed to flow on to it. The water passed down through the sand, upwards through the material in the outer cylinder and overflowed by the spout. The filtered water flowed into a pail or other vessel, from which the waterman filled jars or chatties for barrack use. As much as 10 gallons per hour were yielded, so that one filter was enough for a company.

This filter cost only 1 Rupee. It was very effective, but, like all sand filters, required more care than it would usually obtain in barracks. The large quantity of sand it contained required washing (or at least the upper 6 inches did) once a week, and this duty was liable to be neglected. The performance of the filter was excellent in the Royal Artillery Hospital, but in the Royal Horse Artillery Barracks, it was somewhat uncertain owing to the reason I have mentioned. Moreover, it is not applicable to guard-rooms and isolated married quarters, or to barracks unprovided with water laid on by pipes. So I thought it better to abandon it for the improved three-chatty filter, which is of universal application and less liable to inefficiency from neglect.

Memorandum on the Manufacture of Bone-charcoal.

Animal, or more precisely bone, charcoal is prepared by heating bones in closed vessels, so that the animal matter (principally gelatine), forming about 30 per cent. their weight, shall be decomposed, the volatile matters are driven off and the carbon remains, coating the fine cellular tissue of the bone. In Europe the bones are deprived of their fat and much of their gelatine before being burnt, various economical processes are also employed for the purpose of diminishing the cost of fuel and utilizing the waste products. These would be quite out of place in India at present; the following simple process yields a perfectly good char, and will be found more suitable :—

The bones should be burnt in common chatties. The three-gallon pots used for holding water do very well. A circular kiln should be built of mud, its size being sufficient to hold fourteen pots in two horizontal rows of seven each, placed close together in this manner ⁘ it should be about 3 feet high with an air-hole at bottom at each interval between the pots.

The bones, either whole or broken, are placed in the pots, shaken down so that each pot holds about 20 lbs. of bone; the pots are then placed in the kiln, the lower row being closed by the upper one (and a little clay), the latter being closed by a pan cover and some clay . The clay when burnt prevents any notable access of air, while it is sufficiently porous to allow the escape of gases.

The day after the kiln is charged, the fire may be lighted. A kiln with the above charge will require about 50 lbs. of charcoal placed between the chatties and about 100 lbs. of firewood; some of the latter is used for lighting the fire, the remainder is burnt on top of the charcoal so as to heat the upper row of pots. The gases evolved from the bones soon catch fire, so that there is but little disagreeable smell from the operation. In about four hours after the fires were lighted, the pots will be at a low red heat; they may be kept at this by the addition, if necessary, of some more wood or charcoal on top, and after six hours they may be allowed to cool down slowly. On the next day the kiln may be unloaded.

Some of the bones, especially near the top of the pot, may perhaps be burnt white; these may be rejected. The good char should now be pounded and winnowed. A pair of toothed cylinders (like those of cotton gins) crush the bone with little waste, and cylindrical or other sieves might be used; but on a small scale it is best to pound the charred bone in the same way that rice is husked, and to size it by winnowing. The charcoal should be divided into two sizes—coarse, about the size of a pea, especially for use in the filter of water carts—fine, not smaller than R. L. G. powder, for use in barrack-filter only. Dust should be separated (as little of it being produced as possible), and utilized as a manure. The yield of charcoal is about two-thirds the weight of the bone. It really consists of about ten parts of charcoal spread over the surface of the mineral bone tissue, which contains eighty-four parts phosphate of lime and six parts of carbonate of lime. When the heat is too great, the latter mineral constituent is sometimes reduced to quicklime; the char then heats when wetted, and the water has an alkaline taste; this is, however, removed by washing. The grained charcoal attracts moisture from the air; it should be kept in metal cases or in earthen pots, covered from the air and from dust.

The yield of grained charcoal depends on the amount of dust produced; the following may be taken as the cost of 100 lbs. :—

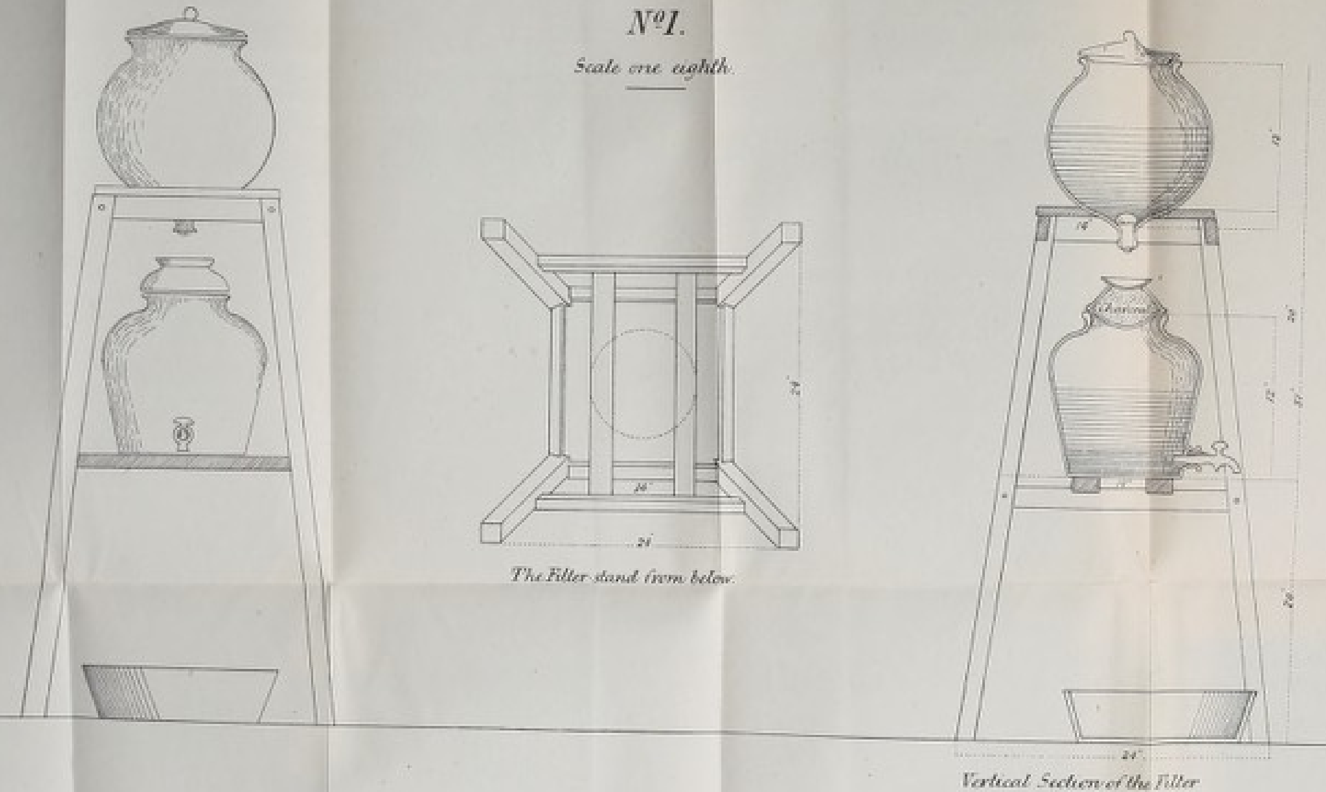
	RS.	A.	P.
300 lbs. bones, at 100 lbs. for 1 Rupee	3	0	0
Loss of pots in burning	0	8	0
Fuel	2	0	0
Labor—pounding and winnowing	2	0	0
Cost of 200 lbs. of char bone	7	8	0
Deduct value of 100 lbs. char dust	1	8	0
Net cost of 100 lbs. grained charcoal	6	0	0

In this estimate I have allowed very liberally for dust, and have credited its value at a low rate. In England the dust (black) is of only

FILTER

No. 1.

Scale one eighth.



Bangalore
25th Jany 1875

(Signed) Edward Nicholson
Surgeon Major B.M.S.

Qr Mr Generals Office
10th March 1875

(True Copy)
Signed H. O'Connell Colonel
Dy Qr Mr General

Govt Litho Departt
Fort Saint George
May 1875 Madras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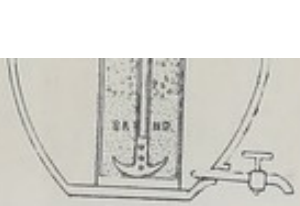

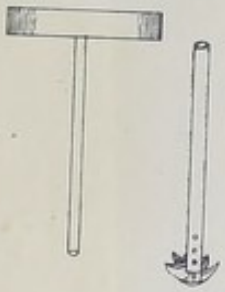

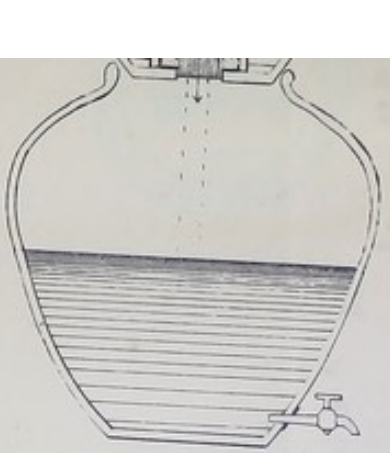

(True Copy)

Ch^c Dep^t Fort St George
Madras May 1875

Q^r M^r General's Office
10th March 1875

(Sig^d) Edward Nicholson
Surgeon Major B.M.S.

(Sig^d) H. O'Connell Colonel
D^y Q^r M^r General.

TRANSFER BY PAINOORSEVALOO CHETTY AND LITHO'ED BY P. J. BALDEUS, GOV^T LITHO PRESS FORT ST GEORGE MADRAS MAY 1875

slightly less value than the grained charcoal; but valuing it as I have, for manure only, and at low rate, the grained charcoal costs not more than 1 Anna per pound. This price admits of reduction by care in pounding. The English price of grained charcoal is not less than 18 shillings per cwt., or 1 Anna 4 Pies per pound.

The weight in bulk of grained charcoal is about 1 lb. to the pint, so that the cost of charcoal per filter may be taken at 1 Anna per pound or per pint. When it can be made as cheaply as this, it is evidently not worthwhile purifying by means of sulphuric acid and permanganate of potash, as is recommended; the drugs would cost nearly as much as the new charcoal, to say nothing of the trouble in procuring and using them. It is better, when charcoal is worn out (say after three months' constant work), to replace it by new, utilizing the spent char for manure.

MADRAS,
10*th March* 1875.

(Signed) E. NICHOLSON, Surgeon-Major,
British Medical Service.

ORDER THEREON, 31st May 1875, No. 2,593.

The Honorable the Governor in Council has perused these reports with much interest, and is glad to learn that the experiment made with Surgeon-Major Nicholson's filter water-carts, during the march of Her Majesty's 89th Foot from Bangalore to Madras, was attended with great success.

2. That officer's barrack-filters have, it is observed, been also approved; but their immediate adoption is not recommended, as a large supply of Macnamara filters is available.

3. His Excellency in Council desires that the thanks of Government be conveyed to Surgeon-Major Nicholson for his valuable services, for which the Right Honorable the Governor-General in Council will be asked to remunerate him with an *honorarium* of Rupees 2,000, as proposed by the Commander-in-Chief.

4. The favorable consideration of the Government of India will be solicited to His Excellency's recommendation that fifty carts of the best materials and workmanship be made up and distributed to two or three large stations in the Madras Presidency for use and further trial, the casks and filters being obtained from England, where Sir Frederick Haines proposes that Surgeon-Major Nicholson, who has proceeded there, should be employed in superintending their construction on such terms as the Secretary of State may decide.

5. The correspondence will be printed, as suggested by His Excellency the Commander-in-Chief, and 100 copies supplied to the Quarter-master-General for distribution.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Docket, 31*st May* 1875, *No.* 2,594.

Copy of the above forwarded to the Secretary to the Government of India, Military Department, for the favorable consideration of the Right Honorable the Governor-General in Council, with special reference to paragraphs 3 and 4.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Selections from the Records of the Madras Government.

FURTHER REPORT

AND

ORDER OF THE MADRAS GOVERNMENT,

UPON THE

Dry Earth System of Sewage

IN THE

MADRAS PRESIDENCY.

EXTRACTED FROM THE PROCEEDINGS OF THE SANITARY COMMISSIONER FOR MADRAS, 1868.

No. XV.

MADRAS:
PRINTED BY H. MORGAN, AT THE GOVERNMENT GAZETTE PRESS.
1869.

FURTHER REPORT

UPON

THE DRY EARTH SYSTEM

OF

SEWAGE.

The History of the "dry earth" system of conservancy, in its application to this Presidency, extends over a period of four years, and is set forth in a mass of correspondence, Proceedings, and Orders of Government, commencing with the latter part of the year 1863.

It is necessary to a full understanding of the interruptions and delays that have occurred in the introduction of the system, to epitomise the more important proceedings on record, and to take a brief survey of the leading points upon which information has been required and obtained, or of questions which still demand elucidation.

2. Experimental trials, sanctioned (so far back as June 1866) in Her Majesty's 60th Rifles, the 2nd Battalion 21st Fusiliers, and Native Lines at Vepery, have not, at the time I write, been brought to a conclusion, no report having yet been received from the 2-21st Regiment at Secunderabad. It has not then been possible to submit the report at an earlier date; indeed, it is now drawn up under great disadvantages from the absence of data necessary to the determination of many points upon which His Excellency the Commander-in-Chief and the Government require information. But Colonel Worster's report, upon the experimental trial of the system in Her Majesty's 60th Rifles, having been forwarded by the Quarter Master General, under instructions from His Excellency the Commander-in-Chief, for such remarks as I may have to offer, I have thought it better to draw up this report, adding as appendices any further reports that may be received while this is preparing for the press, with such postscriptal commentary as may appear necessary.

3. The first document on record in my office is Proceedings of Government, No. 1523, of 4th May 1864, in which sanction was given to the sum of Rupees 500 being disbursed to the Sanitary Commission

for experiments in discovering the most economical and effectual means of introducing the system of dry earth conservancy.

4. In Proceedings, No. 1,376, of 10th April 1865, the Quarter Master General, under date the 26th December 1863, submits an approximate estimate of the cost of the introduction of the system in the different divisions of the Army, and which he figures at Rupees 1,35,371 for provision of new, or alteration of old buildings, and Rupees 942-8-0 as the monthly increase of expenditure for minor appliances and establishments.

5. On the 19th October 1864, the same Officer addressed the Secretary to Government, in the Military Department, in letter No. $\frac{3423}{1087}$, reporting, by order of His Excellency the Commander-in-Chief, the result of the introduction of dry earth as a deodorizer in Hospitals and Jails in this Presidency in very favorable terms, "the efficiency of the system after being largely tried is reported to be attested by, it may be said, the whole service, there being scarcely a dissentient voice." The difficulty of arriving at any satisfactory or definite information in regard to the question of cost is noticed; the only reliable data being those afforded by the Physician of the General Hospital, who assigns eight annas per month for the European, and three annas two pie for the Native, giving an increase of Rupees 44 per mensem in that Hospital, as compared with the old system. The letter concluded as follows: "I am desired by His Excellency to say that if, even without an addition to establishments, such marked benefit has accrued from the use of dry earth, nothing but perfect success can be anticipated when its introduction is systematised and promoted by the grant of further aid."

6. The Officiating Principal Inspector General of the Medical Department, in his letter dated 6th of October 1864, No. 339, to the address of the Quarter Master General, which forms part of the same Proceedings, after reviewing reports from numerous Medical Officers, who, under a Departmental Circular Order, No. 1,573, of 12th May 1864, had been directed to submit reports after three months' trial, and especially to note whether "the new system can be arranged for with the present conservancy establishment," writes that "the experimental trial they have made goes conclusively to prove the virtue of the dry earth system as a deodorizer in this country and its superiority over that hitherto in use."

7. The most valuable of the reports submitted in these 'Proceedings,' is that by Dr. Blacklock, the then Physician of the General Hospital, and which has been already alluded to. The most important conclusion arrived at by Dr. Blacklock was the comparative value of soils, pure clays being found to possess large deodorizing powers, seven

pounds being equal to seventeen of the best earth found near Madras, and two pounds capable of absorbing one pound of water (or urine ?)

8. With considerable pains and care Dr. Blacklock framed an estimate of the cost of the *new*, compared with the *old*, system in hospitals. The expense attending the new system for a hospital of 200 sick Europeans, is fixed at Rupees 157-12-0, and under the old, Rupees 116; the difference (excess) under the earth system being Rupees 41-12-0 per mensem. For 100 Native sick the earth system is assumed to cost Rupees 15-8-0, more than the old. On the 27th December 1864, the Quarter Master General again addressed the Secretary to Government in letter No. 11,790 A, in which he brings to notice that His Excellency the Commander-in-Chief highly approves of the suggestions of the Sanitary Commission, that the new system of dry earth conservancy should be made applicable to all buildings and localities occupied by soldiers, and after noticing that "the Sanitary Commission should be requested to draft a general order, explanatory of the mode of operation of the new system, in order that no failure may arise from want of knowledge," remarked that "the system introduced by Dr. Hathaway, which consists in carting away the excreta in air-tight iron boxes without any attempt at previous deodorization, may, therefore, now be considered as superseded by this latter measure, and the alterations proposed to existing buildings are no longer necessary."

9. The Proceedings close with a letter, No. 1,471, of 23rd February 1865, from the Barrack Master to the Secretary to Government in the Military Department, from which the following extracts are made: "With reference to the proposed general introduction of the dry system of conservancy, I have the honor to report that the published opinions, as to its advantages, have been fully confirmed by the trials at the privies erected for the use of the families of the Regiment in Garrison, and for the East Indian Clerks in the N. E. Berm. It has also been tried in the several guard-room privies in the Fort, and the improvement in the atmosphere is so marked, that I have no doubt, with a larger and more constant supply of earth, and the addition of pans and receptacles, that no ill effect or real annoyances would ever be experienced even in these unventilated casemates."

The letter then proceeds to point out that the costly system of standard plan privies, with the requisite watching establishments, will no longer be a necessity. Mechanical contrivances for delivery of earth into the pans are suggested, and as to expense it is remarked that "the cost of supply of dry earth would be trifling, and as receptacles and pans form part of the furniture of the new privies, it will be merely an anticipation of the expense under this head."

In the order upon these Proceedings, the Government review the question of expenditure, and sanction the introduction of the system under the restrictions proposed by the Barrack Master. Plans and estimates for an earth store and cart shed, to meet "present requirements at stations where the experiment is in operation," were directed to be prepared by the Public Works Department, in communication with the Sanitary Commission, and the latter body were directed "to draw up a set of rules explanatory of the operation of the system, to be printed in pamphlet form, and translated into the vernacular languages for general information and distribution." Finally, the proceedings were ordered to be reported to the Government of India, with an intimation that "the experiments hitherto recorded have proved satisfactory, and that thus far the system commends itself for general adoption."

10. G. O. No. 2,229, dated 4th June 1865. In these Proceedings the Controller of Military Accounts reports that funds have not been provided to meet the extra establishment applied for by the Officer Commanding the 2nd Battalion 21st Fusiliers then at Bellary, and Government order "that pending receipt of final orders from the Government of India * * * no additional expense can be sanctioned."

11. G. O. No. 2,629 of 15th July 1865. In these Proceedings the Acting President of the Sanitary Commission informs the Government that, in communication with the Barrack Master, self-acting machines have been designed, and recommends their introduction into the guard-room at the Wallajah gate, the General Hospital, and Barrack latrines at Saint Thomas' Mount. The President of the Sanitary Commission also intimates that the preparation of the rules, contemplated in Order of Government, No. 1,376 of 10th April 1865, must stand over till the conclusion of experiments. The Government in their order upon these Proceedings approved of the trial of self-acting apparatus being undertaken, and signified their intention to take into consideration the question of a reward of Rupees 100 for the best machine, "on the report of the experiments being submitted."

12. No. 387, of 29th January 1866, gives publication to a letter from the Secretary to the Government of India, No. 1,326, of 30th November 1865, to the Quarter Master General, intimating for the information of His Excellency the Commander-in-Chief, "that whilst the Right Honorable the Governor General of India in Council quite concurs in His Excellency's opinion that no further trial is necessary to prove the superiority of the dry earth sewage system," he considered three months' further trial desirable; sanctions the necessary outlay and appliances recommended by the Bengal Sanitary Commission; suggests

the invention of some kind of hopper to the consideration of the Barrack Department, and Department Public Works, and inculcates a reduction in the number of bheesties employed under the old system.

13. These Proceedings also contain a valuable report by the Bengal Sanitary Commission, regarding the dry earth system. The President states that he had acquired a mass of evidence from all quarters, which had been most carefully analysed by the Secretary, and from which he arrived at the conclusion "that dry earth has answered all the ends claimed for it by the Rev. Mr. Moule, that it is superior to the 'dry surface' system," and even Dr. Ross, who urges certain obstacles to the practical working of the scheme, admits "that there can be no doubt of its perfect success."

14. The conditions necessary to the efficient working of the system, the President pronounces to be dryness, immediate application, and sufficiency in quantity. Appliances in the shape of mallets, sieves, scoops, scrapers for cleaning pans, and earth stores in the privies, are considered to be necessary.

The practical objections to the system, which have been urged, he enumerates as comprising—*(a.)* The necessity for provision of large quantities of earth, and its storage during the rains. *(b.)* The fact that the soldiers will not apply the earth themselves, and consequently that the constant presence of a sweeper in the latrine is necessary. (This objection is met by the fact that even under the old system, the presence of a toty in the rear passage was necessary to remove the pans after use, and the provision of some self-acting machinery to meet this objection is urged). *(c.)* That the weight of earth to be removed is so large, that the system cannot be carried out without a large increase of establishment. This objection is met by the remark that the difficulty is not great, except in relation to the urinals. The working of the new, as compared with that of the old system is commented upon, and it is advanced that so far as the latrines are concerned, there is practically little difference in the amount to be removed.

15. In the urinals, however, the Commission think that the difficulty, owing to the enormous quantity of earth to be brought and removed, "is practically insuperable."

It is then suggested that the urine should be dealt with in the old way, being removed in air-tight receptacles, and it is added "the modified plan here recommended not only leads to no expense but may actually effect a saving; for the use of lime and other so-called deodorants is done away with, and no deodorizer is used but dry earth, which can be had for nothing, and carted in at little or no extra expense."

16. The President then gives the practical conclusions at which the Commission had arrived, and which may be summarized thus:—

(a.) That the dry earth system should be rigidly applied to all latrines.

(b.) That the amount of dry earth required for urinals is so enormous, that it cannot be carried out in them.

(c.) That pans designed to separate the solid and fluid feculence should be adopted if possible.

(d.) That a 'hopper' be fitted to each pan, so as to do away with the necessity of having a menial on duty in the latrines.

(e.) That certain small appliances as mallets, sieves, and scoops be allowed (two of the two former to each latrine, and one of the latter to every three pans), and masonry receptacles for earth in the latrines.

(f.) That means should be devised for drying the earth in wet weather.

(g.) That light vessels be provided for removal of urine and dry earth deodorized fœces.

(h.) That the soil be removed to a distance from Barracks, and the solid and fluid excreta be buried in separate pits.

17. The utilization of the excreta, both solid and fluid, in soldiers' gardens is touched upon; but any doubtful experiment is deprecated till the results of certain experiments, then being made in several of the Jails in the North-West Provinces, are made known.

The Commission did not consider any alteration in existing buildings necessary, and expressed an opinion that "the addition of one sweeper and one cart at the small extra cost of Rupees 250 per annum for a Regiment of British Infantry" would, under any circumstances, suffice for the efficient working of the system.

In a note appended, the Commission write, "that under the earth system, the services of five bheesties may be dispensed with in every Regiment, effecting a saving of Rupees 300 per annum, or Rupees 50 more than the greatest possible cost which the modified earth system would entail."

In the order upon these Proceedings, "the Governor in Council is of opinion that the proposed experimental trial, to determine the supply of earth receptacles, &c., required to carry into effect the dry earth system, should be undertaken also in this Presidency at one or two stations occupied by European troops, as His Excellency the Commander-in-Chief may select: the result being reported for the information of Government."

18. The next document is Proceedings of Government, No. 1,295, of 12th April 1866, in which the Officiating President of the Sanita y

Commission recommends that an experimental trial of the system be made in Her Majesty's 60th Rifles at Fort Saint George, and the 2nd Battalion 21st Fusiliers then as now at Secunderabad both in the Barrack latrine and family quarters. Certain alterations to existing buildings are also suggested, comprising raising the rear wall and roofing in the rear passage of the privies, and enlarging the arches to facilitate the removal of the pans.

The pans themselves are recommended to be of sheet iron. The establishment is recommended to be remodelled upon the Bengal scale at an additional cost of 20½ Rupees per mensem. The recommendation of the Bengal Sanitary Commission that the excreta passed at time of defecation only should be dealt with upon the dry earth system, leaving the urine at the urinals to be removed as formerly in air-tight vessels, is also adopted.

19. A calculation is made of the quantity of earth to be brought and excreta to be removed as follows :—

Men 910+20 per cent. women and children ...	= 1,092
Earth at three pounds per head	3,276
Excreta (solid and fluid)	1,124
Solid poudrette to be removed	4,400
Urine in air-tight vessels	1,402
Total...	5,802

A cart load is estimated at 1,500 pounds, so that there would be two and a half cart loads of earth to be brought in daily and four of excreta to be carried away.

20. A new pan with the object suggested by the Bengal Sanitary Commission, viz., the separation of the solid and fluid excreta is advocated.

But the more important suggestion made, is the provision of a pugmill for the thorough admixture of the earth and excreta ; a piece of machinery which is not alluded to in any Proceedings of the Bengal Government.

From actual experience of the utility of this mill, as demonstrated at the Military Male Orphan Asylum, the Commission express the opinion that " an apparatus of this nature is an actual necessity at every dry earth latrine."

Mr. Gover's testimony is quoted, and the following extract is given from that gentleman's report :—

" I cannot lay too much stress upon the mill. It at once removes any difficulty about the disposal and subsequent action of the poudrette. The soil is so perfectly amalgamated with the earth that when once dry

an ordinary quantity of water will not render it offensive. The mixing process is also done so easily that the toties approve of the system, and thus it is saved the risk of wilful neglect. * * * * Further, the process is so cleanly that the advantage of fully carrying it out is patent to the lowest intelligence. Lastly, it takes so short a time that one mill would amply suffice for 1,000 men; while it is so simple in construction and use, that nothing is required *(sic)*. The total cost of a mill need not exceed 20 Rupees."

21. The Commission next proceed to recommend the provision of suitable carts, and that the Regimental toties should be instructed under Mr. Gover, at the Military Male Orphan Asylum, in all the essentials of the system. Favorable notice is also taken of a self-acting dry earth machine, but the Commission do not commit themselves to a positive opinion as to its merits till more extended trial. The disposal of the poudrette is touched upon and its burial advised till its commercial value as a manure becomes known and appreciated.

In the order upon these Proceedings, the Governor in Council considers further information necessary, especially as to the source whence the supply of earth is to be derived, and the locality of disposal of poudrette before incurring any additional expenditure.

The desirability of extending the system to the whole Regiment at once is questioned, "the object being to ascertain the comparative effects and expenditure of the two systems by working both simultaneously." Further orders were held in abeyance pending the receipt of the information called for.

22. The next Proceedings in chronological order (No. 2,205 of the 28th June 1866) contain a further report from the Officiating President, Sanitary Commission, in letter dated 30th April 1866, No. 969, to the address of the Controller of Military Accounts, who submits it with covering letter marked D, of 28th May 1866, in which he comments upon the continued absence of information regarding the source of supply of dry earth, and the place of deposit of the poudrette upon which the expense of the system, it is alleged, mainly depends. He points out that the removal of the poudrette upon the old system would necessitate a rearrangement of the contract, and suggests that the Commission, in communication with the Barrack Master, should be requested to decide upon "the quarter from which earth is to be derived." The Officiating President of the Commission observes that it is not the duty of the Commission to furnish details of the description required.

23. These Proceedings detail the experiments made by Dr. Fawcus in the Alipore Jail in relation to the question of supply of earth, which tend to prove that "the deodorizing power of the soil is chiefly depend-

ent upon the amount of organic matter it contains." Other questions are touched upon, which need not, however, be enlarged upon here.

In 'order thereon' the Barrack Master is authorised to invite tenders for supply of dry earth and removal of poudrette from the latrines in the Fort. Instructions were directed to be issued in the Department of Public Works to prepare estimates for the requisite alterations to the privies, and the erection of pugmills, and the instruction of a certain number of toties under Mr. Gover at the Male Asylum was authorised. Measures were also sanctioned for the early introduction of the system in the 2nd Battalion 21st Regiment at Secunderabad. The expenditure was ordered to be carefully noted and watched, and a report to be submitted through the Quarter Master General's Department at the expiration of six months." from the date of its being brought into operation." The Controller of Military Accounts was directed to provide funds in the regular estimate to meet the extra expenditure involved. In point of fact every obstacle was removed to the efficient introduction of the system.

24. No. 3,634, of 17th October 1866, sanctions the acceptance of a tender for the supply of dry earth to the Fort and Vepery latrines, and intimates that " no further sanction is required for the provision of what is absolutely necessary to carry out an experiment already sanctioned, and for which funds are ordered to be provided," and " the Governor in Council trusts that under this explanatory order no further impediments or delay will occur in bringing the new system into full operation."

This order was passed with reference to an application for buckets and carts by the Barrack Master in his letter, dated 8th August 1866, No. 716, which formed part of the Proceedings, and which also contained a comparative estimate of the cost of the *existing* and *earth* system of conservancy, the difference being in favor of the new system by Rupees 172-2-0 per annum.

25. Subsequently (Proceedings of Government, No. 386 of 31st January 1867) the Barrack Master reports that delay has occurred in procuring the necessary equipments in carts and pugmill, and that in consequence the experiments must stand over. The Government in their order regret to learn that the experimental measures, for the introduction of the dry earth system into the privies of H. M.'s 60th Rifles, sanctioned so far back as June 1866, have not yet been carried out, and direct the Public Works Department to call for full explanation from the proper quarter with respect to the delay in the provision of the pugmill, and intimate to the Barrack Master that it was competent to him to have procured carts, and that he ought to have provided them

with reference to the last paragraph of G. O. No. 3,634 of 17th October 1866, and direct him to proceed with the experiments in his department.

26. Proceedings No. 749 of 1st March 1867, contain letters from the Officer Commanding Centre Division ; from the Sanitary Commissioner to the Secretary to Government ; from the Barrack Master to the Sanitary Commissioner; from the Secretary to the Sanitary Commissioner to the Barrack Master; and from the Deputy Inspector General of Hospitals, Presidency Division, relating to the latrine at Vepery in which delays had occurred in introducing the dry earth system.

The conservancy of this latrine is unfavorably reported upon by the Deputy Inspector General of Hospitals, and personal inspection by the Secretary to the Sanitary Commissioner confirmed the unfavorable opinion. It is pointed out that although the latrine was, in point of construction, fully approved by the Sanitary Commissioner and was designed for dry earth conservancy, the building was found in a most filthy state, and that in point of fact it was a source of greater offence than the old open latrine in lieu of which it was constructed. This state of the latrine is attributed to the insufficiency of the conservancy establishment, especially in carts.

In the order of Government it is directed that the conservancy establishments for the Native Corps at Madras will be maintained as heretofore under the Barrack Department for the purpose of carrying out the experimental use of the dry earth system, the additional establishment for the line conservancy, authorised in Proceedings of Government, No. 3,037 of 30th August 1866, (G. O. C. C. No. 104, of 12th October 1866,) being for the present held in abeyance, but authority is conveyed for the establishment under the Barrack Department being augmented to Rupees 180 per mensem, if found to be absolutely necessary.

27. No. 389 of 11th March, contains copies of letters from the Under-Secretary to the Government of India, dated 14th June 1866, No. 1,853, to the Secretary to Government, Fort Saint George, and from the Sanitary Commissioner for Bengal, No. 299 of 15th May 1866. In the former the Government of India request to be informed, " whether in respect to all the Provinces of the Madras Presidency, the system of dry earth sewage has been thoroughly established, and whether it is really a great public benefit."

28. The Sanitary Commissioner for Bengal in his letter contrasts the system of conservancy introduced by Dr. Hathaway with the new 'earth system,' and, after explaining the points of difference in the two systems, at length sums up as follows.

I. That Dr. Hathaway's system was a very excellent form of conservancy and a great advance on any former system which had been in force, but that,

II. It was altogether different from and inferior to the dry earth conservancy recommended by Mr. Moule.

29. In Proceedings No. 1,112 of 25th March 1867, the Barrack Master addresses the Controller of Military Accounts, soliciting an increase of Rupees 63-2-0 to the establishment for working the system, including the pugmill and female latrines at Vepery, and Rupees 10 per mensem for supervision of the Regimental arrangements in the Fort. The Governor in Council duly sanctions the expenditure "subject to revision hereafter."

30. The Proceedings next in order, No. 1,598 of 2nd May, are of importance, as containing a Memorandum from the Honorable Mr. Ellis, late Sanitary Commissioner, in which, after briefly alluding to the delays which had occurred in the introduction of the system, he proceeds to point out the delay that more especially marked the provision of pugmills, and after their supply, "the imperfect manner of their construction, and the negligence which had attended the carrying out of the conservancy system."

The correspondence on the subject of the pugmill, Mr. Ellis shews, extended from the 15th February 1866, to 15th February 1867, when the Superintending Engineer solicited sanction for the expenditure of Rupees 115 for the experimental pugmill, and 150 Rupees for a new one at the Vepery latrine.

31. On the 1st March 1867, the new privy was opened in the Fort, but the pugmill was found to be faulty, being pronounced too large and cumbersome, and not in accordance with the plan submitted to the Sanitary Commissioner by the Superintending Engineer. The faults of construction are minutely entered into, and it is remarked that not only does the Fort pugmill differ in point of capacity and construction from the standard pugmill at the Military Male Orphan Asylum, but Mr. Ellis adds, "I have, from personal examination, satisfied myself that in details of management there is great negligence."

The working of the mill is contrasted with that at the Male Asylum, and it is shewn that in the Fort the "excreta were simply emptied into the pugmill and there allowed to remain decomposing until the earth is added just before the milling process is commenced;" owing to this it was found that when the valve at the bottom was opened it "gave exit to a quantity of offensive ammoniacal gas and then watery and most offensive poudrette."

The Memorandum concludes with the remark that, "judged by the working of the system at the Military Male Orphan Asylum it is an entire success, while judged by the experiments in the Fort it would be necessary to state that the system is a failure."

This Memorandum is made the subject of a letter from the Barrack Master, under date the 27th March, in which he states that every care was taken to explain the system to the attendants, and certain "rules prescribed as a guide in carrying out the method." These rules are given *in extenso*, and certainly if they had been attended to, results such as those witnessed and reported by the Honorable Mr. Ellis could not have attended the working of the mill.

32. The Barrack Master further brings to notice defects in the construction of the privies in relation to the dry earth system, and want of ventilation in them. He notices also that it is not possible to make the soldier assist in the working of the system, as the boys in the Male Asylum had been trained to do by Mr. Gover.

The mills are pronounced to be "far too large and expensive." The Barrack Master concludes by submitting, "that negligence cannot be imputed to his Department." The Government in their order thereon admit that the Barrack Master has done his best, under the circumstances, to carry out the experiment, and the better ventilation of the privies is ordered.

33. The Proceedings No. 1,375, of 6th May, in the Department of Public Works, contain replies from the Executive Engineer of No. 1, or Northern Range, to the Memorandum by the Honorable Mr. Ellis, in which it is asserted that the pugmill was made in strict accordance with the plan approved by the Sanitary Commissioner. In a Memorandum attached, the Executive Engineer answers in detail the statements advanced by Mr. Ellis.

I do not dwell upon this matter. It is evident that much misconception and misunderstanding existed in regard to the pugmill, which was built upon a certain approved plan, but this design did not appear to have been intended as a 'working' plan, but merely as a general indication of the kind of mill required.

This is the view the Government appear to have taken of the question in their order thereon, which, while regretting the misunderstanding in regard to the construction and management of the mill, and the great loss of time in carrying out the experimental measures ordered, express the hope "that the steps which have now been taken by the Superintending Engineer will result in an early determination of the question of,

whether the system can be successfully brought into operation throughout the Presidency."

34. On the 21st May 1867, Proceedings in the Public Works Department, No. 1,454, of 14th diem, were communicated in the Judicial Department by Order No. 827. These Proceedings contain an extract from a report by Dr. Mouat on dry earth conservancy in the Jails of the Lower Provinces of the Bengal Presidency for 1864-65.

Dr. Mouat remarks that the introduction of the system "has led to a remarkable change in the condition of such extremely unhealthy Jails as Monghyr and Gya, and that it is without exception the greatest public benefit conferred by a private individual in a matter so essential to public health that I am acquainted with."

Alluding to Dr. Hathaway's system he remarks, "I entertain little doubt that the burying of large quantities of dried ordure, mixed with sand, in the garden of the Central Jail at Lahore, has been the chief cause of the great sickness that has since prevailed in that prison."

35. The essential condition of success in Mr. Moule's system is affirmed to be "that all ordure should be thoroughly deodorized before it is buried, *when it can no longer undergo putrefactive fermentation, or disengage any of those noxious gases which are perceptible to the senses and injurious to the health of those exposed to their influence.*"

This deodorization, Dr. Mouat proceeds to say, "*appears to be only completely effected by garden soil, containing a certain quantity of organic matter, and is not produced by sand, clay, or any ordinary earth.*"

I have italicised both these passages as having a most important bearing upon the system, and which will be further discussed presently. Dr. Mouat then acknowledges his indebtedness to Major Baird and Dr. Thompson "for the excellent plans and models of self-acting earth closets, cheap in construction, simple in arrangement, adapted to the habits of Natives as well as of Europeans, and suited for use in India."

In conclusion, "a series of experiments, to determine the length of time necessary to completely deodorize ordure in the damp climate of Bengal, so as to admit of its being stored or buried without risk of subsequent putrefactive fermentation," are alluded to, but which had not been brought to a conclusion at the time he wrote. This report has not, that I am aware of, been forwarded to this Presidency, at any rate it does not form a portion of the records of my office. The subject is undoubtedly one of very great importance as bearing upon the danger or otherwise of burying masses of mixed earth and ordure (or the "mill stuff") in the neighbourhood of Barracks, Hospitals, and Towns, upon which opinion at present varies widely. .

36. On the 16th May 1867, an official Memorandum, in the Judicial Department, No. 143, was received from the Under Secretary to Government, requesting, with reference to Proceedings of Government of 11th of March, "that the Sanitary Commissioner will be good enough to submit, with as little delay as possible, the report of Mr. Moule's dry earth sewage system, as it is required for immediate submission to the Government of India, who have called for it by telegraph." To this the Honorable Mr. Ellis replied on the 22nd idem, by letter No. 125, to the address of the Chief Secretary to Government, that in the Proceedings to which he was referred, no report was called for, and that he was not even then in a position to furnish the information. Mr. Ellis then proceeds to note the action taken in the matter, both in regard to European and Native Regiments, and remarks, "that there has not been sufficient trial to enable exact details of results to be furnished."

It was, however, represented generally that the results, as shewn in the Vepery Lines, had been most satisfactory; that no serious difficulty had been experienced by the Regimental authorities in enforcing the system which was very much liked by the Sepoys themselves; reference is made to the Proceedings of Government of the 2nd and 6th of May in the Military and Public Works Departments, for information as to the causes of delay in the introduction of the complete system, and it is remarked that no information had been received of the result of the experiment at Secunderabad.

The opinion was also expressed that "it is no exaggeration to say that wherever large numbers *under control* are congregated, Mr. Moule's system of conservancy has been entirely successful, and that it is so far a great public benefit."

The objection to the system was represented to be the great cost of procuring earth for daily use, and of its removal; and preference was expressed on the score of economy to water conservancy by sewers whenever water supply is available.

The opinion was also offered that sewage thus diluted by water has probably more fertilizing properties than the excreta mixed with dry earth and known as poudrette; but it is added, "as in many stations in India a good system of drainage and water supply are both deficient, Mr. Moule's system of dry earth sewage is the best means available for our Barracks, Hospitals, Jails, and other public Institutions."

38. The next document is an order in the Judicial Department, No. 1,105, of 11th July 1867, communicating Circular No. 50, from the Government of India, dated Simla, 10th June 1867, in the Public Works Department, with copy of a letter from the Sanitary Commissioner for

Bengal, reviewing Dr. Mouat's report, and the plan of latrine recommended by him for Jails, which is considered "more elaborate than desirable." A simple shed, provided with earthen-ware pans, the Commissioner pronounces an admirable arrangement for prisoners, and all such contrivances as 'scuttles for earth,' 'urinal boxes on wheels,' &c., unnecessary. He consequently condemns the introduction of costly latrines into Jails. He also disputes Dr. Mouat's opinion that the 'burying of sewage in Jail gardens is a dangerous proceeding,' and 'that the burial of masses of ordure and sand in the garden of the 'Central Jail at Lahore was the chief cause of the great sickness that 'prevailed there.'

Sewage, the Sanitary Commissioner remarks, "is now buried, I may say, in all the Jail gardens of the North-West Provinces and the Punjab," and so long as it is buried in such a way as to act as manure, he considers that it could not be disposed of in a better or a safer manner. The sickness which prevailed in the Lahore Jail, it is contended, was in no way due to the disposal of sewage within the premises, and anxiety is expressed that "the circulation of his (Dr. Mouat's) opinion by the Government of India should not interfere with the excellent conservancy arrangements that are now generally carried out in the Jails of Upper India."

39. This document is followed up by an extract from the Proceedings of the Sanitary Commissioner for Bengal for the month of August 1867, communicated in Proceedings of this Government under date 14th November, in which the disposal of sewage is again considered. In this document it is advanced that the night soil, removed from Barracks and buried in deep pits, takes a long time to decompose and become resolved into its ultimate elements, and that "during the very long period taken up by this process noxious gases may be evolved through any cracks in the soil, or organic matters may become infiltrated into the water supply; but that apart from these possible sources of danger, it cannot be denied that this mode of disposal of sewage is far from being intelligent."

The great difficulty of finding a market for the sewage is then commented upon, and the desirability of making the cultivators acquainted with its great value as a fertilizer of the soil. To this end the establishment of model farms in the outskirts of every cantonment is suggested for the utilization of the sewage of Barracks and Hospitals.

40. The records close with a Docket Memorandum, No. 1,445, from the Quarter Master General, of 27th September 1867, forwarding a letter, No. 1,330, of 7th idem, from the Barrack Master, Fort St.

George, covering a report on the six months' experimental conservancy in the privies in use with the European Troops in Garrison, and conveying the opinion "that as a means of conservancy earth is undoubtedly efficacious in temporarily shutting in emanations and thus preserving the interior of privies free from unpleasantness," but that in this respect it is in no way more effectual than the system introduced by Dr. Hathaway. The Barrack Master condemns the pugmill, inasmuch as that the incorporation fails, he asserts, to effect deodorization of the mixed soil, and recommends that "the opinion of a scientific Chemist may be taken as to what changes may take place during the process, and whether ultimate decay of the milled matter is at all accelerated."

41. Colonel Worster's Report will be found appended, as well as a commentary upon it prepared at my request by Mr. Gover, to both of which I shall have occasion to allude hereafter.

I have now made a careful and, I think, fair resumé of all that has come before Government in regard to the very important question of dry earth conservancy, and proceed to discuss the subject in its more important details, which may now be considered to be nearly exhausted, materials existing for the determination and satisfactory solution of most of the questions that have arisen out of the original inquiry. This was first limited to the properties of dry earth as a deodorizer of excrementitious matters, and its capability of rendering them so inoffensive and innocuous by the arrest of decomposition as to admit of their retention in our dwellings, latrines, and night-closets, till such time as removal could be effected without the "*ad interim*" pollution of the atmosphere by the liberation of the gaseous products of decomposition.

42. That dry earth has this power has been established by a mass of evidence that is incontrovertible, and it may, I think, be safely alleged that few questions that have been made the subject of inquiry have been set at rest so satisfactorily, and with so little conflicting testimony as the one under consideration. But other questions have been engrafted upon the original one, most of them of great importance on financial grounds, that is, as affecting the cost of introduction of the system. The principal of these may be stated as follows :—

A. What is the *quantity* of earth required to deodorize *(a)* an average evacuation of an adult (that is, the mixture of fœces and urine passed into a latrine tub or similar vessel), and *(b)* the additional average quantity of urine of twenty-four hours in excess of that voided during defecation.

B. What *quality* of earth is best suited to the object in view.

C. What apparatus and appliances are necessary to the efficient

working of the system, *(a)* in the latrines *(b)* to the incorporation of the mass of earth and ordure, so as to effect its removal without nuisance.

D. What additional establishment is necessary *(a)* to bring, prepare, and store the earth, and *(b)* to remove the same after use in the latrines and urinals.

E. The disposal of the mass of earth and soil (poudrette, as it has been called,) in regard to the *(a)* sanitary and *(b)* financial aspect of the question.

F. The difficulties in the way of the introduction of the system generally into Barracks, Hospitals, and Public Institutions, and the objections which have been raised to it.

G. The cost of working the system in comparison with that before in operation, the "dry surface" system of Dr. Hathaway.

43. These several questions will be answered so far as the data at my disposal may admit of. *I.—Does dry earth possess the efficient deodorant properties claimed for it by the Reverend Mr. Moule?*

That gentleman invests it with the following properties:—"It at once stops emission of offensive smell, it prevents fermentation, and these results are so complete and lasting, that either the same day or after a week, or even a longer period the mass of soil and earth can be removed from the room and the premises without offence."

The records already epitomised endorse the opinion expressed above. I purpose to advance the more important and most reliable testimony only. The "Prison Committee, assembled at Calcutta in 1864, composed of a body of observers whose testimony is unimpeachable, write in their Memorandum, dated 29th March 1864,"* "The Committee having personally tested the extraordinary efficacy of dry earth as a deodorizer when sprinkled or sifted over either fœcal or urinous matter, beg to recommend its universal adoption."

* Proceedings of Government, No. 1,376, of 10th April 1865.

44. In December 1865, the Secretary to the Government of India, in the Military Department, in his letter, No. 1,326, dated 30th November, to the address of the Quarter Master General, distinctly states that the Right Honorable the Governor General and His Excellency the Commander-in-Chief, are perfectly in accord as to the superiority of "the dry earth system of sewage."

In a very recent document, Proceedings of the Sanitary Commissioner for Bengal for August 1867, the Sanitary Commissioner writes,

"Its practical value has been fully established, and its claim to be considered the best form of conservancy yet adopted in this country has been almost universally acknowledged."

The President of the late Sanitary Commission of this Presidency, in his report, dated 12th December 1864, assures the Government that he is "now satisfied that it possesses a marked superiority over all other means of conservancy generally available in India." In a subsequent report, dated 22nd May 1867, the Honorable Mr. Ellis offers the following additional testimony advanced, it must be remembered, after a most careful consideration and analysis of evidence from every quarter, and upon large personal experience of the working of the system, "It is therefore no exaggeration to say that wherever large number of persons *under control* are congregated, Mr. Moule's system has been entirely successful, and that so far it is a great public benefit."

45. Mr. Frederick C. Krepp, in his recent work, "The Sewage Question," which is an exhaustive review of all the known systems and methods of sewage, admits that "the capacity of loose earth to absorb and deodorize fœcal matters is well known; there being, perhaps, no better solvent to take up the ammonia and other gases evolved, and to unite in one highly fertilizing compost what before were two or three most offensive and useless substances."

It appears scarcely necessary to adduce any further testimony; but it may be noted that all Military, Medical, and other Officers who have given any attention to the subject are unanimous in asserting that the power of dry earth, to arrest or render dormant those changes in excrementitious matters which cause offensiveness, is absolute.

46. The only opinion which has been expressed, adverse to the general view, is that recorded by Surgeon Major Ross, of the Bengal Army,* in which he gained the support of the Inspector General of Hospitals, Her Majesty's British Service, who writes, "the new system does not appear to have sufficient advantage over the old to make it advisable that Government should incur extra expense in carrying it out."

* Proceedings of Madras Government and Order No. 187, of 29th January 1866.

This objection, however, rests upon financial grounds, and which the President of the Sanitary Commission, Mr. Strachey, disposed of by observing that the old system, so far as the latrines were concerned, was just as costly as the new, inasmuch as that an equal quantity of *water* was, under the former system, used in the pans and in their cleansing as

of *earth* under the latter. He framed the following table in support of this statement :—

Old system.	lbs.	oz.	New or "dry earth" system.	lbs.	oz.
Solid feculence	0	5	....	0	5
Urine...	0	11	....	0	11
Water used in pans and cleaning. ...	3	2	Earth used	3	0
Total...	4	2	Total...	4	0

and added this commentary, "the advantage in the latrines is, therefore, in favor of the dry earth system as regards the very point on which exception has been taken to it."

But even Dr. Ross, although opposed to the general introduction of the system, allows, in regard to the value of dry earth as a deodorizer, "that there can be no doubt of the perfect success of the earth system."

I am justified, therefore, in saying that the deodorizing power of dry earth, so far as relates to its capability of delaying putrefactive changes in excrementitious matters, and thus rendering their detention in our dwellings, till such time as it may be convenient to remove them, possible, is established beyond doubt or question.

47. *II.—What is the quantity of dry earth necessary to the deodorization* (a) *of an ordinary dejection (assumed to consist of* 5 *oz. of solid and* 11 *oz. of fluid feculence), and* (b) *the average quantity of urine passed by each individual in twenty-four hours in excess of that voided under the first conditions.* ?

Perfect accord is not obtained upon those points ; observers vary in their estimates in accordance with the kind of earth used. In regard to the first condition the Reverend Mr. Moule fixes the unit at 2·5 pounds, and this amount has a general agreement with conclusions arrived at by other observers. Colonel Worster, for instance, in his recent report (Appendix A.) writes, that "the former quantity (2·5 pounds) or even less, though practically it is expedient to apply that unit, has been found fully effective for internal conservancy," that is for deodorization of the excreta, solid and fluid, in the privy pans.

Surgeon Major Ross, in Proceedings already quoted, No. 387, of 24th January 1866, fixes the units at three pounds, and Mr. Gover, in his report (Appendix B.) adopts Mr. Moule's original unit or pounds 2·5. Dr. Blacklock on the other hand, who instituted a series of experiments at the General Hospital, detailed in Proceedings of Government,

No. 1,376, of 10th April 1865, adopted a much higher standard, claiming as much as seventeen pounds for the European.

This estimate, however, involved the deodorization of the whole excreta, that is, of the contents of the urinals, as well as those of the latrine pans; and further, the calculation referred to men in hospital who might naturally be expected to resort to latrines more frequently than men in health. Further, there was no separate urinals, and the latrine pans received all excreta, fluid and solid.

The necessity for the use of so large a quantity was not, however, shared by the Sub-Committee, composed of Dr. Macfarlane and my present Secretary Dr. Montgomery, who expressed an opinion in their report, dated 31st August 1864, in the following words: "We hope that further experiment will demonstrate that a lower rate per man will suffice when the hospital is finished." But Dr. Blacklock, upon further trial with an earth better adapted to the purpose, modified his opinion, and reduced the quantity to seven pounds for the European, and 2·5 for the Native.

48. It may be here incidentally remarked that Dr. Blacklock's allegation, that the European passes a greater weight both of solid and fluid excreta than the Native, has not been corroborated by more recent observers; indeed, it has quite recently been asserted by Dr. Fawcus, as the result of experiments carried out at the Jail at Alipore, that the solid excreta of Natives are more bulky and more weighty than those of the Europeans. From all that has been written on the subject, 2·5 pounds may be accepted as the weight of earth necessary to deodorize and maintain in a state of inoffensiveness the solid and fluid dejecta of a healthy adult as ordinarily passed into a privy pan or tub of moderate sectional area. Colonel Worster has satisfactorily shewn that the sectional area of the vessels used materially influences the amount of earth required to fully cover each evacuation, and consequently, to ensure uniformity of action, the vessels should theoretically be cylindrical, or at any rate should have such a mean sectional area as will allow of 2·5 pounds being adopted as the unit.

49. It remains to determine *the weight of earth required to deodorize the average quantity of urine passed by each individual in excess of that voided with each fæcal dejection.*

Surgeon Major Ross's experiments, already alluded to, are the most reliable on this head. He calculates that two and a quarter pounds will be required for each use of the urinal, and allows three such uses in the twenty-four hours. The aggregate amount of urine passed on these several occasions he estimates at thirty fluid ounces or one and a half pounds (volume and weight may be accepted as convertible terms) per

head per diem. This is equivalent to thirty-six pounds of earth to each gallon of urine.

From experiments I myself instituted some years ago, I should have fixed a higher figure, and Dr. Blacklock found that five and a half pounds of earth absorbed one pound of urine or water, or in the proportion of forty-four pounds to the gallon.* But accepting Dr. Ross's lower unit as a fair average one, we still have the very large quantity of thirty-six pounds to each gallon of urine.

Estimating the amount of urine as above at one and a half pints or pounds per man per diem, we obtain for 1,000 men 68437·5 gallons per annum, which multiplied by thirty-six pounds the quantity of earth to the deodorization of each gallon, raises the amount to 2,463,750 pounds or rather over 1,099 tons !

No other reliable experiments upon this point have been made, for in Colonel Worster's recent report it is shewn that the amount of urine voided during the night was not taken into calculation, the contents of the urinals being thrown into the sea.

The results of the trial of the system in the 2-21st Fusiliers at Secunderabad have not yet been communicated, so that the data for a final settlement of this question are still imperfect. The amount of earth required, however, even under the lowest estimate is so large, as to be almost, if not entirely, prohibitive : unless by a process of desiccation the earth can be used, as it has been proved it can be, over and over again.

50. *What quality or kind of earth is best suited to the purpose?*

Dr. Blacklock has shewn that clay has larger deodorizing properties than loam, and this has been corroborated by other observers. Dr. Fawcus of Bengal has further proved by a series of carefully conducted experiments, which are detailed in the Proceedings of this Government, No. 2,205, of 28th June 1866, that those earths which are the richest in organic matter possess the highest deodorizing powers.

The Reverend Mr. Moule advanced that the mixture of earth and ordure could be used over and over again even to the tenth time without loss of deodorant properties, but it would appear by Dr. Fawcus's experiments, that the deodorizing powers are thereby actually enhanced. This appears to be a "*reductio ad absurdum.*" It is, however, shewn, that soil which had been selected from a pit in which ordure had been twice buried within a period of six months, yielded better results than ordinary fresh earth. Should this be substantiated by further experiment, one of the difficulties in the way of working the system, viz., the

* Pure clays have higher absorbent power, two pounds being capable of absorbing one pound of water (or urine ?)

provision of earth will be met, since old pits, after a given period of rest, can be re-opened and the mould again used.

At any rate, a careful selection of earth has an important bearing upon the financial aspect of the question, for, as Dr. Blacklock has shewn, seven pounds of clay have the same deodorizing power as seventeen pounds of the ordinary sandy loam procurable at Madras. And this selection, when the enormous quantity of earth required in the urinals is considered, it becomes necessary to press upon the attention of the authorities engaged in the conservancy of Regiments and Public Institutions. In relation also to the economy of provision of earth, further experiments are necessary, as to the practicability of using the contents of the poudrette pits a second or any further number of times.

These experiments should be designed to determine the length of time that it takes under varying conditions of soil, moisture, and season of the year to effect those changes in the buried mass which result in a rich mould in which all decomposition of organic matter has ceased, thereby rendering it fit for re-use in the latrines. Dr. Mouat of Bengal instituted a series of experiments to this end, but the results have not been communicated to this Government.

Practically, in the present aspect of the question, the enormous quantity of earth required to deodorize the fluid excreta, renders its use in urinals almost prohibitive, especially in Presidency towns where difficulty is experienced, owing to the great distances from which the earth has to be brought in obtaining a supply. This subject will be again alluded to under the head of cost of working the system.

51. *What apparatus and appliances are necessary to the efficient working of the system* (a) *in the latrines and urinals* (b) *to the incorporation of the mass of earth and ordure so as to effect its removal without nuisance?*

The state of *dryness* and *mechanical division* of the earth have important bearings upon this question. Perfect dryness is not practically attainable except under the operation of artificial heat, and this absolute state of dryness is not necessary, for so long as the earth is not *wet*, its deodorizing powers are not materially affected. Doubtless the hygrometric condition of the atmosphere has some deteriorating influence, but practically this may be left out of the question, as all that is really necessary is to procure the earth as dry as possible, and to store it in any ordinary roofed-in building so that rain cannot get access to it.

It is scarcely necessary to take into account the provision of implements required to dig the earth, since they form part of the equipment of every Regiment and Public Institution; though undoubtedly some

additional expense is incurred under this head, in the 'wear and tear' of existing implements, and the provision of additional ones. But *mechanical division* of the earth, by its reduction to a fine powder, has been proved to favor its action, and hence the necessity has arisen for the provision of sieves or screens to separate the finer particles. The precise state of division to which it is necessary to reduce the earth has not been accurately determined.

52. Mr. Gover, in his remarks upon Colonel Worster's report (Appendix B) states that fine division is not necessary, and that sieves with meshes of one inch square will answer all purposes. He lays considerable stress upon this point in relation to the necessity of "freeing the process of preparation of all unnecessary refinements."

But at the same time it will be remarked that he qualifies this opinion by an expression with which he advances it that "anything under an inch in diameter will answer very well, provided, as always happens, that there is a considerable proportion of fine soil." An extension of this argument clearly means that the *more* fine soil the better, and that if *all* was fine less would be required to attain the desired end.

Mr. Gover does not consider mallets and sieves at all necessary, and does not employ them. He uses the earth as he takes it from the ground, merely breaking the larger clods with the spade or 'mahmotty,' and finds that by the time it is required for use in the latrines it has acquired a sufficiently fine state of division.

Personally I have no experience in the use of the sieve. I have not found it necessary when a suitable soil is selected, but with Mr. Gover have considered that the earth can be reduced to a sufficiently fine powder without its aid. For supply of "self-acting closets," to be presently alluded to, it will, however, be undoubtedly necessary to use the earth in a fine state of division, and hence sieves will be necessary.

Provision of appliances—"Pug-mill."

53. But further appliances, and those of a more costly nature are necessary, or have been considered so in this Presidency, though no mention is made of them in Bengal or Bombay; I allude to "*Pugmills*" as a means of incorporation of the mass of earth and ordure.

There are two sets of published experiments from which to judge of the necessity for machinery of this nature, and of its efficacy as a means of incorporating the mass so as to render it inoffensive, and thus to put it into the condition most suitable for its removal. I allude to those undertaken by Colonel Worster in the Fort, and those by Mr. Gover at the Military Male Orphan Asylum, both of whose detailed reports will be found appended. Judged by Colonel Worster's report, the

mill must be pronounced an absolute failure ; estimated by Mr. Gover's testimony, a most undoubted success ; and this not only upon the grounds of efficiency in the admixture of the material, but (*quoad* the Male Orphan Asylum) as actually saving of labor and expense.

It must be admitted that incorporation of the mixed masses of earth and feculence before removal if not actually necessary to the maintenance of purity by the arrest of decomposition and to the removal of the soil without offensiveness, is highly advisable.

It must be equally admitted that due admixture cannot be effected in the privy pans themselves, and consequently that some machinery is necessary, and the pugmill is supposed to answer the object in view.

54. The mill first erected at the Fort, which was said to have been designed upon a plan approved of by the then Sanitary Commissioner, cost Rupees 150, and failed to work well. It was too large and cumbersome, and entailed heavy labor. The Sanitary Commissioner, however, has denied that the mill was at all in accordance with his plan. The fact would appear to be, that the plan was accepted as a 'working' plan, when it was only intended to indicate generally the character of mill required. But at any rate it was found not to answer the purpose. It had a capacity of 40 cubic feet, could only be worked from stages 4½ feet from the ground, required four men to work it, the time occupied being from ¾ to 1¾ of an hour.

It was consequently replaced (on the 26th April and 7th of May 1867) by two others of a smaller and more convenient size, having a capacity of 12 cubic feet, and capable of being worked in from 20 to 25 minutes.

55. In regard to the efficacy of these mills in effecting those changes in the incorporated mass necessary to its removal without offensiveness, Colonel Worster writes, "that no great change is effected by the incorporation is evident by the fact that however *comparatively inoffensive the mass may be when discharged from the mill,* such inoffensiveness is but temporary, the fœcal odour soon returns more quickly in damp than in dry weather;" and again, "In all cases, even when the mill-stuff has become perfectly dry and then inoffensive, the elements of decomposition are merely dormant and need only the application of water to restore them to noxious activity."

The italicised passage above is an admission that the mill-stuff when discharged from the mill is comparatively inoffensive, and this is the end the mill is supposed to bring about. It is not, I conceive, advanced even by the most enthusiastic advocates of the mill that absolute inoffensive-

ness is attainable. Mr. Gover, for instance, does not claim this power for the mill, but only that the incorporation of the mass renders it so far inoffensive that it can be kept and removed without any noxious emanations.

56. But, further on in his report, Colonel Worster denies to the milling process even this advantage of bringing about comparative inoffensiveness, for he proceeds to say "that during the process gases are liberated in a most offensive form," and this he considers so great an objection that he even questions whether it is "consistent with principle that * * * even menial attendants should be subjected to such concentrated exhalations when the result of their labor is utterly nullified by the incorporated matter being deposited amongst the reeking refuse of the town."

There is no mistaking this language; it certainly means that the milling process is attended by extrication of such deleterious gases that it is cruel to expose the attendants to their influence; and that seeing that after use the stuff is buried, it might as well be carried away direct from the latrines and deposited out of sight, without the intervention of the milling process. In fact the words convey a most sweeping condemnation of the utility of the 'mill.'

57. But testimony of a diametrically opposite nature is given by Mr. Gover, of the Military Male Orphan Asylum (see Appendix B.) in his Commentary on Colonel Worster's report.

Mr. Gover admits that milling is laborious, while the operation continues, but adds "that with suitable mills properly worked a quarter of an hour is amply sufficient to ensure complete mixture." He shews also that even accepting Colonel Worster's statement that three operations daily of 20 minutes' duration are necessary, that the labour only occupies one hour in the 24. But as regards the most important objection raised by Colonel Worster, that the mill fails utterly and entirely to render the mass inoffensive, Mr. Gover writes, "that the result of his experience does not in any way corroborate it."

He does not contend for absolute absence of smell, but affirms that it is not great, and that a suitable cover would prevent even that; and he appeals for corroboration of his statement to the Honorable Mr. Ellis, the late Dr. Macpherson, my present Secretary Dr. Montgomery, and Dr. Smith, all of whom have been present at the milling process. As for the menial attendants, he writes, "they have not yet ceased wondering at the strange exemption from the many former disadvantages of their profession."

58. The very different conclusions arrived at are due to the different treatment that the contents of the privy tubs are subjected to

before being passed through the mill. The Honorable Mr. Ellis, in his Memorandum dated 22nd March 1867, published in Proceedings of Government of the 6th May, writes, "In the Military Male Orphan Asylum, where the conservancy is admirably conducted, the excreta are covered with earth immediately upon being passed into the latrine vessels, and, if required, an additional quantity of earth is added before these vessels are emptied into the pugmill. * * * In the Fort, on the contrary, the excreta are simply emptied into the pugmill, and there allowed to remain decomposing until the earth is added just before the milling process is commenced." It is not difficult to understand, under the conditions just noted, that deleterious gases would be generated, and, indeed, Mr. Ellis adds that when the valve was opened "it gave exit to a quantity of offensive ammoniacal gas and most offensive poudrette," and on a subsequent occasion, "the exit of pure fœces and urine which had been emptied into the pugmill apparently without any earth."

59. Having personally acquainted myself with the process of milling as carried out at the Military Male Orphan Asylum, and witnessed the operation from first to last, I can testify to the utility of the process and the capability of the mill to place the mass under those conditions necessary to its incorporation not only without the extrication of any offensive gases, but I may certainly say, without any offensiveness whatever. I purposely visited the institution without previous notice. Mr. Gover was good enough to go through the whole process. I first visited the latrine, which was perfectly free from smell. The privy pans were then taken and arranged outside. The toty added to each a handful or two of earth, and then transferred the contents of the tubs one after another to the mill. I stood over the man the whole of this time, and was not conscious of any smell whatever. The milling process occupied a quarter of an hour, and when the valve was opened the mass welled out as a homogeneous moist 'magma' or paste quite free from any fœcal odour that could be detected at the distance of a yard from it, and I believe that the mass might have been conveyed in an open cart through the streets without any one being made conscious of its nature.

After the mill had been cleaned by a little dry earth being thrown into it, I looked into its mouth, and although, of course, there was some ill-odour, it was very slight, and was certainly not appreciable at a distance of even a foot from it. The ability then of the mill to perform all that is required of it was established to my entire satisfaction. It appeared also to be worked with comparative ease entailing certainly no amount of labour upon the two men who worked it and who relieved each other at intervals of every five minutes or so.

60. I am, therefore, satisfied that if the whole process, the preparation of the mass of earth and night-soil for the mill, and the milling itself, be properly performed in a suitable mill, the resulting mass is a nearly inodorous compound.

But to ensure this result it is necessary to pay every attention to each part of the process—the pans must have first of all a layer of earth to receive the excreta upon, additions of earth must be made to each contribution to the pans, and the whole be well mingled with such further addition of earth as may be necessary, before being transferred to the mill. The pans must be then scrubbed with a little dry earth, and a fresh charge of earth placed in them before being replaced in the privies. The mill after use must also be cleaned with a little fresh earth.

61. If these several steps are carefully and systematically taken the latrines will be free from any fœcal odour, the mill itself will be almost free from taint, and the poudrette can be taken away by a cart or barrow without a bystander being conscious of any offensive gaseous emanations. Efficient supervision, in fact, ensures all that is contemplated by the use of the mill, while neglect entails failure and needless expenditure.

Colonel Worster fully recognized the necessity for this methodical working of every part of the system, and laid down rules for each step of the process, which are found in Proceedings of Government, No. 1,598 of 2nd May 1867, but which were evidently not attended to in working the mill at the Fort.

62. In regard to the mill at the Male Orphan Asylum, Mr. Gover informed me that it was erected at a cost of 20 Rupees, and that it had been in use for a year without having been thrown out of use for more than a day at any one time, a matter of no moment as its capacity admitted of two days' accumulation of the contents of the privy pans.

Having witnessed the efficient working of the mill at the Male Asylum, I subsequently visited the Lines of the 2nd Regiment N. I. at Vepery to watch the process of milling by the mill erected in connection with the latrines of that Regiment. The process was a lamentable failure, owing to causes which will be presently explained. The mill being charged with the earth and ordure removed from the latrine, four men proceeded to work it, and with extreme labor managed to make a few revolutions; two women then gave their aid (six people in all) and after violent and almost ineffectual efforts one of the blades of the mill broke.

The door being opened the mixture of earth and excrement was a hard mass, which had to be picked out with an iron implement, instead as in the Asylum mill of welling out as a soft tenacious pasty mass. The cause of failure was manifestly the too large proportion of earth. The

latrines are on the 'trench-system.' The trenches appeared to be simply filled or nearly so with earth not supplied in any relative proportion to the excrement voided into them; consequently, instead of the two and a half or three pounds which have been proved to be necessary not only to deodorization butto the formation of a compost of such consistence as can be easily worked by the mill, there was so great a preponderance of earth that the resistance offered was insurmountable. It is necessary, in fact, to the success of the mill that the proportion of earth should be reduced to the minimum consistent with the primary object of deodorization.

63. But further the construction of the mill is faulty. Mr. Gover, who, owing to the failure above alluded to, was good enough to inspect it, states that there is an error in construction, the spokes being inserted into the spindle *square* instead of *diagonally* as had been ordered; and that as they were nearly three inches broad, the resistance was very great, requiring enormous power to overcome it, as the blades, owing to their square form, instead of passing through the compost as a wedge, carried a mass before them, or in Mr. Gover's words, "carried round and round a belt of matter their own width."

The mill then was not only faulty in construction, but the mass of earth and excrement put into it was not of a proper consistence; did not contain those relative proportions of earth and ordure which have been proved necessary to that intimate admixture to be effected by the mill. The failure then is not to be laid at the door of the "Pugmill," as a machine designed for a specific purpose and which it is capable of meeting if all conditions necessary to its success are attended to, but to faulty construction, and inattention to the details of working.

But although a properly constructed mill is undoubtedly capable of performing all that is required of it under certain relative proportions of 'earth and excrement,' and is eminently adapted for use in the latrines of British Regiments or Institutions where the excreta are received into pans or tubs, and treated with a regulated quantity of earth, I do not think it is applicable to Native latrines upon the trench principle in which it is difficult, if not actually impossible, to regulate the amount of earth in relation to that of excrement passed into the trenches which it is so necessary to maintain.

64. The difficulty which has been experienced in Regimental latrines of making the soldier apply earth to his dejecta after rising from the seat, and the necessity consequently of employing extra attendants to do this for him; the unfitness also of many existing latrines, owing to the smallness of the arches and thickness of the walls, and consequent impossibility of applying the earth from the rear, have led to the necessity of designing some self-acting apparatus.

65. Appliances of this nature were sanctioned by the Government in their Proceedings, No. 2,629 of 15th July 1865, and were introduced into the family quarters in Fort Saint George.

Earth closets.

In Proceedings of 2nd May 1867, No. 1,598, allusion is made to these mechanical "shoots which twice fell out of order," and Colonel Worster, in his final report (Appendix A, paragraph 24,) notes "in the new division of the family privy, twelve machines were furnished for the delivery of the earth, but from faulty construction of the shoots, have been and still are perfectly useless." Mr. Gover in his "remarks upon Colonel Worster's report," alluding to self-acting appliances says, "the machines that have been tried had failed, and at present one or more toties have always to be present in each latrine to apply the earth." Up to the present time, therefore, these self-acting appliances have entirely failed, and I have no record of any better success having attended their introduction in other Presidencies.

66. Mr. Gover, however, "after many trials has now completed a machine which, so far as used at the Asylum, is said to succeed admirably." This machine I have inspected, and it certainly appears to work freely and satisfactorily. It is, perhaps, rather clumsy looking; but this, considering the use for which it is designed, employment in Regimental privies, when any more refined piece of apparatus would speedily be thrown out of order, is, perhaps, a recommendation.

The machine consists of a hopper put in motion by a set of strong iron levers attached to the seat, the depression of which by the weight of the person using it, tilts the mouth of the hopper backwards to receive a charge of earth from a reservoir above it. On the individual again rising, the hopper falls back into its first position delivering its charge of two and a half pounds of earth through a shoot into the vessel beneath.

The cost of the machine will not, Mr. Gover states, exceed Rs. 12. He has prepared a model in wood for the requisite 'castings' of the iron work. Plans and drawings with a specification and a brief description by Mr. Gover, will be found in Appendix D.

I am disposed to think that the elevation of the seat above the floor of the privy may be lessened, thus saving a good deal of masonry work. Mr. Gover, however, lays stress upon it as necessary to the easy removal of the buckets by the toty; but the act of stooping is not one of fatigue to a native, who would just as readily remove a pan on a level with the floor as one at some elevation.

67. The provision of dry earth and removal of the incorporated mass of earth and ordure affects importantly the financial aspect of the system. Various

Cost of provision of earth.

estimates have been framed of the quantity of earth required, and of '*poudrette*' to be removed, and consequently equally dissonant estimates of the cost of provision of transport. Colonel Worster's estimate is 560 tons per annum for the latrines, and 83½ tons for the urinals, or in all 643½ tons per annum for 1,000 men; but as before noted a portion only of the urine was treated upon the dry earth system under his experiments.

Dr. Ross on the other hand, whose investigations have been before alluded to, estimates that nine and three-quarter pounds per man, if all the urine in the urinals be also deodorized, will be required. This raises the amount required to be supplied for 1,000 men to something like 1,588 tons per annum, while the mixed earth and ordure to be removed will amount to 1,995 or say 2,000 tons! This is undoubtedly an enormous mass of soiled earth to transport to the place of deposit.

I have elsewhere shewn upon the authority of the Sanitary Commissioner for Bengal that, as relates to the latrines, the earth required scarcely more than replaces the water used under the old system. But the amount of earth required for the urinals is so large as practically to amount to a prohibition to its use, and it is certainly most desirable to find some process which may render it possible to dispense with the use of earth as a deodorant for the fluid excreta.

68. The President of the Sanitary Commission for Bengal, in his report published in Proceedings of this Government, No. 387 of 29th January 1866, recommends that the contents of the urinals be carted away as before; efforts being made by extreme cleanliness and frequent emptying of the vessels to prevent putrefactive changes before removal. But this it is feared is hopeless, and it therefore becomes necessary to look about for some deodorizing compound which will prevent decomposition, and add but little to bulk and consequent cost of removal. I believe that the use of carbolic acid will meet these desiderata. It is well known that if the acidity of the urine can be maintained, decomposition will not ensue. Carbolic acid possesses not only the chemical property of an acid, but special and specific powers of arrest of those changes which constitute decomposition, and is well worthy of trial in Regimental urinals. The quantity required to effect the desired object must be a matter of experiment; that once determined, the cost can easily be arrived at.

69. Experiments have already been performed with "*McDougall's Disinfecting Powder*," which contains carbolic acid in association with sulphurous acid, lime, and magnesia, and the results were very favorable. The experiments are detailed in Proceedings of the Bengal Sanitary Commissioner for August 1867.

Dr. Stewart Clarke states that six per cent.* is sufficient to deodorize and maintain in a state of freedom from ill-odour the solid and fluid excreta of latrines and urinals. Estimating the fluid excreta voided in the urinals at 30 fluid ounces or 1½ pints per man per diem, the total quantity for 1,000 men per annum is 547,500 pounds or pints. Six per cent. upon this amounts to 32,850 pounds, giving a grand total *to be removed* of 580,350 pounds. In the earth process the 547,500 pounds of urine would require, at 6¾ pounds of earth to every 30 ounces of urine, 2,463,750 pounds to effect the same deodorization, as is ensured by 32,850 pounds of the "disinfecting powder" and raises the amount to be removed, to no less than 3 011,250 pounds or 1,344 tons!

The cost-price of McDougall's powders is £10 per ton, so that the quantity required by the above estimate for every 1,000 men would have a value of 1,460 Rs., add to this 35 per cent. for freight, carriage, &c., the amount is raised to 1,971 Rs. per annum, or Rs. 164 per mensem. The cost of carriage for removal of the contents of the urinals would be scarcely affected, as the powder only adds six per cent. to bulk, and raises the total amount to be removed to about 1,590 pounds a day.

The earth process on the other hand raises the amount to be daily removed to 10,125 pounds, so that extra carriage to the extent of 8,535 pounds a day is saved. This, at 1,500 pounds† for a cart load, represents say 5·6 cart loads.

70. Assuming that this would necessitate the employment of three carts (each making two trips a day,) at a monthly hire of 22 Rupees, the sum represented is Rs. 66, and this may, perhaps, be accepted as the *additional* cost of dealing with the urine upon the "dry earth" system, while, as beforeremarked, the addition of the disinfecting powder is so small as not to necessitate any carriage in excess of that necessary to the removal of the urine itself. Further, the cost of provision of so much dry earth and its cartage *to* the urinals is done away with. I venture upon the following figures as an approximate estimate of the annual cost of working the two systems in a Regiment of 1,000 strong in urinals only.

		RS.
Cost of 32,850 pounds of McDougall's Disinfecting Powder		1,971
Cost of eight bandy-loads of earth, at 5 As. a load, for 365 days for urinals alone	912	1,704
Three additional carts to remove the mixture of earth and urine, at 22 Rupees per mensem ...	792	
Difference		267

* His figures are 2·4 oz. per man per diem, or fifteen pounds per 100 men—100 men, each pass 2·5 pounds or pints of excreta per diem (one pound five ounces solid and eleven fluid in latrines, and 1·5 pounds in urinals) then 250 : 100 :: 15 : 6.

† But unless carts specially designed for the purpose are provided and powerful cattle used, 1,000 pounds is a fair load. Carts usually furnished by contractors up-country will not carry 1,500 pounds.

If, therefore, McDougall's powder be equally effective as a deodorant in the urinals, and there is abundant evidence that it is so, it would prove cheaper than earth at the Presidency, where the cost of removal is much greater than in the above estimate. If liquid carbolic acid could be substituted it would probably be cheaper still; but this at present I have no data to determine.

71. I have said that there is abundant evidence to prove the efficacy of McDougall's powder as a deodorant. I now proceed to adduce testimony to this effect, and first I will quote from the annual report for 1866, by the Sanitary Commissioner for Bengal.

"Experiments have been conducted with McDougall's disinfecting powder in Fort William, and in the Alipore Jail in Bengal; in the Meerut and Banda prisons of the North-West Provinces; in the Calcutta General Hospital; in the Meerut College Hospital; in the latrines of the European Infantry Regiment at Meerut; in the stables of a Cavalry Regiment, and also in the slaughter-houses at the same station. The trial has thus been varied and complete, including different circumstances and climates." The result has been fully to maintain the high character of the powder as an immediate and thorough deodorizer of great power. The value in this respect has been fully and universally acknowledged, and it has been shewn that a quantity as small as one to two ounces per head is practically sufficient for all ordinary conservancy purposes, sufficient in fact to prevent all unpleasant odours until the sewage can be conveniently removed. Major Malleson adds, "for ordinary conservancy purposes however dry earth appears amply sufficient—it is generally to be had without difficulty, it costs nothing beyond carriage, * * for general use nothing more can be desired."

But then follows the very important exception that "in this Presidency, the only Military Cantonment in which earth is not readily procurable is Fort William, and here, McDougall's powder might with advantage be employed. Its use here has been found to be particularly successful, and the expense is less by Rupees 600 a year than was entailed by the use of lime."

I have elsewhere stated, however, that the Sanitary Commissioner for Bengal recommended the restriction of the use of earth to the latrines so that the expression above made use of, "for all ordinary purposes," applies, I believe, to latrines only, while it is in urinals that I suggest the use of this deodorizing powder, instead of dry earth for reasons already given.

But the powder has higher and more important properties than that of simple deodorization to which Major Malleson briefly alludes when he writes, "for use when epidemic disease threatens, or when its invasion

has actually taken place, McDougall's powder is an agent of great value, and in order that it may freely be used on such occasions it is very desirable that all hospitals should be supplied with it."

72. But the coal tar acids (carbolic, cresylic) have even higher disinfecting powers than the powder alluded to, and in order that a clear idea may be formed of the value of these fluids, I quote from Mr. Crookes's experiments in relation to the cattle plague as given by Dr. Parkes in the Army Medical Statistical and Sanitary Reports for 1864. It would take up too much space to detail all the experiments made, I must, therefore, content myself with the deductions drawn from them.

After remarking that the experiments "point out in a striking manner the difference between the mere deodorizers and antiseptics," Mr. Crookes writes: "Hitherto attention has been almost entirely confined to the deodorization of gases arising from putrescence. The effect has been combated, whilst the removal of the cause has received scarcely any attention. Chloride of lime, one of the strongest of the class of deodorizers, acts, as has been shewn, only on the gases of existing putrefaction; but it has no influence on the future. Carbolic acid on the other hand has scarcely any action on fetid gases, *but it attacks the cause which produces them, and at the same time puts the organic matter in such a state that it never re-acquires its tendency to putrefy*"—(the italics are mine.)

Mr. Crookes next undertook, by a series of critical experiments, to determine in what way carbolic acid acted in arresting decomposition. These experiments were directed especially towards elucidating the influence of the acid over ordinary fermentation, by adding it in very small quantities to sugar and yeast in full fermentation, and to fresh brewer's yeast. In both instances the process of fermentation was instantly arrested. Mr. Crookes makes the following commentary, "The above experiments prove conclusively that carbolic acid has a special action on the fermentation induced by organized matter; it not only arrests it instantly when in progress, but it prevents the development of future fermentation."

73. The action of the acid upon purely chemical ferments was then investigated, with negative results, upon which Mr. Crookes remarks, "It, therefore, appears that carbolic acid acts by attacking vitality in some mysterious way." Its action upon vitality was accordingly investigated, and it was found that a few drops of a solution of carbolic acid containing one per cent., added to a liquid in which cheese mites existed, immediately destroyed them. That an aqueous solution added to water in which small fish were swimming, immediately killed them; that under the microscope a very weak solution added to water containing various infusorial animalcules, as spirillœ, vibrios, monads, &c., destroyed

them at once. These animalcules, Mr. Crookes adds, "are almost the invariable accompaniments of putrefactive fermentation. The above experiment has been tried with putrid blood, sour paste, and decayed cheese, and in every instance the destruction of vitality, and the arrest of putrefaction have been simultaneous." Carbolic acid further kills caterpillars, beetles, crickets, fleas, moths, and gnats, as also flies, ants, and their eggs, lice, bugs, tics, acari, &c., and "when such animals are killed with it their bodies dry up with the air and resist putrefaction for some time."

74. A few more quotations, and I have done. "It may be considered to be definitely proved that the vapour of carbolic acid in the atmosphere exerts a special selective power over all minute organisms possessing life. If the contagious matter of cattle plague is possessed of organic vitality, as must now be admitted, it will be destroyed beyond the possibility of revival when brought into contact with the vapour." Apply this to the germ of other infectious diseases, and it is impossible to over-estimate the value of carbolic acid.

75. Dr. Parkes, in commenting upon the experiments above alluded to, writes, "Subsequent experiments have, I understand, confirmed Mr. Crookes's opinion of the great effect of carbolic acid when rightly used in arresting cattle plague; sound animals have been kept within eight feet of sick beasts without taking the plague when the air was constantly kept charged with carbolic acid. But if this be so, it is evident that its powers are likely to be still greater in the cases of typhoid and yellow fevers, cholera, and putrid dysentery, in all of which cases an amount of ordinary putrefaction seems to be combined with the peculiar unknown chemical conditions which are special to the viri themselves."

76. Some years ago, when I was the means of introducing the use of coal tar into the barracks and hospitals of this Presidency, I little thought that properties such as those just described would be proved to belong to its vapour, (of which carbolic acid is the essential principle,) and I certainly consider that in recommending this, acid to the attention of His Excellency the Commander-in-Chief and Government for use in urinals in the place of dry earth, I am fully justified by the evidence I have adduced; indeed, it becomes a question whether its use in the latrines ought not to be insisted upon, in every instance in which cholera, typhoid fever, or putrid or epidemic dysentery may manifest itself in a regiment or station.

77. *What additional establishment is necessary to the efficient working of the system* (a) *to bring, prepare, and store the earth and to distribute it in the latrines;* (b) *to remove the same after use in the latrines and urinals?*

This question is a very difficult one to answer satisfactorily. In fact till it be determined to what exact extent the system is to be worked, that is, whether the use of dry earth is to be restricted to the latrines or to be extended to the urinals also, it is not possible to determine the point. The main question is, can the system be worked with the same establishment as the old, or Dr. Hathaway's system, or does it necessitate additional attendants, means of carriage, &c. ?

It has been already noted, that while some Medical Officers have worked it with existing establishments, others have required extra servants and additional carts. The President of the Bengal Sanitary Commission has recorded his opinion, that so long as earth is used only in the latrines, (and he has advised that it be thus restricted) no additional expense need be incurred on this head; but that if the system be extended to the urinals, additional establishment, especially carts, will be needed.

78. The Bengal establishment under the old system for a Regiment of British Infantry, it has been shewn, consists of four carts at 25 Rupees each, and thirty toties at 5, giving a total monthly cost of Rupees 250. This is 20½ Rupees in excess of the sum at first allowed in Her Majesty's 60th Rifles on the introduction of the experiment in that Corps. If the application of dry earth be limited to the latrines, leaving the urine to be dealt with as formerly, or treated upon the system of deodorization by carbolic acid, or the carbolates (McDougall's Disinfecting Powder,) the above allowance for a Regiment of British Infantry will suffice. For instance, the total excreta of 1,000 men and earth, and carbolic acid required for deodorization may be stated as follows :—

	lbs.
Solid and fluid excreta of 1,000 men, passed into the privy pans, at 1 lb. each (5 solid and 11 fluid)...	1,000
Earth at 2½ lbs. per head	2,500
Urine in urinals, at 1½ pints or pounds per man ...	1,500
Carbolic acid to deodorize, at 3 per cent	150
Total pounds ...	5,150

Estimating a cart-load at 1,500 pounds, which I note is that assigned by the Barrack Master, two carts in one trip could bring daily 3,000 pounds, of earth, or 500 pounds over and above the requirements of the privies. There would be, however, 5,150 pounds to be removed, 3,500 pounds from the privies, and 1,650 from the urinals. The former (latrine contributions) equals 2·3 cart-loads; the latter 1·1 loads—total 3·4. But as the urine will have to be removed in iron r eceptacles, additional weight and space must be allowed, so that four carts will meet the requirements.

79. In regard to attendants, three toties per Company, or thirty for an entire Regiment are sufficient to perform all the duties of the latrines and urinals including the employment of one man as a 'constant watcher' to place earth in the pans after each use of the utensil. I would not, however, limit or absolutely fix the *nature* of the establishment, but allow Commanding Officers to increase or decrease the number of carts and toties to meet local requirements, restricting them merely to a certain sum represented by—

	Rs.
Four carts, at 25 Rupees each.....	100
Thirty toties, at 5 do.	150
Total...	250

which should amply suffice for the conservancy of a Regiment upon the modified system above indicated. But should the Government decide that the dry earth system be also applied to the urinals, the amount of compost to be removed is so largely increased as to necessitate the provision of additional carts.

The 187 gallons of urine (the product of 1,000 men, at one and a half pounds each) would require, at thirty-six pounds for each gallon, 6,732 pounds, for which additional carriage both in provision and removal would be required to the extent certainly of four carts, at a monthly increase of 100 Rupees, raising the amount to Rupees 350.

80. *The disposal of the mass of earth and excrement in regard to the* (a) *sanitary and* (b) *financial aspect of the question.*

The object hitherto at most stations has simply been to bury the mass out of the senses of sight and smell, and at such convenient and yet remote distances from barracks, hospitals, and stations, as may be supposed to remove all danger of contamination of the air or water. Doubtless this is a very improvident measure, as the right method of disposal is to return the whole excrementitious matter to the soil as manure, for which in Europe it has a high commercial value. But in India its value is not appreciated, at any rate not to an extent which makes it marketable, consequently its burial in pits is the only alternative left.

81. The Bengal Sanitary Commissioner has suggested, and in so doing re-echoes recommendations that have before emanated from different quarters, that it should be utilized in farms to be established by Government in association with every large station.

The measure is deserving of every consideration, not only as a means of turning to profitable account a valuable fertilizing compost which is now thrown away, but as tending to bring home to the native mind the commercial value of the manure. If the cultivator can be made to

comprehend by direct demonstration, that land which has become more and more exhausted by successive crops, can have its fertility restored, and be made to yield a tenfold return, he will in course of time, though he is so proverbially slow to acquire new ideas, or to quit the groove in which he has travelled for so many generations, avail himself of the rich store of wealth now neglected or even wasted.

82. The sanitary aspect of the question of burial of these excreta in pits, and the danger thereby accruing, has latterly attracted much attention. Dr. Mouat, the Inspector General of Prisons in Bengal, attributed the great sickness in the Lahore Jail, to deposit of ordure within the premises of the jail. The Sanitary Commissioner, however, took exception to the view, and considered that there was evidence to prove that the sickness was assignable to other causes. In the Proceedings of the Sanitary Commissioner for that Presidency for August 1867, it is, however, acknowledged that the burial of night-soil is not unattended by danger, and the risk of contamination of the water supply is made the ground of the recommendation already alluded to, the utilization of the soil in Government model farms.

83. Colonel Worster in his report has made the proneness of the milled mass to decomposition one of his objections to the system; but it applies equally and more forcibly to the old system, in which the excreta were buried without mixture with earth, and in which, consequently, there was not only more rapid decomposition, but owing to the fluidity of the mass, more rapid percolation into the soil, and consequently greater danger of contamination of any neighbouring springs of water. But admixture with earth retards decomposition so far that there is certainly less danger of this nature. Experiments are wanting to determine the nature of the changes that take place in buried "mill-stuff."

84. On the occasion of my visit to the Male Asylum, I requested Mr. Gover to open a pit of known age. One in which the compost from the mill had been buried six months was selected. I found the mass moist but inodorous. Doubtless had it been exposed to the necessary conditions, excess of moisture and heat, decomposition would have set in; but this cannot be advanced as an argument as Colonel Worster has made it against the "dry earth system of sewage," and consequently all the chemical evidences of decomposition in the mill-stuff which he has brought forward, fall to the ground. It has never been advanced that decomposition of excrement is arrested or put a stop to by admixture with earth, only that is retarded and the mass put into a condition favorable to its retention upon the premises till it can be removed and disposed of either by utilization as a manure, or by burial at a safe

distance from habitations. At present it is not found possible to utilize it. It has no commercial value, and consequently burial is the only alternative, and that, there is reason to believe, is less objectionable in the case of a mixture of earth and excrement than in the instance of unmixed, undeodorized night-soil.

85. But carbolic acid, it is alleged, actually arrests decomposition, so that it is reasonable to suppose that sewage deodorized by it may be buried without risk of contamination of springs of water; indeed, Mr. Crookes, whose report has been already alluded to, states that the liquid manure which flows from dunghills, which have been habitually treated by carbolic acid, oozes away without smell.

Dr. Palmer, of the Presidency General Hospital, Calcutta, states that urine deodorized by McDougall's powder can be thrown on grass land without ill effect after twelve hours. The use of carbolic acid or the carbolates might thus tend to remove the objection which has been raised to the disposal of sewage in pits, not only by arresting decomposition and rendering it incapable of taking on any further action of that nature, but by admitting of its immediate disposal on grass lands or soldiers' gardens, or in model farms in closer contiguity to cantonments, barracks, and hospitals, than it has been hitherto considered safe to allow the use of sewage deodorized only by dry earth.

86. *What are the principal objections that have been raised to the general introduction of the system?*

These have been already touched upon and comprise the labor and additional carriage required for provision of the earth, and removal of poudrette and its final disposal. But none of these difficulties are insurmountable, nor do they necessarily entail any additional expense, for in many Regiments and Public Institutions the system is being worked without any application having been made for extra establishments.

Mr. Gover, who deodorizes the urine as well as the contents of the privy pans, has placed on record that he has actually been able to reduce his expenditure under the head of conservancy; but he works the system, perhaps, under exceptional advantages, inasmuch as that he procures the earth upon his own premises, buries the poudrette there also, and employs the labor of the inmates of the asylum under his charge to carry out every step of the system.

Under less favorable circumstances, and especially in our Presidency towns, there may be a difficulty in procuring the earth necessary to a *full* working of the system except at a large cost for labor and establishment, and I have pointed out a means of deodorization of the urine in the urinals which while it adds little to bulk and consequent cost of

carriage, does away with the necessity of provision of so much earth and of removal of such an enormous bulk of poudrette.

87. In regard to *objections* which have been raised against the system, the most important are embodied in the report by Colonel Worster upon the result of the six months' experimental trial in the latrines in the Fort. Prior to my assuming the office of Sanitary Commissioner, that report had been submitted to Mr. Gover, of the Military Male Orphan Asylum, for comment, which will be found in Appendix B. Mr. Gover has made an exhaustive and, I think, a very fair analysis of Colonel Worster's report, and I can add little to it. He opens by condensing the report into a number of postulates contained in the different paragraphs, and then proceeds to reply to each.

It is shewn, in the first place, that Colonel Worster himself admits the perfect success of the system in regard to its power to ensure freedom from offence within the latrines. He then proceeds to combat Colonel Worster's views that the milling process fails to meet the object for which the mill was designed. He denies that it is laborious, that it is offensive or prejudicial to the health of the workers of the mill, and that the inoffensiveness of the poudrette is only temporary. Indeed, he combats all Colonel Worster's arguments, and I think successfully.

But important as many of the questions are which Colonel Worster raises, I do not think they are quite within the compass of the inquiry. The question, as originally propounded, was—Does dry earth absorb all noxious gases, the product of decomposition, and thus keep our privies and urinaries free from offence? and does it further exert that influence for a sufficient length of time to enable the mass of earth and feculence to be removed at regular and convenient intervals, still without offence or nuisance?

Other questions, such as disposal of the sewage, and its value as a fertilizer of the soil, have been naturally engrafted upon the inquiry; but provided it can be shewn that the original object, purity of the atmosphere of our latrines and urinals, and capability of removal of the contents of the pans and urinals without nuisance, has been gained; the dry earth system must be pronounced a perfect success; and this verdict has been recorded "*nemine contradicente.*"

88. I have elsewhere stated that having personally witnessed the operation of milling at the Male Asylum, and I may now add at the Fort latrines, I am perfectly convinced of the capability of the mill, if properly constructed, to turn out an inodorous mass fit to be removed in open carts. That this mass, under certain favoring conditions, is subject to decomposition, I do not deny, though it has been advanced that the compost is incapable of those changes to which all organic matter

is subject. I certainly should never have myself claimed for the milled mass such "complete immunity from deleterious influences; or have considered that, by this mechanical admixture (in the mill), some radical change is induced whereby the elements of decomposition are not only absorbed but are retained in an innocuous and inoffensive condition until decay has altogether ceased," which Colonel Worster, in paragraph 8 of his report states has been claimed for it—I presume upon theauthority of Dr. Mouat of Bengal.

Being prepared then to admit that decomposition may take place and most likely does take place in the milled mass in the pits in which it is deposited, and that thus there is a measure of danger of contamination of neighbouring springs of water, I do not think it necessary to go into the question of the precise chemical changes that take place, or to discuss the nature of the animalcular forms of life which are generated.

89. These minute organisms invade all organic matters undergoing decay in communication with atmospheric air, and if it is necessary to resort to chemical tests and the microscope to prove the existence of decomposition in masses of matter removed from the privies and urinals, we may safely say that the dry earth has brought about that measure of deodorization and arrest of putrefactive changes which is claimed for it; and certainly has the power to place the excrementitious matter which it masks and hides, in a condition best suited to its deposit in pits.

But, as excess of moisture is necessary to putrefactive change, it is in our power, by drying the compost and storing it in pits roofed over and duly secured against the entrance of subsoil water, to keep it for any length of time, or until it may be convenient to dispose of it as manure, for which purpose it is held by many high authorities to possess equal value with guano. At present no encouragement is afforded for such storage; but still the fact that it can be so stored at will without the occurrence of putrefactive fermentation meets the objection raised by Colonel Worster. Further, we have evidence that even without these precautions compost of this nature, which had been buried for six months in the Male Asylum compound, was perfectly free from the evidences, as ordinarily afforded to the senses, of decomposition.

90. Whether chemical tests might not have detected traces of ammonia and other gases, or the microscope revealed monads and vibrios and other forms of animalcular life on exposure of the mass to the air, I am not prepared to say; but this I can confidently assert that it might have been applied to arable or garden land, and in point of fact is so disposed of in gardens at Madras, without any ill effect so far as can be detected by the sense of smell.

91. The foregoing portion of this report was written shortly after my assumption of the duties of this office, and is now going through the press. I had hoped ere this to have received information through the Commissary General, applied for on the 4th January, that would have enabled me to come to some definite conclusions upon the question of cost of working the new, in comparison with the old, system.

It is manifestly impossible to arrive at any decision upon the point, founded upon the experiments that have been undertaken at the Presidency, where the expenses attending the provision of earth, owing to the distance from which it has to be brought, and the disposal of the poudrette, consequent upon the distance to which it has to be conveyed, are exceptionally great. I have also still to note the absence of any report from Secunderabad.

92. Having reason to know that it is considered desirable that this report should be submitted without waiting for further information under the head of cost, inasmuch as that, if the system can be pronounced to be attended with results undoubtedly and unquestionably exercising a sanitary influence upon the health of the troops, it will be sanctioned and adopted authoritatively, irrespective of any inconsiderable additional expense; I now bring it to a conclusion, reserving the privilege of submitting a supplementary report should information called for enable me to put the question of cost before His Excellency the Commander-in-Chief and Government in a reliable form.

93. The following is a summary of the conclusions that I consider the evidence justifies my adopting:—

I.—That dry earth is an efficient and cheap deodorizer of night-soil.

II.—That it is capable of arresting or keeping in abeyance putrefactive changes in such matters.

III.—That its use in *Latrines* will not be found to entail any additional expense under the head of conservancy; but that

IV.—Its use in *Urinals* must, owing to the large quantity of earth required to be provided, and of mixed earth and urine to be removed, entail a not inconsiderable additional outlay.

V.—That this outlay may be reduced at the Presidency by substituting (in the urinaries) "McDougall's Disinfecting Powder" for dry earth.

VI.—That *selection* of earths is of importance, as their deodorizing powers vary. The earth best suited to the purpose is a rich garden mould.

VII.—That the "Pugmill," if properly constructed and efficiently worked, effects such admixture of the earth and excrement as renders the compost inoffensive, and admits of its retention upon the premises

till such time as it may be convenient to remove it. That the 'mill' is therefore a convenient and desirable adjunct to latrines for European Troops; but that it is not necessary for Native latrines, inasmuch as that it is difficult to apportion earth to excrement in that exact quantity essential to the proper working of the mill.

VIII.—That the poudrette may be kept in a *dry* state for long periods without putrefactive changes setting in, but that if water gains access to it, decomposition may occur. Buried in pits and covered over I have found it free from smell at the expiration of six months.

IX.—That sites for pits for deposit or burial of the poudrette should be selected with care with reference to the 'dip' of the strata forming the surface or subsoils of the locality, so as to guard against contamination of the water supply.

X.—That the poudrette may be utilized in soldiers' gardens, provided it be at once dug or ploughed into the soil.

XI.—That the urine, if deodorized by McDougall's Disinfecting Powder, may also be used for irrigation of grass lands upon the confines of stations.

Lastly, there is abundant evidence to prove that the introduction of the dry earth system has effected a marked change in the sanitary conditions of barrack and hospital privies and urinaries; and that it has exerted a most beneficial influence upon the health of the troops.

94. I desire, in conclusion, to direct special attention to that portion of the report in which the question of substituting the use of carbolic acid for earth in urinaries is discussed.

I would advise the use of this disinfectant (I use the term advisedly upon the authority of Messrs. Smith and Crookes, whose experiments in reference to the cattle plague have been noted at page 33,) systematically in hospitals at all times, and in barracks during the existence of epidemic disease, or an unusual prevalence of dysentery, either in the form of carbolic acid itself, or in that of McDougall's Disinfecting Powder.*

Coal tar, of which carbolic acid and allied acids are the essential principle, should be used freely at all times both in hospital and barrack latrines, the vessels, seats, and walls to the height of two feet being periodically painted with it, indeed it should form an integral part of the dry earth system of conservancy.

J. L. Ranking,
Sanitary Commissioner for Madras.

Office of Sanitary Commissioner,
Madras, 18*th March* 1868.

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* Its use has been sanctioned to the barrack urinaries at Fort William, Calcutta, on account of the expense attending the provision of dry earth.

APPENDIX A.

REPORT ON THE EXPERIMENTAL EARTH CONSERVANCY IN THE PRIVIES IN USE WITH EUROPEAN TROOPS IN FORT SAINT GEORGE,

BY THE BARRACK MASTER, FORT SAINT GEORGE.

These experiments extend through a period of six months, commencing on the 1st March, and ending on the 31st August 1867. Their object, as inferred from the Proceedings of the Sanitary Commission, and Orders thereon, was to determine the effect of earth as a means of conservancy, the minimum quantity (or unit of application) required for the interior of privies, and the combined unit, for interior conservancy and defecation of the "mixed soil," by incorporation in a pugmill. The two former present little difficulty; but the latter is not so readily arrived at. It is very considerably influenced by the amount of fluid excretion, the humidity of the air, and also of the earth, at the time of its application; an accord can only take place when the unit for interior conservancy is sufficient to absorb the whole of the fluids under one or all of these conditions, so as to form a coherent mass when thoroughly combined in the mill.

2. Independent of these conditions, the unit will vary according to the size and sectional areas of the vessels in use, larger areas requiring larger quantities for effectual covering and shutting in offensive emanations.

3. In speaking, therefore, of a definite quantity of earth as an effective unit, it must be understood that it has reference to the dimensions of the vessels in which it has been determined. For example, in such a vessel as the old pattern privy tub, which had to be retained for some time in the detached privies, the top and bottom areas are 283½ and 154 square inches, and a layer of earth at each of these sections of half an inch in thickness, will weigh about 6½ and 3½ pounds, but as the covering is not usually in the form of an even layer, the quantity will generally be in excess of these numbers according to circumstances.

4. This variation had been previously noticed in the use of a self-delivery apparatus applied to a tub of this description, when at times, as the vessel filled, it was found necessary to cause a double and treble discharge of earth for effectual covering, thus increasing the unit of three pounds, for which the valves had been adjusted, to double and treble that quantity.

5. With the buckets authorised and procured for this experiment, similar sectional areas are 113 and 63¼ square inches, the corresponding weights being 2·5 and 1·6 pounds. The former quantity, or even less, though practically it is expedient to apply that unit, has been found fully effective for interior conservancy, to which no addition has been necessary during the dry season, for the subsequent combination in the pugmill.

6. During the prevalence of southerly winds, and in cooler weather, when the per-centage of fluid excretion and humidity in the air is greater, the quantity of earth for combined conservancy must be increased to about three pounds, according to circumstances,* for complete and quick incorporation in the mill; and it may be inferred that it must be further augmented during very damp weather, and in the monsoon, when the conditions previously mentioned have arrived at a maximum.

7. Before entering into further detail, it may be well to offer some remarks on the supposed advantages of this combined system of conservancy, as its extension may, in some measure, depend on the results deduced from these and similar investigations.

8. From what has been stated on this subject, it would seem that after incorporation in the mill, complete immunity is insured from deleterious influences, and that by this mechanical admixture some radical change has been induced, whereby the elements of decomposition are not only absorbed, but are retained in an innocuous and inoffensive condition, until decay has altogether ceased.

9. That no great change is effected by the incorporation, even with large quantities of earth, is evidenced by the fact that, however comparatively inoffensive the mass may be when discharged from the mill, such inoffensiveness is but temporary; the fœcal odour soon returns more quickly in damp, than in dry weather, and can only be shut in by a covering of dry earth to render it inoffensive.

10. It has been further stated, that when the mass has once become dry "the application of an ordinary quantity of water will not cause offence," and consequently it may be exposed or buried without

* At least 3½ volumes of earth to one of water are required to form a coherent mass. An ounce or 1·73 cubic inches of water will, therefore, require 3·5 × 1·73 or 6 cubic inches of earth, the weight of which is about 4·25 oz.

contaminating the air or drainage waters, or be applied directly to the soil as an inoffensive fertilizer.

11. Repeated experiments do not confirm these views. In all cases, even when the mill-stuff has become perfectly dry and then inoffensive, the elements of decomposition are merely dormant, and need but the application of water to restore them to noxious activity—a few hundred grains soon giving out sulphuretted hydrogen gas, and invariably shewing the presence of alkaline salts and ammonia on being tested with the usual re-agents.*

[Note, para. 11.—As one example out of many trials, a small portion of mill-stuff was taken on the 30th April, being then comparatively inoffensive. In a short time the fœcal odour returned very perceptibly, and increased to positive unpleasantness. On the 3rd of May it was offensive; a little water was then added, and sulphuretted hydrogen gas was evolved in the course of the afternoon. The watery solution was then decanted with a little of the sewage remaining in suspension, and an equal bulk, or rather more of earth, was thrown over the original portion for subsequent examination. On testing the solution the presence of alkaline salts, and ammonia especially, was very evident.

(2.) The remainder was decanted with a few grains of the matter and examined with a microscope at the Medical College by Dr. Wyndowe. Although not sufficiently powerful to bring out the object very clearly, a drop of the clear solution was found teeming with animal life.

(3.) On submitting it shortly afterwards to the more powerful instrument of Captain Mitchell, Superintendent of the Museum, that gentleman agreed that the animalculæ were of the class "Vibriones," which are only present in highly nitrogenised matter, and which by their agency, as well by chemical action, undergoes transformations to more simple forms.

(4.) On the 25th May, Captain Mitchell writes, that the solution still had a "nasty smell," and that the same "animalculæ" were present in large numbers.

(5.) It was not until a month after its being left at the Museum, that the solution had ceased to emit an offensive odour, and the "Vibriones" had disappeared.

(6.) On the 24th July, the portion of matter which was covered with dry earth was examined; sulphuretted hydrogen was still evolved on the application of water, and ammonia was abundantly present. It was then dried perfectly, and subsequently used as a filter bed of about an

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* See Note appended.

inch in thickness; distilled water was then added gently, until a sufficient quantity had passed through for testing. Ammonia was still present, and the filter bed soon became offensive.

(7.) Like results have been obtained from various specimens containing various quantities of earth from the Fort, Male Asylum, and from the Vepery pugmills.

(8.) The "soil pit" at Perambore was visited on the 22nd April, and the earlier milled stuff exposed on the surface was tested, and found both alkaline and ammoniacal.

(9.) It may thence be inferred that burial, with these elements remaining in the mass, will leave the drainage waters still liable to pollution.]

W. K. W.

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12. Whatever effect then may be attributed to this incorporation, it is evident that these elements are not so readily eradicated, or that any material chemical change can possibly occur, by which decomposition can be so effectually and immediately arrested as supposed. During the process, however, gases are liberated in a most offensive form and, so far from the proportion present in the mass being diminished in volume, the final conversion into imputrefiable products may, in some degree, be accelerated; but under any circumstances this conversion must still be a work of time, and so long as the mass continues moist, as it is when discharged from the mill, putrefaction will continue until the conversion is complete.

13. It may, therefore, be inferred, that in burying a moist mass of this description, there is risk of the drainage waters being polluted, especially during heavy rains, for whatever is soluble is then more readily acted on than when in a drier and more solid form of aggregation.

14. It is in the dry state alone that earth, or rather the oxygen of the air contained within its pores, has the power of effecting combinations innocuously. Practically this condition does not prevail; the earth becomes moistened by contact with the fluid excretion, and the air, in a great measure, is displaced; so that there would appear to be little difference, as to the ultimate results of decomposition, between the burial of milled masses, and unmixed matter; as in either case, the soil being moistened, putrefaction will continue until it becomes dry, when its power of effecting combinations inoffensively is restored.

15. It may be urged that, in the burial of unmixed matter, some portions, from not being in immediate contact with the soil, would undergo a more rapid and deleterious decomposition, and inconvenience might be felt from exhalations, but as the soil would absorb any gases that may be evolved, it is apprehended that no really prejudicial influences would result, provided the covering of dry earth be of sufficient thickness.

16. Should more extended experiment lead to the conclusion, that final decomposition of the combined matter is importantly accelerated by the disengagement of gases during the process of incorporation, the advantage of the pugmill may then be in part admitted; but a question will still remain for consideration, whether the prospective advantage thus gained, will at all compensate for the noisomeness occasioned by the liberation of these gases so immediately in the vicinity of barracks, or populated neighbourhoods. It seems scarcely consistent with principle, that, here at least, even menial attendants should be subjected to such concentrated exhalations, when the result of their labor is utterly nullified by the incorporated matter being deposited among the reeking refuse of the town.

17. Reverting to the subject of simple conservancy, it may be concluded that no immediate chemical action ensues on the application of earth, and that its effect is in merely temporarily shutting in emanations from putrescent matter; ashes or even sand have a like mechanical effect, though they have no power either to promote or prevent decomposition.

18. In this respect, soils differ very considerably in their properties of disinfection; but as there was little room for selection, these experiments have been carried out with earth containing a portion of sand (stiffer soil was found to obstruct the milling process), and also deliquescent salts which are common to almost all the earths in the vicinity of Madras.

19. Although the earth from this cause is more liable to be affected by moisture, its efficacy for interior conservancy is not materially lessened. For urinals, also, since the earth may be dried and used again, and so on, until it has lost its absorptive properties, the presence of these salts is comparatively of little importance; but in the case of the mill, it becomes of moment, as it necessitates an increased expenditure of earth.

20. In applying earth to the vessels, scoops have been used by attendants within the privies, the construction of the latter compelling this objectionable alternative, but from all view of the interior being precluded, (until very recently) it was naturally to be expected that they would at times evade the duty of a regular supply.

21. It would have been of little avail, in these instances, to have threatened the men with fine or discharge ; employment was easily obtainable elsewhere with less laborious duties and on higher wages, while it was almost certain that, in the event of discharge, they could not easily be replaced.

22. In the "men's privy" of the Regiment, which was constructed for carrying out Dr. Hathaway's system, attempts were made for some time at the commencement, to apply the earth by special contrivances from the rear, but owing to the lowness and depth of the arches, they were quite futile ; the supply was irregular, and could only be effected by the withdrawal of the vessels.

23. To effect the supply with facility from the rear, it is now evident that very considerable alterations to this privy are absolutely necessary.

24. In the men's division of the family privy, twelve machines were furnished for the delivery of the earth, but from faulty construction of the shoots, have been, and still are, perfectly useless.

25. Two pugmills were provided for the Regimental privies, but were more adapted for steam power than for manual labor. They were upwards of six feet high, and three feet diameter with a capacity of forty cubic feet, and could only be worked from stages about four and a half feet from the ground. Four men were required to work the shaft of either of these mills, when the mass become at all coherent, and having to mount the stage to enable them to discharge the contents of the vessels into the mill, their work was by no means light. The time occupied in completing the operation varied from $1\frac{3}{4}$ to $\frac{3}{4}$ of an hour according to the quantity of earth applied. Subsequently, these mills were replaced by others* of a smaller and more convenient size—about twelve cubic feet capacity, and the labour of working them was not so oppressive or prolonged—being reduced to from twenty-five to twenty minutes ; but it is necessary, even with the small numbers at present with the Regiment, to make use of them three times during the day.

26. The Artillery Guard and Band privies being plain structures, or appropriations from the fortifications, without passages in the rear, necessarily required personal attendance in the interior.

27. In the Regimental privies the earth has been applied from morning until evening during the whole course of the experiment, except at the commencement as previously mentioned, but no intermediate supplies have been made during the night, the earth for this period being added to the vessels in the morning, preparatory to incorporation in the pugmill.

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* Regimental privy, 26th April. Family privy, 7th May.

28. This break in the conservancy, together with an increase of numbers during the night, in the ratio of about four to five, from the married men having to resort to the privy (the family privy being closed), somewhat affects the numerical determinations.

29. In the morning conservancy, especially for the families, from the vessels having to be sent to the mill for disposal, there has always been a large excess of fluid, evidently due to a quantity of slops thrown into them, which has rendered the expenditure of earth quite disproportioned to the numbers in occupation of the quarters.

30. Under these circumstances, in order to simplify matters as far as possible, all free fluid has been removed for some time past in air-tight receptacles, as in Dr. Hathaway's effective system. The daily expenditure of earth in the Regimental privies has also been divided, as shewn in the Statement A, from the 22nd May 1867, into "night" and "day" quantities, the "unit" for interior conservancy being entered, instead of the "rate" on the strength in which it had previously been involved.

31. The "day" period is nominally from 6 A. M. to 6 P. M., the time the attendants are employed, but practically, owing to the time taken up in removing and cleaning the vessels, it is reduced to about eleven hours. The resulting "day numbers" on the unit are thus diminished in the men's privy, while the "night" numbers are increased, irrespective of any increase from the married men resorting to the privy.

32. But for these sources of disturbance, it would be easy to arrive at sufficiently approximate numerical results, by which the annual supply of earth for plain conservancy for a full Regiment could be regulated.

33. In the present case, from the cessation of continuous conservancy during the night, and from the increase of numbers for that period —while the "day" is but eleven hours long—it will be necessary, either to rely on the day period alone, to obtain the probable numbers for whom earth has to be provided, or, to combine the "day" and "night" quantities, and by averages and per-centages, obtain data, on which further computations may be based.

34. The latter appears preferable, from its embracing the whole twenty-four hours, and, although it may be questioned whether the application of the "day unit" to the aggregate night expenditure is admissible, yet, as the results of the incorporations are so generally alike, there seems no reason why the computations should be restricted to the shorter period, in which there will still be uncertainties incidental to manual service by scoops, the measure of which will not always correspond with the weights imputed to them.

35. The following abstract shews the results both for the 'day' and 'night' expenditure for three months, and the derived numbers and per-centages, exclusive of the sick in hospital and guards.

Months.	Total number of Men.		Total expenditure.	Mean daily expenditure on unit of 2·5 lbs. and derived numbers.		Ratio of day to night.	Per-centage.
			lbs.				
June ...	Day.....	12,513	29,491	983	388	93 on 100	
	Night...	15,270	10,276	342	136	26·7 ,,	
						119	19 per cent.
July ...	Day.....	12,710	31,130	1,004	401	97 on 100	
	Night...	15,624	11,989	387	158	31 ,,	
						128	28 ,,
August.	Day.....	13,144	30,582	986	394	93 on 100	
	Night...	16,089	12,883	415	166	32 ,,	
						125	25 ,,

36. Taking the mean for purposes of calculation at 25 per cent., and computing the annual quantity of earth required for plain conservancy for a Regiment of 1,000 men, women, and children in garrison (exclusive of sick), the unit being 2·5 pounds, the amount will be $1{,}250 \times 2{\cdot}5 \times 365 = 1{,}140{,}625$ pounds, or about 509 tons.

37. For combined conservancy it is difficult to estimate the actual quantity that will be required, especially during the monsoon, or on days when the air is saturated with moisture. Mr. Gover, the Superintendent of the Male Asylum, who has at all times most obligingly afforded every information on this system of conservancy, states that he makes no difference in the quantity throughout the year. No comparison, however, can be instituted between the results on 300 boys, and on 1,000 adults. The unit must undoubtedly be increased to meet varying conditions, and it will be better, therefore, to divide the year into periods of 185 and 180 days, one in which the unit of 2·5 pounds is applicable, the other, when it will be increased to three pounds, as an average, per man per diem.

38. The total quantity will thus be, for the first period, $1{,}250 \times 2{\cdot}5 \times 185 = 578{,}125$; second period $1{,}250 \times 3 \times 180 = 675{,}000$, making a total of 1,253,125, or nearly 560 tons.

39. This amount is quite irrespective of contingencies arising from misuse of the vessels, which, no doubt, will be effectually checked when the conservancy reverts to Regimental supervision; but it will be necessary to provide a close cart for the reception of slops and free fluids at the family quarters, for removal and discharge into the sea.

40. The quantity of earth for the urinals of a Regiment remains to be computed. As the night vessels in barracks are not supplied with earth—the contents being emptied into the sea—the expenditure has been confined to the day, the earth being dried and returned for use as previously stated. In this manner a weekly issue of 2,156 pounds has sufficed for the garrison, averaging about 600 men daily.

41. The annual quantity may, therefore, be taken in this proportion for the men of a Regiment, and will be 186,836 pounds, increasing the former total by 83½ tons.

560
83½
Total...643½

42. It seems perfectly unnecessary that, here at least, earth should be used for this purpose. It would be infinitely preferable to arrange by a series of pipes, so that the urine should be received at once into small barrel hand-carts, which could readily be drawn to the beach, and the contents allowed to escape inoffensively by a hinged pipe directly into the water.

43. The number of attendants required for carrying out the earth conservancy for a full Regiment, supposing the earth can be applied from the rear passage, will be as follows :—

Establishment.
Regimental Toties... Rs. 90.

44. For storing, pounding, sifting, and supplying earth to the privy and vessels, &c., and working the pug-mill four or five times a day, at least ten men will be required to perform the duties efficiently, as the work is both heavy and incessant. This establishment must be solely restricted to the privies ; both the day and night urinals, barrack drains, &c., &c., being attended to by additional numbers according to the strength of the Regiment.

Single Men's Privy.

45. At the present rates (5 Rupees each,) the cost of ten men will be 50 Rupees per mensem, but it is very doubtful whether they will be content with such wages for the work required of them.

46. For the family privy, four male and four female attendants will be required for similar duties, and the cost will be for—

Family Privy.

Four Males, at	Rs.	5	= 20
Four Females, at	,,	5	= 20
Making a total of Rs.			40

47. It may be here mentioned that, owing to the distance of the present privies from the barracks and quarters, it is very desirable that night privies should be built and fitted with self-acting machines for better conservancy, and obviating some of the difficulties experienced during the course of these experiments.

48. In regard to the removal of the "soil," it is impossible at present to form other than an approximate estimate of the cost, as by a recent order of the Municipal Commissioners, a double conveyance by carts and boats is necessitated. The outlay for the latter is estimated at Rupees 400. Tubs also will be required for the reception of the soil, and three platform carts to carry the tubs to the boats, for final conveyance to the soil pits; besides current expenses as yet undecided, probably amounting to Rupees 93 monthly.

Conservancy of Artillery and Guard Privies.

49. In the Artillery, Guard, and Band privies, circumstances caused a different arrangement for their conservancy, owing to the impossibility of procuring buckets in sufficient numbers, (to replace the tubs,) corresponding with those in use in the Regimental privies, from which the effective unit would be ultimately derived.

50. It was also not apparent how the establishment should be apportioned with due regard to equality of work, while there was no doubt that on obtaining smaller vessels their labor would be considerably lightened.

51. Some of these privies were used but by six or eight persons, and to have increased the establishment for a continuous conservancy in such cases, would have increased its cost, without any apparent corresponding advantage. The application of earth was, therefore, occasional, and on removal—as it had been previously from gratuitous supplies by the Contractor, until such time as the buckets were procurable.

52. Delay still occurring in obtaining these vessels, the earth was applied to the tubs more frequently, and to the full extent required, both for shutting in emanations, and for effectual covering in the receptacles, in which the matter was removed, time not permitting the contents being incorporated in the large mills then in use.

53. It has been already stated that the unit quantity of earth depends on the size of the vessels, but it was perplexing to find that, after making every allowance for coverings, the expenditure far exceeded all previous calculation. It was soon evident that the privies were resorted to by other than those for whom they were specially allotted, and even by native servants, thus precluding all attempts to arrive at any numerical determinations. This, however, is now of little moment, the unit being deduced from a different and more convenient vessel.

54. On the buckets coming into use in June, natives were excluded from the privies, and earth was applied by the attendants, making their rounds every half hour, the Bandsmen themselves applying the earth in their own privies. The buckets were removed from the Artillery privy

three times, and from the Guard and Band privies twice during the day. These arrangements seemed so effective in preserving the interiors free from taint, that it was considered unnecessary to increase the establishment, more especially as there are periods during the day when the privies are seldom resorted to.

55. As an experiment, the conservancy has been effected without increasing the establishment for the Garrison, though it will be necessary to augment it, should the earth system be continued and conducted without intermission.

56. The quantity of earth required for a Battery of Artillery for a single men's and family privy of 75 men on the previous data will be for plain conservancy per annum $93 \times 2\frac{1}{2} \times 365$ ... ... * 84,862

Artillery, 1 Battery.

* 84,862
15,860
100,722 lbs. = 45 tons.

† 93,140
15,860
109,000 lbs. = 49 tons.

Combined conservancy.	1st period ...	42,920
	2nd period ...	† 50,220
		93,140
	Urinals	15,860

57. For the Garrison Guards and Band with families the quantity will be for 51 men, and 54, including women and children, respectively,

For plain conservancy ... ... ‡ 118,625

‡ 118,625
19,604
138,229 lbs. = 62 tons.

‖ 130,140
19,604
149,744 lbs. = 67 tons.

Combined conservancy.	1st period ...	59,940
	2nd period ...	70,200
		‖ 130,140
	Urinals	19,604

58. The establishment for the Artillery may be restricted to two men at present, as the families are allowed the use of the family privy of the Regiment.

59. For the Garrison, owing to the scattered position of the privies,§ it will be necessary to increase the present establishment (ten) by six men for full combined conservancy, and to provide a separate pugmill, in order that the incorporating process may be effected independently.

60. With increased numbers in the Regiment its mills will be scarcely available, and unless the incorporation be effected in proper time, inconvenient delay may occur in the removal of the "soil." The cost

§ See plan accompanying.

of these attendants will be 80 Rupees a month. The cost (in detail) of these establishments, amounting to Rupees 2,783-1-0, together with that of the experimental conservancy, Rupees 2,620-3-6, is shewn in detail in the Appendix (B. C.)

Exclusive of cartage and boat removal.

61. There can be no doubt, however, that these establishments could be very considerably reduced by providing small hand-carts, and fitting each privy with self-acting earth delivery machines; both labor and cost would be diminished, and the conservancy and supervision rendered more effective; a point of some significance at the present time, when a lurking danger is suspected in almost every smell.

(Signed) W. K. Worster, Colonel,
Barrack Master.

Fort St. George,
7th September 1867.

STATEMENT A.

REGIMENTAL PRIVY.

Mean daily expenditure, mean rates and numbers, with notes.

Month.		Mean strength.	Mean expenditure.	Mean rate on mean strength.	Remarks.
			lbs.		
March 1867.	1	422	1,416	3·35	3 lbs. "Owing to the depth of the arches and their small height, it was found necessary to place the buckets low enough for easy application of earth. The floor became soiled, the buckets even then put close up (2nd), when the supply became impassable without withdrawing the vessels to the rear, for the purpose, and as the back wall precluded all view of the inside, it was irregular, various plans were tried to overcome obstacles, but they failed.
	2 to 8	369	732	1·98	
	9 & 10	330	686	2·07	
	11 to 13	327	925	2·82	
	14 to 16	328	958	2·92	
	17	329	992	3·015	"The arches were cut away (7th to 28th), and (15) zinc shoots fitted to facilitate the supply of earth, but the arrangements were still defective.
	18 to 20	349	892	2·25	
	21 & 22	374	993	2·65	"It would have been useless to continue the experiment under these hindrances, it was, therefore, considered necessary to place men in front however objectionable such an alternative might be, so soon as an Overseer could be obtained for overlooking the men.
	23 to 30	366	1,118	3·054	
	31	361	993	2·75	"The mill broke on the 2nd and was under repair to the 6th, and on the 22nd to the 27th. The mills were so large and the resistance became so great when the mass was coherent, that it was prolonged for more easy incorporation.
					"The results merely shew that earth, even in small quantities, improves the interior of the privy."
April 1867.	1 & 2	461	1,055	2·29	"The interior free from taint, but oppressively hot during the day. Mill blade broke on the 1st, repaired on the 6th, and again under repair from the 11th to the 14th. On the 15th combined quantity for effective milling, but tainted after a little while. 16th, experiments on defecation with larger quantities of earth. Specimens retained for subsequent testing. Smell returns after discharge from the mill.
	3 to 14	458	1,254	2·73	
	15	467	1,591	3·40	
	16 to 30	448	2,178	4·85	"The effect of the along shore wind on the earth was at times very apparent, mean humidity of the air 76 per cent.
					lbs. 3, C.N. (day) 22nd. "Visited the Kilpauk, (abandoned) and Perambore soil pits. The former free from smell, the latter intolerable; tested some of the early mill-stuff. Ammonia present. 26th, new small mill used, much more effective than the cumbersome ones previously furnished. 30th, mill out of order, quantity for combined conservancy 3 lbs., humidity 73 per cent."
May 1867.	1 & 2	418	1,268	3·03	"Interior inoffensive; mill repaired. Milling effective, but earth still affected by the dampness of the atmosphere (mean humidity 73). Quantity for combined conservancy 3 lbs. Specimens for testing offensive after a few hours.
	3 to 8	416	1,562	3·75	
	9 & 10	411	1,161	2·82	"Reckoning the men entering the privy in 12 hours for ten days the extreme differences were *plus* 3 and *minus* 16 compared with the strength. The men employed for this purpose were overlooked.
	11 to 19	411	1,438	3·49	
	20 & 21	400	1,569	3·92	"The interior and combined quantities coincide 3 lbs. (day) humidity 74 per cent.

Month.		Mean strength.	Night. Mean expenditure.	Night. Mean resulting number on unit of 2·5.	Day of 11 Hours. Mean expenditure.	Day of 11 Hours. Mean resulting number on unit of 2·5.	Remarks.
			lbs.	No.	lbs.	No.	
May.—*Continued.*	22	419	301	120	1,247	415	"Interior and combined day quantities coincide—2½ lbs., 'humidity' 64 per cent."
	23 & 24	414	276	110	989	329	
	25	420	215	86	1,419	473	
	26	420	215	86	1,333	444	
	27 to 31	423	251	99	975	374	
June.	1 to 7	422	322	128	989	395	"No change in the quantity of earth. On the 4th milling affected by damp. 12th and 13th closets made use of as urinals. Regiment attendants refused to work. Specimens tested. Ammonia present, offensive after a little while.
	8 to 11	422	338	135	956	382	
	12 & 13	Closets made use of as urinals. 3,827 lbs. expended.					
	14	411	344	137	989	395	
	15 to 21	409	354	141	964	385	"Mean number increased during the night by 92."
	22 to 30	417	351	139	973	389	
July.	1 to 7	414	371	148	972	388	"No change in the quantity of earth for incorporation. On the 12th the mill spindle broke, a new iron spindle being provided on the 14th. "The matter from the mill smells after a short time; effect of milling perceptible in the N. St. George's Lunette. "On the 2nd and 3rd of this month sixty-two men, between 6 and 9 P. M., entered the privy, and in the morning, from 4 to 6, forty-three were counted."*
	8 to 14	402	370	148	979	391	
	15 to 21	407	395	157	967	386	
	22 to 31	416	396	158	969	386	
August.	1 to 7	421	401	159	973	389	"The same quantity of earth as in July. 10th, rain. Regiment mill affected. No protection like the family mill which had been provided with an umbrella on the spindle. "On the 17th and 18th the entries into the privy were again counted for two days, the differences were *plus* 15 and *minus* 9 in 12 hours. "The whole of the specimens of milled matter remaining were moistened on the 31st August, and on the 2nd of September they were noisomely offensive and were thrown into the sea. "Mean number increased during the night by 95."
	8 to 14	436	409	163	980	391	
	15 to 21	419	433	173	1,007	402	
	22 to 31	421	417	166	985	394	

* Mean number increased during the night by 94.

FAMILY PRIVY.

Mean daily expenditure, mean rates and numbers, with notes.

Month.		Mean strength.	Mean expenditure.	Mean rate on mean strength.	Remarks.
			lbs.		
March 1867.	1 & 2	157	441	2·80	"The men's division of this privy provided with 12 self-acting machines, but the delivery was uncertain, the shoots apparently adapted for sand. This privy is well ventilated, and the interior was free from unpleasantness, except from occasional soiling of the floor by the children.
	3 to 7	160	530	3·31	
	8	160	496	3·1	
	9 to 11	160	506	3·16	
	12	150	527	3·51	
	13 to 17	158	503	3·18	
	18	160	562	3·51	
	19 to 24	160	493	3·08	"Vessels being sent, both morning and evening, from the quarters, the results for combined conservancy uncertain, as slops were evidently put into the vessels. The mill was more effective than the men's privy mill, the blades being longer, and the work was lighter from there being fewer numbers, while the privy was not used at night—the married men having to resort to the single men's privy.
	25 to 30	159	545	3·43	
	31	160	498	3·11	"N.B.—The vessels sent contain both solid and fluid excretions. The privy is too distant."
April 1867.	1 to 7	161	494	3·06	"The interior as before; the machines were attended to, but without effecting improvement. They are useless. The same uncertainty attending the combined conservancy; rags in the vessels; requested the Quarter Master to stop this."
	8 to 14	158	485	3·06	
	15 to 21	159	559	3·51	
	22 to 30	162	559	3·45	
May 1867.	1 to 7	162	566	3·49	"Interior, &c., as before. Numbers increased by a Battery of Artillery, arrived on the 22nd. Slops increased,—if not permitted they would have been probably thrown into the drains, and have fouled the ditch; putrescent matter having been found in the drains.
	8 to 14	162	562	3·46	
	15 to 17	162	530	3·27	
	18 to 21	212	575	2·71	
	22 to 27	212	692	3·26	
	28 to 31	206	642	3·11	"There is an occasional flow of urine from the drains into the ditch early in the morning."

Month.		Mean strength.	Day of 11 hours.		Remarks.
			Mean expenditure.	Mean resulting No. on unit of 2·5 lbs.	
			lbs.		
June 1867.	1 to 7	203	445	177	"Interior as usual. Mill rate still disturbed in the morning, day process with 2½ pounds effective."
	8 to 14	206	429	171	
	15 to 21	206	142	165	
	22 to 30	203	419	167	
			297 lbs	...	Average expenditure for night conservancy.
July 1867.	1 to 7	207	416	166	As before.
	8 to 14	212	449	179	
	15 to 21	212	446	178	
	22 to 28	209	448	179	
	29 to 31	208	449	179	
			301 lbs	...	Average expenditure for night conservancy.

FAMILY PRIVY.—*(Concluded.)*

Mean daily expenditure, mean rates and numbers, with notes.

Month.		Mean strength.	Day of 11 hours. Mean expenditure.	Mean resulting No. on unit of 2·5 lbs.	Remarks.
			lbs.		
Aug. 1867.	1 to 7	209	455	181	As before.
	8 to 14	211	457	182	
	15 to 21	213	458	183	
	22 to 28	208	456	182	
	29 to 31	203	468	186	
			313 lbs	...	Average expenditure for night conservancy.

Mean expenditure of earth for the Artillery Guard and Band Privies.

Month.		Mean strength.	Mean expenditure daily.			
			lbs.			
1867.						
March.	1 to 31	491	123			
April....	1 to 30	149	528			
May ...	1 to 31	149	882			
June.	1 to 11	149	480			
	Buckets	Garrison		Artillery. Mean strength.	Mean expenditure daily.	
	12 to 18	105	313	48	153	
	19 to 25	105	297	48	135	
	26 to 30	105	205	48	133	
July.	1 to 7	105	279	48	134	
	8 to 14	105	281	48	133	
	15 to 21	105	274	48	132	
	22 to 28	105	276	48	134	
	29 to 31	105	274	48	132	
August.	1 to 7	105	281	44	133	
	8 to 14	105	281	44	135	
	15 to 21	105	284	44	135	
	22 to 28	105	274	44	136	
	29 to 31	105	279	44	137	Artillery mean resulting percentage 12.

B.

Cost of experimental Dry Earth Conservancy for six months.

No.		Rate.	Total per month.	Total for the last six months.	Grand Total.
		RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
2	New Earth carts with frames	...	...	204 7 6	
	Alterations and repairs to two Platform carts, furnishing side frames, boxes, tiring wheels, &c.	...	...	128 2 0	
58	Galvanized iron buckets	...	...	159 14 0	
41	Do. do., small	...	...	72 9 6	
76	Iron funnels	...	...	59 3 2	
					624 4 0
	Cost of making and repairing Pugmills (Furnished by the D. P. W.)	...	...	259 15 11	
	Constructing twelve self-acting closets, and repairing the same ... ... (Furnished by the D. P. W.)	...	...	370 4 1	
					630 4 0
	ESTABLISHMENT.				
	March and April.				
4	Male Toties for male portion of the Family privy	4 6 0	17 8 0	35 0 0	
4	Female do. for female do. do. ...	4 6 0	17 8 0	35 0 0	
4	Male do. for Regimental privy	4 6 0	17 8 0	35 0 0	
	Famine allowance to Regimental Toties ...	1 0 0	4 0 0	8 0 0	
10	Male garrison Toties	4 6 0	43 12 0	87 8 0	
	Famine allowance to do.	1 0 0	10 0 0	20 0 0	
	May to August.				
4	Male Toties for male portion of the Female privy	5 0 0	20 0 0	80 0 0	
4	Female do. for female do. do. ...	5 0 0	20 0 0	80 0 0	
4	Male do. for Regimental privy	5 0 0	20 0 0	80 0 0	
10	Male garrison Toties	5 0 0	50 0 0	200 0 0	
	March to August 1867.				
4	Pairs of bullocks, &c., to remove the night soil.	16 0 0	64 0 0	384 0 0	
764	Cart-loads of earth, at 5 As. per cart-load...	...	...	238 12 0	
	For a Private of 3rd Battalion 60th Rifles, for supervising the earth conservancy, from 29th March to 31st August 1867 ...	10 0 0	10 0 0	50 15 6	
1	Male garrison Toty Maistry	5 4 0	5 4 0	31 8 8	
					1,365 11 6
				Total ...	2,620 3 6

220 Cart-loads remaining in the Earth Store—(computed.)

(Signed) W. K. WORSTER, Colonel,
Barrack Master.

7th September 1867.

Estimated Expenditure of Earth and Cost of Conservancy, per annum for the whole Garrison.

	Strength per day.	Simple conservancy, half period.	Combined conservancy, half period.	Urinals per annum.		Total.	Cart-loads.	Rate.	Amount per annum.	Total per annum.
								RS. A. P.	RS. A. P.	RS. A. P.
Regimental Families and children ...	1,000 + 25 per cent. = 1,250	5,78,125	6,75,000	1,000	1,86,836	1,439,961	1,440	0 5 0	450 0 0	
Artillery	75 + 25 ,, = 93	42,920	50,220	85	15,860	109,000	109	0 5 0	34 1 0	
Guard	51 + 25 ,, = 63	29,045	34,020	51	9,516	72,581	73	0 5 0	22 13 0	
Band	54 + 25 ,, = 67	30,895	36,180	54	10,088	77,163	77	0 5 0	24 1 0	
As there will be difficulty in drying the earth during the monsoon, six weeks' supply should be provided to make up for loss of earth							26	0 5 0	8 2 0	
										539 1 0

ESTABLISHMENT.

Regimental Privy	10 Toties	5 0 0	600 0 0	
Family do.	4 Male Toties	5 0 0	240 0 0	
	4 Female Toties	5 0 0	240 0 0	
Artillery do.	2 Male Toties	5 0 0	120 0 0	
Garrison do.	16 Do. do.	5 0 0	960 0 0	
	1 Toty Maistry	7 0 0	84 0 0	
				2,244 0 0
			Total...	2,783 1 0

REMOVAL CONTRACT.

	RS.
Three pairs of bullocks, at 16 Rupees each, 48 ...	... 576
Two Boat transport. } Undecided.	
Boatmen and Pit Coolies. }	

(Signed) W. K. WORSTER, Colonel,
Barrack Master.

7th September 1867.

APPENDIX B.

REMARKS UPON COLONEL WORSTER'S REPORT BY C. E. GOVER.

1. Before entering into a discussion of any point in the report before me, it will be well to have a clear idea of what it contains. I will, therefore, give a very brief summary of the facts described or principles laid down in each paragraph.

Para. 1. States that experiments were made during six months upon these points—Is dry earth a good means of conservancy? What is the minimum quantity required for interior conservancy?

What is the combined quantity required; that is, including defecation in a pugmill? The first two are easily decided, the third varies with circumstances.

Paras. 2—4. Point out that the shape and size of closet vessels is important.

Para. 5. States that in suitable buckets, 2·5 pounds of dry earth is fully effective for interior conservancy; and that, in dry weather, the same quantity is equally effective for the pugmill.

Para. 6. This amount of earth must be increased, when the air carries more moisture, to three pounds per excretion. In the monsoon a still further increase is necessary.

Para. 7. Proposes preliminary discussion concerning "combined" conservancy.

Paras. 8, 9. Infer, from what has been publicly stated, that pugging ensures complete immunity from deleterious influence, and renders poudrette altogether innocuous and inoffensive. Denies this alleged fact, and asserts that the inoffensiveness of the poudrette after discharge from the mill is but temporary, since the fœcal odour soon returns.

Paras. 10, 11. Quote—"The application of an ordinary quantity of water will not cause offence." Infer that poudrette may be freely exposed, buried, or applied to the soil as manure without offence. Denies this. Repeated experiments prove that decay is merely dormant, and only water is required to renew the putrefactive process. Sulphuretted hydrogen, alkaline salts, and ammonia are then evolved.

Paras. 12, 13. The process of milling cannot eradicate the elements of putrefaction. Gases are, however, liberated during the process in a most offensive form, and in that proportion less remain with the poudrette. The final conversion of the poudrette must, under all

circumstances, be a work of time. It must, therefore, be dangerous to bury poudrette, especially during heavy rains, since the soluble portions will be carried down.

Para. 14. Only dry earth can effect combination innocuously; practically this condition does not prevail, since contact necessarily damps the earth. There is, therefore, little difference between the burial of milled and unmixed matter, since in either case putrefaction will continue until the mass is dry.

Para. 15. It may be urged that exhalations would arise from unmixed soil. Provided the earth covering be dry and sufficiently thick, all such exhalations would be absorbed by the covering earth.

Para. 16. Should experience shew that the disengagement of gas during milling materially accelerates decomposition, the mill would be useful, but not so much as to counterbalance the noisomeness of the process, and the suffering of the toties!

Paras. 17—19. The application of earth temporarily shuts in emanation. Other substances have this power. They have not the power of promoting or preventing decomposition. Soils vary in their power of disinfection. That employed in the Fort contains sand and salts; it is, therefore, more liable to be affected by moisture. This is unimportant, except in the mill which requires more earth in that proportion.

Paras. 20—24. Earth is applied in scoops from the pans, through defect in closets. But it is useless to fine or discharge toties, since those who left could not be replaced. Attempts to supply earth from rear failed in the "Men's privy." To succeed, great alterations in the closet are necessary. Twelve hoppers in family privy entirely failed.

Para. 25. Two pugmills were supplied to Regimental privies, but were too large and cumbrous. Time occupied from $\frac{3}{4}$ to $1\frac{3}{4}$ hours. Two smaller mills were afterwards built. These succeeded better and occupied from 20 to 25 minutes. They are used three times a day.

Para. 26. Artillery and Band closets must be served from front.

Paras. 27—30. Earth has only been applied to excretions during the day. Night evacuations receive earth in the morning. This affects the numerical determinations. Family buckets contain slops, and, therefore, require more earth. Lately, to simplify matters, the free liquid from the night is carried away in Punjab vessels.

Paras. 31—35. Day period, 11 hours; night, 13 hours. The calculations that follow are based upon separate observations for night and day. Combining the two, it is found that 25 per cent. of the strength use the closets twice a day.

Para. 36. Annual demand for a Regiment of 1,000 strength is 509 tons for interior conservancy.

Para. 37. Requirement for combined conservancy is difficult to ascertain. Mr. Gover makes no alteration for season. This is not proper. The unit must be increased during monsoon. The year should be divided into two parts—185 days, at 2·5 pounds, and 180 days, at three pounds.

Paras. 38, 39. This will raise the demand for 1,000 strength to 560 tons a year; but this amount will avail if all work correctly. A cart will be necessary.

Para. 40. Urinals require separate earth—83½ tons for 1,000 strength.

Para. 42. Deodorization of urine unnecessary in the Fort. It should go into the sea.

Paras. 43—45. Attendants proposed—

Single men's privy—10 toties, cost 50 Rs. per mensem.

Family do.	4 men,	„	20	„	„
	4 women,	„	20	„	„
Regimental privies...18			90		

Para. 47. Night privies required with hoppers.

Paras. 48—55. Other charges for carriage, probably Rupees 93 per mensem.

Para. 56. Earth required for Battery = 49 tons per annum.

Para. 57. For Garrison Guards and Band = 67 „ „

Para. 58. Establishment required for Artillery = 2 toties.

Para. 59. Do. do. for Garrison = 16 „

Para. 60. Do. do. will cost Rs. 2,783·1 per annum.

Para. 61. Do. may be reduced considerably under certain circumstances.

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2. I presume that the objects of the dry earth conservancy are three-fold—to ensure freedom from offence within the latrine; to ensure the inoffensive conveyance of the contents of the latrine vessels to a given point; and to permit the effectual and innocuous employment of fœcal matter (including urine) as manure. With regard to the first point, Colonel Worster admits fully the perfect success of dry earth. An application of 2·5 pounds of earth after each evacuation has been found ample to render the interior of the closets perfectly sweet.

3. With regard to the second and third points, Colonel Worster is strongly of opinion that the pugmill is not only of no benefit, but positively does harm. The grounds of his objection are—

(a). That milling is very laborious.

(b). That, under certain circumstances, it demands a larger supply of earth than is necessary for interior conservancy.

(c). That the operation of milling is intolerably offensive and must be prejudicial to the toties.

(d). That the inoffensiveness of the poudrette when it leaves the mill is merely temporary.

(e). That ultimate arrest of the putrefactive process is not and cannot be hastened by "milling."

(f). That it must be unwise to expose or bury poudrette, since it will either affect the air or the water.

(g). That pugged poudrette will at any time become offensive by the application of water.

4. I will venture to discuss each of these points.

5. *(a)*. It is true that milling is laborious while the operation continues. But with suitable mills, properly worked, a quarter of an hour is amply sufficient to ensure complete mixture. With the mills now in use, Colonel Worster estimates the time required at from 20 to 25 minutes. With the large number of persons in the Fort, the mills require to be worked three times a day, so that the total demand on their account is one hour's labor per diem. This surely is not beyond what any man ought to expect, and certainly cannot be a hardship. The time occupied does not in any way interfere with the ordinary arrangements of the latrine, since there is always an interval of some hours between the removals of the buckets; and, in no case, can milling extend through more than a fraction of the time thus left free.

6. *(b.)* It is also true that, under certain circumstances, the mill demands a larger supply of earth than would otherwise be necessary. Colonel Worster estimates that three pounds would be required in wet weather instead of two and a half pounds, and judges that the extra supply would be required for 180 days in the year.

7. It is necessary to remark, in passing, that there surely must be some mistake in an estimate which supposes that half the year in Madras is wet. Eighty-five days is about the average number in which any rain at all falls throughout the year, and on more than half these occasions the fall is very slight. There are only about eleven days in the year when more than one inch of rain falls. It is evident that nothing but a considerable fall could make a perceptible alteration in the quantity of earth required. But accepting the estimate in the report, the objection simply amounts to this—that on 180 days half a cart-load more of earth would be required. As a cart-load when delivered costs but 5 Annas, the extra supply would cost 2½ Annas, or perhaps 3 Annas per diem. I do not think that the objection when thus put into its real

form, will be thought to be of much weight. Colonel Worster is slightly inaccurate in his description of my practice. I do not indeed vary the quantity applied in the closet, but when more earth is required, it is applied at the mill as the mixture may need it.

8. *(c)*. My experience does not in any way corroborate the next objection. I have very frequently been present during the whole operation of milling, and very many other gentlemen have been also present, but have never met with the great noisomeness described. Of course the buckets cannot be emptied without some offence, but this would be equally great under any system, since they must be emptied at least twice a day. When an occasional sprinkling of earth upon the contents of the mill is given, the effluvia is certainly not great, and a suitable cover would prevent even that. I had a cover made for the mill under my charge, but have not used it, as it did not appear to be necessary. The boys and very many visitors have often witnessed the operation, but no complaint has been made. I believe both the Honorable R. S. Ellis and Dr. Macpherson when Sanitary Commissioners, Dr. Montgomery and Dr. Smith when Secretaries, have been present. They can thus speak from experience. As for the toties, they have not yet ceased wondering at their strange exemption from the many former disadvantages of their profession.

9. *(d)*. It is true that an effluvia does sometimes arise from the poudrette, after that it may have issued from the mill without offence. This was expected, since it is not pretended that *wet* poudrette is always inoffensive. Dryness is the essence of the system. But the inference to be drawn from Colonel Worster's language is, that the first inoffensiveness is fleeting, while the return of the offence is tolerably permanent. The fact is that the odour does not often return at all; and when it does recur, the action is but very temporary. As soon as the outside of the mass is tolerably dry, or if the whole mass be buried immediately, effluvia ceases. Under ordinary circumstances in Madras, the action pointed out in the report is so unimportant that it may be altogether disregarded: since in the hot season the drying of the outside is so rapid that the secondary action is anticipated, and Colonel Worster very truly states that a covering of dry earth (a small quantity sifted over it is ample) will at all times obviate the evil. What is more strange is that during the monsoon there appears to be no secondary action at all. During the late heavy rains, I have looked in vain for the return of the effluvia. Considerable heat must, therefore, be present together with air saturated with moisture, to overcome the marvellous power possessed by earth. Colonel Travers, who has long used the poudrette produced here, will be able to shew how very seldom he has noticed the return of the odour.

10. *(c.)* It is also quite true that the milling process only renders "the elements of decomposition merely dormant," and does not, *of itself*, in any way prevent ultimate putrefaction of the same kind as if earth had not been applied. There is no doubt that the action of the earth is merely mechanical. By the intimate admixture caused by the mill, each particle of earth seizes as it were a particle of fœcal matter and keeps it by its side. Water in sufficient quantity will, however, at any time dissolve the tie. But this curious property of earth is precisely the key to the whole question, and it is strange that its force should not have been observed. Nature exhibits a marvellous process of compensation. The earth is constantly receiving deleterious matter; but on and near the surface, whence the gases set free would issue to poison the air, nature has placed a wonderful series of re-agents and absorbents—the vegetable world. It would not be right to explain here how this process goes on, even if it were known by what power the fibres that tip the roots dissolve the substances they meet. Perhaps the most pungent and offensive of substances frequently employed is guano. Yet if it be placed in the way of the roots of certain plants, it is immediately decomposed, and disappears wholly from the soil. Just so with human ordure. Its effluvia is offensive and dangerous, yet if brought in the way of growing plants in a sufficiently diluted form it is immediately decomposed, and while affording the best nourishment to the plants, is rendered innocuous under all circumstances. The only thing wanting is a means of conveying and preserving this feculent matter to the soil without injury to the atmosphere. This point is considered of so much importance by the Government of India, that the Governor General has recently sent Circulars to all parts of the country, to urge upon its officials the duty of trying to discover a means of rendering it possible so far to defecate the poudrette as to make it expedient to store or convey it to other places without polluting the atmosphere. The pugmill meets the difficulty to its full extent. Colonel Worster admits that it does render dormant the putrefactive process, he would also admit that it dilutes the fœcal matter in a manner that demands no further labor or expense. Here then is a complete series of beneficial effects. The application of earth renders the closets sweet. The milling process renders the poudrette inoffensive, but preserves its fertilizing properties. Poudrette thus made can be innocuously carried to the fields where vegetation is languishing for want of suitable sustenance, and arrives there precisely in that form in which it can best be applied. Putrefaction is rendered dormant until the roots, with their strange chemical powers, appear on the scene, and at once liberate the pair so closely conjoined, and render the whole perfectly harmless to either air or water.

11. So important and effective is this natural process, that any quantity of poudrette might be thoroughly decomposed without any possible disadvantage by the immediate cultivation over the beds containing it of some rapidly growing plant whose roots are strongly absorbent. Guinea and Hurrialee grass are common plants in this district, which would probably answer admirably, while succulent vegetables, as beet-root, turnips, potatoes, and others of the same kind would probably be still more suitable. I have more than once tried the experiment on a small scale with great success, and have no doubt whatever that as a means of decomposition only, some such system would be found perfectly successful. Colonel Travers has proved beyond doubt that pugged poudrette is highly valuable as manure, and does not require that long preparation which so many other manures need. His experiments also shew very clearly that the decomposition effected by the roots of plants is very rapid. Where it is desired rapidly to decompose the poudrette, it has been found that a few weeks is often amply sufficient to cause all traces of ordure to disappear. My own experiments have produced the same results.

12. This being the case, the objection made in the report before me becomes plainly the best possible evidence of the success and suitability of the pugmill.

13. *(f.)* It is also true that poudrette will at any time become offensive by the application of water, if applied under certain conditions. But experience has confirmed the opinion that is quoted only to deny it, viz., that an ordinary climatic application of water will not cause offence. I have, for two successive years, given the matter a fair trial. A heap of about twenty tons of pugged poudrette was exposed throughout the whole of the monsoon of 1866. I will not go so far as to say that there was never any effluvia from the wet heap, but certainly there was nothing to cause offence at a distance of six or seven yards. As a further experiment, another heap of about ten tons was this year exposed to the whole of the rain that fell during the months from July to the end of October, and repeated observation enables me to say that there was no perceptible smell on any occasion when I visited the place. It is of course beyond contradiction that a heap of pure feculent matter under similar circumstances would have been intolerable. Buried poudrette never gives out any effluvia perceptible to the nose. These facts make it quite certain that pugging does afford very considerable protection against decomposition.

14. Of course I do not wish to be understood to challenge, in any degree, the results of Colonel Worster's very careful experiments. But

I conceive there is a very great difference between trying experiments in an air-tight bottle and in the open air. The fact that the air passes freely through the heap or soil is of considerable importance. It is well known that both the oxygen and nitrogen of the atmosphere readily combine with other gases in certain proportions; and, therefore, if decomposition goes on slowly, it is very probable that the atmospheric oxygen and other gases may combine with and render innocuous the gases so gradually evolved. If, on the other hand, an air-tight bottle be employed, the oxygen within it is soon absorbed and further remedial action prevented. However this may be, it is quite certain that poudrette will, in the open air, bear a large admixture with water without becoming offensive. A palpable evidence of this is given at the mill itself, where although the poudrette issues almost at the point of saturation, it is comparatively inoffensive. As a further illustration of this point, I would mention that the poudrette made this morning (November 30th) was exposed to the whole force of the very heavy rain that has fallen. The pit in which it was placed is now full of water, and has been so for at least seven hours. Yet at this time (5 P. M.) there is no perceptible smell. The temperature has been too low to permit the secondary action referred to above, while the intimate union with earth has, as yet, prevented that decomposition which, if earth had not been applied, would have disengaged from so large a quantity of ordure gases sufficient to have poisoned the atmosphere to a very considerable distance. It is, therefore, very clear that the mill does, even under the most unfavorable circumstances, have a very important effect in retarding decomposition when water is applied.

15. *(g.)* The foregoing considerations dispose of the next objection—that poudrette cannot safely be exposed or buried during the dry weather. During the monsoon there is more difficulty. It has, however, been shown that, even during the monsoon, poudrette has a manifest and very great advantage over pure or unmixed feculent matter. Analogy would certainly lead us to conclude that there would be corresponding advantage in its burial. Beyond this, and the fact that I have never been able to detect serious alteration for the worse in buried poudrette, my present knowledge does not enable me to go. But, taking the worst possible case, and supposing that poudrette would behave no better than unmixed feculent matter, it is impossible to discover how this fact can prove pugging to be injudicious. The ordure must be buried in any case. If pugged poudrette be no better, it can be no worse than fœces. If the objection be, therefore, adopted to its full extent, it simply proves that here is a point in which pugging does not actually benefit.

16. All the objections to the pugmill that occur to me have now been considered. It will be seen that the chief objection is in reality a full and complete admission of the excellence of the pugmill, and that the only tangible disadvantage pointed out is that at certain periods of the year the supply of earth will cost 2½ Annas a day more.

17. There is much in the remainder of the report that does not require notice from me. My further remarks shall, therefore, be confined to the three points—establishment, removal of poudrette, and apparatus.

18. With regard to the first, it is not stated what the previous charge was, and it is therefore impossible to say what increase of expense there has been. But it is suggested that it is by no means necessary that so much pains should be taken to reduce the earth to powder. Repeated observation and experiment have proved that, provided there is a certain proportion of powder, it is not an evil when small lumps occur. Anything under an inch in diameter will answer very well, provided (as always happens) that there is a considerable portion of fine soil. A standard sieve, with meshes an inch wide transversely, would enable one toty to sift with ease the whole of the earth required. One woman could crush all the lumps beyond the standard size. I venture to lay considerable stress upon this point, as it is certain that any system that is to be employed by a large number of uninterested persons must, to succeed, be free from refinements that can only be carried out by zealous supporters.

19. There can also be no doubt that two or three suitable handcarts or barrows would greatly reduce the amount of labor.

20 In these two ways alone a considerable saving of labor and therefore of expense might be made.

21. When the question of apparatus is considered, I shall be able to point out a means for still further reducing the present labors of the toties. The saving thus made would, of course, enable a further reduction of establishment to be made. It seems quite possible that the establishment may be reduced quite 50 per cent., although, of course, my knowledge of the circumstances, even after more than one visit, does not suffice to enable me to speak with any certainty upon this point. It would not be right if it were omitted to be mentioned that the salaries of the men-toties are decidedly low.

22. With regard to the second point, Colonel Worster suggests that the urine should be thrown into the sea. It is hard to conceive any reasonable objection to this proposal. Indeed, to one unacquainted with official secrets, it seems very hard to understand why the whole of the refuse should not be thrown into the sea. Its current flows past

The Fort gates. The ocean is nature's grand crucible—never polluted by any quantity of filth that man can put into it. At Liverpool the arm of the sea, called the River Mersey, receives the drainage of one of the greatest and filthiest cities in the world. To the filth of more than a million of people is added the refuse of innumerable manufactories, such as render the River Irwell as black as ink; yet at the foot of the landing stage the water runs as clear and bright as in mid-ocean. The Thames daily carries seawards from London the sewerage of three millions of people; yet at Southend the sea has absorbed it all, and remains without a stain. At Bristol, Marseilles, and Portsmouth a similar result is seen.

23. Madras possesses singular advantages in this respect. Throughout the year a strong current glides past the shore. For six months or thereabouts it flows in one direction, and for another six months it flows back again. No amount of earth thrown in can form a bank, and especially such light matter as forms the mass of the collections. Sir Arthur Cotton proved very clearly in his paper upon the proposed Madras Breakwater that the action of the current is so powerful that no accumulation of sand or other loose material could make a bank near the shore. There is not a tide throughout the year which does not remove a thousand tons of sand upon every mile of the beach, and small indeed would be the task of removing the street collections of Madras. There appears to be no valid reason why the present Pier should not be employed as a means of causing the refuse to be thrown into the current. Of course the discharge would always be made from the side facing the direction of the current, so that the piles would not intercept the material thus thrown in. If this could not be permitted, all that is required is that two stages should be erected extending a hundred feet into the sea at low tide—one should be at Royapooram, to be used when the current flows towards the north, and the other just near the new Workshops of Department Public Works, to be employed when the current turns towards the south. All refuse could be thus easily disposed of; and till poudrette be appreciated as manure, it also could be thus effectually removed from all possible injurious contact with either air or water. When nature has furnished so immense and perfect a deodorizing agent, which will, at the same time, remove without expense to mid-ocean all that is useless to ourselves, it does seem strange that rubbish depôts and filth boats and the whole present apparatus of removal should be kept up.

24. However all this may be, there can be no doubt that the whole of the closet products of the Fort might, without possible injury to any person or thing, at once be thrown into the sea. In that case

the pugmill would not be required until the value of poudrette as manure were better known. The buckets could be removed short distances and then emptied without causing inconvenience to any body. If this suggestion were carried out, the whole of the charges for removal might be struck out from Colonel Worster's table.

25. The third point, "apparatus," becomes important, when it is remembered that almost all authorities are agreed that the soldier or adult user of the latrine will not apply the earth himself. There seems good reason to doubt the correctness of this view, especially since some other similar ideas have proved incorrect; but the weight of authority is such that it is not likely the experiment will be tried. If the person himself will not apply the earth, it must be done for him either by machinery or by the toties. The machines that have been tried have failed, and at present one or more toties have always to be present in each latrine to apply the earth. It is plain that this must largely increase the number of toties required, and the consequent expense must be great. For some time past I have been engaged in the construction of an apparatus that may answer its purpose; and, after many trials, have now completed a machine which, so far as used here, succeeds admirably. Should further trial prove that it is adapted for general use, I shall be happy to place it at the disposal of Government. If it or any other suitable machine should be applied to the closets, the necessary number of toties will be largely diminished, with a corresponding saving of expense.

26. A supply of suitable hand-carts, like those used upon the Railway for the carriage of lamps, would greatly economize labor in the removal of closet pans.

27. There is very much in Colonel Worster's report which shews that the construction of the closets is very faulty. Personal inspection makes it clear that one chief difficulty has arisen from the thickness of the walls. The buckets should be removed from behind, but the arches are so small and the wall so thick that the bucket appears to be at the end of a miniature tunnel which must be very inconvenient to the toties. The best material for building closets appears to be "beton" or Portland cement concrete. A wall of this material, four inches thick, would be as strong as a brick wall of the best quality nine inches thick. Beton is perfectly impervious to damp, and will retain no effluvia that may exist in its neighbourhood. It can be employed without difficulty, and becomes as hard and enduring as the best stone. If this be not employed, a double wall, composed of roofing felt, three inches apart, would answer admirably, the interval being filled in with sand. The felt should, of course, be stretched upon a strong frame, and would only be employed

to fill in the large arches or other means of supporting the roof. By either of these arrangements, the buckets would be placed within reach of the toty's hand, while all needful strength would be secured. Either way would be cheaper than brick and chunam, and would serve very much better.

APPENDIX C.

REPORT ON DRY EARTH CONSERVANCY IN THE MILITARY MALE ORPHAN ASYLUM, MADRAS.

BY C. E. GOVER, PRINCIPAL AND SECRETARY.

MILITARY MALE ORPHAN ASYLUM,
December 6th, 1867.

TO THE SANITARY COMMISSIONER, MADRAS.

SIR,—In reply to your letter of the 7th November 1867, I have the honor to report upon the sanitary arrangements of this Institution connected with the latrines.

2. The Institution contains three main branches—the upper school of 236 lads, the nursery of about sixty lads, and the hospital containing on an average about five patients. At the present time there is but one lad on the sick list with a broken arm. For a fortnight past he has been the only occupant of the hospital.

3. The upper school is provided with a day closet, about fifty yards from the building; and a night closet, which occupies a corner of the dormitory and opens into it.

4. The nursery has but one closet, in the same building with the school-room and dormitory, but only opening into the verandah of the latter. The hospital is furnished with a day closet, about forty yards distant. The demands of the night are supplied by vessels in a corner of the larger room. The hospital is under the charge of the medical officer who is responsible for its condition, except so far as I may neglect to carry out his wishes. The rest of the Institution is under the charge of the Principal, who is responsible for everything.

5. In describing the present condition of the Asylum, I will commence with the upper school, and then describe the nursery hospital The day closet of the upper school is an airy building of very suitable construction. The actual closet and earth store are roofed, all the rest is open.

6. There is accommodation for sixteen persons at once. This is found amply sufficient for 250 lads. The only special arrangements are—an earth receiver, a paper receiver, and an urinal. The latter is a large wooden box, well tarred, which is kept filled with earth. Those who resort to the closet to pass urine only use this. The separation of the urinary excretion goes no further than this, since all combined evacuations are received into the buckets at the seats. The earth receiver is large enough to contain two days' supply of earth, so that in case of rain or accident the full demand shall still be met. In the closet is an iron scoop, sufficiently large to contain easily the proper quantity of earth. The *modus operandi* is very simple. When a person visits the latrine, he goes to the earth receiver as soon as he has risen, fills the scoop with earth and then drops the latter into the bucket, returning the scoop to the receiver. This is all that is required to render the interior of the closet perfectly sweet. Twice a day, when the buckets are tolerably full, they are emptied into the pugmill. This is usually done at 7 A. M. and 4 P. M. The operation of pugging takes about a quarter of an hour. When this is completed, the toty has nothing further to do till the time arrives for the next emptying, except occasionally to sweep the closet.

7. In dry weather, the earth required is daily dug by the lads from another portion of the compound, and conveyed straight to the receiver in the latrine, without either drying or pulverizing. To save trouble in digging, the place from which earth is to be dug is well watered, so that the earth when it reaches the latrine is by no means dry. I find that this gives no inconvenience beyond requiring a little extra earth in the pugmill. The earth store at the back of the closet is kept constantly full, but is not resorted to except in weather so wet as to make it inexpedient for the lads to be employed in digging.

8. In former reports I have minutely described the pugmill in use here. As it has been formally adopted by Government, it will not be necessary to describe it again. Suffice it to say that the same mill is now in use, and fully answers all previous descriptions of its utility and convenience. It immediately and thoroughly deodorizes the closet products without causing inconvenience or annoyance to anybody. It gives but half an hour's labor to the toty daily, but in that short space of time converts the fœcal matter into an inoffensive yet very valuable manure, for which there is a considerable demand. I could at almost all times dispose of much more than is manufactured without expense or trouble. If it were thought advisable the poudrette could doubtless be sold, and thus to some extent repay our expenses. The poudrette issues from the mill without odour, in the form of a thick dark

clay, but when dry, assumes a light brown colour. To dry it, I merely spread the mass, as it issues from the mill, upon the ground, taking care to break it up occasionally with a hoe, as otherwise the outside rapidly dries, and the mass cakes without being dry within. In certain states of the atmosphere there is a slight return of the fœcal odour while the poudrette is drying, but this can be immediately prevented by sprinkling a little earth over the surface. It has occasionally happened that a heap has gathered, but during ordinary weather it is quite impossible to distinguish it from a heap of ordinary earth. A very considerable fall of rain will cause no perceptible change. The milling so completely incorporates the mixture, that every particle of ordure is protected by a particle of earth adhering so closely that nothing but the continued application of water will separate them, and allow decomposition to commence.

9. I have largely employed the poudrette so manufactured as manure, with most beneficial results. Where water is soon to be applied in considerable quantities, the poudrette should not be employed as top dressing. The sun will gradually exhaust its fertilizing properties, water would tend to produce decomposition too rapidly. If it be ploughed in, so as to be covered with a few inches of soil, it proves a valuable aid to the cultivator without any disadvantages to counterbalance the good it affords.

10. The night closet is arranged upon the same principle as has been found so successful in the day latrine, except that it is much less convenient, and does not afford accommodation for earth urinal. The buckets are removed every morning, and their contents are passed through the mill.

11. The nursery closet is not so great a success. The children using it are so young—from five to eight years—that they cannot be depended upon to place earth in the vessels. I am, therefore, obliged to post a sentry there. With this arrangement all works well. The buckets here are also emptied twice a day into the mill. I propose, as soon as a more suitable room is provided, to furnish this closet with a self-acting apparatus that shall supply the earth. The present closet is only about seven feet square, and is singularly inconvenient in every way.

12. The arrangements of the hospital are very similar. The medical officer, Dr. Walter, will be able to give an independent report regarding them.

13. The whole of the closets are served by the one pugmill, which is amply large enough for a strength fifty per cent. in excess of any that we have yet reached. Irrespective of the hospital, where the proper duties of the toty are nominal, one toty performs the whole duty of the

Institution and of the several houses in the compound, comprising a total of about 350 persons. Nor is he by any means overworked. I give him the high salary of 8 Rupees, but this was chiefly as a recompense, for the fact that before the introduction of the earth system three persons were employed to perform the duties now discharged by this one man. The salary of this toty is now the sole expense incurred for the management of our latrines. As some misconception has arisen with regard to the question, whether or not there has been a diminution of expense here, I wish particularly to state that before the dry earth conservancy was introduced two toties were required for the closets themselves, and a bandyman and pair of bullocks for the removal of the ordure. The cost of all was not less than about Rupees 30 per mensem. The total expense now is Rupees 8 per mensem, so that in one case there has been a direct saving of about Rupees 22 per mensem. The produce of the sale of bullocks and cart more than paid the expense of the change, including the cost of the pugmill and the substitution of galvanized iron buckets for earthen chatties within the latrine. It should not, however, be forgotten that we possess a great advantage in the fact that the lads dig and carry the earth that is required. If earth were purchased, it would cost 5 Annas a cart-load. Two cart-loads would last three days, so that the charge on this head would be about 3½ Annas per diem. If this be added, it would follow that the cost to us, under less favorable circumstances, would be something less than Rupees 15 per mensem. This estimate would still leave a saving of Rupees 15 per mensem.

14. Perhaps I may be permitted to mention that ever since the introduction of the present system, the Asylum has been singularly healthy. One dreadful epidemic of cholera raged all round us, but there was no attack here. One case of death by sickness has occurred, but there can be little doubt that, humanly speaking, this was owing to causes external to the Asylum, over which we had no control. I believe the number of hospital cases last year was the lowest on record, although the orphans maintained were much more numerous than before. This year, as far as it has gone, has been even less marked by sickness. Of course it is not possible to say that this gratifying exemption from sickness is absolutely owing, either altogether or in part, to the improvement that has occurred in our latrines, but I trust it will not be considered presumptuous in me to believe that some portion of the improvement is due, humanly speaking, to the sanitary improvement that has occurred.

15. It is necessary that the former state of the Institution should be described. My first report to the Sanitary Commissioner contains

sufficient information on this point. I will, therefore, conclude by merely saying that to dry earth we owe a most marvellous improvement in our comfort, and that the pugmill is a very efficient means of giving to the earth its maximum power. I know of no drawback to the use of either in this place. The earth renders the closet sweet, the mill prevents the mixture thus obtained from ever becoming offensive or injurious unless under unusual influence.

I have the honor to be, &c.,

CHARLES E. GOVER,

Principal and Secy., M. M. O. Asylum.

The foregoing papers are certified as True Copies.

By order,

HOWARD B. MONTGOMERY, M. D.,

Secy. Sany. Commissioner for Madras.

APPENDIX D.

DESCRIPTION OF SELF-ACTING EARTH HOPPER FOR USE IN DRY CONSERVANCY LATRINES.

BY CHARLES E. GOVER.

The perspective view given in the large diagram will at once shew the general construction of the apparatus. The objects to be gained were chiefly these :—

1. An invariable supply of earth to the latrine vessels as soon as the user rises.
2. An easy withdrawal of the vessel by the toty when necessary.
3. Such a timing of the fall of the earth, as to ensure that those using the latrine shall not be inconvenienced by any dust that may arise.
4. Such a construction of the seat that the mouth of the bucket shall be so close to the seat that no urine shall escape by the front.
5. Special care to be taken that by no carelessness can any part of the user's person be crushed or caught.

6. Such a construction of the apparatus as to permit the use of unscreened and undried earth.

7. Non-liability to fracture or to be out of order.

8. Easy construction and repair when necessary.

9. A minimum of expense.

Before proceeding to describe the apparatus in detail, I would premise that its full benefit can never be derived unless the wall of the closet itself be erected somewhat after the fashion shewn in the perspective drawing. The closets should be in pairs. Between the pairs the wall should project to allow for the erection of steps, or the placing of a ladder to enable the toty to fill the receiver.

The essential part of the apparatus is the Charger (Fig. N). When the closet is unoccupied, the Charger is in the position shewn in Figs. B. and D.; the former being a bird's eye view of the Receiver and Charger, and the latter a side view, the dotted lines in which shew the condition of the interior of the Receiver. The seat, which works on a hinge at the front, is raised about an inch at the back. Immediately one sits upon the seat, his weight depresses it. Fig. E. exhibits an under-view of the seat, and Fig. F. a section shewing the iron struts by which the seat is connected with the lever shewn in Fig. H. When the seat is depressed, it carries down with it one end of this lever. This raises the other end, which is attached by an arm to the base of the Charger which it consequently raises, and throws into the position shewn in Figs. A. and C. The charge is now open at top and closed at bottom. Earth from the Receiver immediately runs into and fills it. Thus matters remain so long as the seat is occupied.

The Charger is made of solid wood, and is therefore heavy. Its weight is greatly increased by the insertion of a mass of iron or lead of about ten pounds weight as far from the axis as is consistent with strength. The weight of the sitter keeps the Charger up. Immediately he has risen, though not till then, the weight of the Charger brings it down, opening the bottom of the charge, and forcing the earth it contains downwards into the spout, which conveys it to the bucket. The time this operation takes is amply sufficient to allow the occupant to be well removed from the seat before the earth falls. The spout, Fig. O. should be only about fifteen degrees from the perpendicular, and not less than eighteen inches long, in order that the earth may receive sufficient momentum to enable it to fall well towards the front of the bucket, so that it may always crown the top of the heap that may be formed within the bucket. To secure the same object, the lower portion of the spout is curved outwards, so as to assist in throwing the earth to the proper distance.

The first of the desiderata referred to before is secured, partly by the spout being open, so that it cannot choke, but chiefly by the construction of the Receiver and Charger, the latter of which is the bottom of the former, and cannot move without bringing the earth with it. The slightest dampness always causes earth to "stick," unless great care be taken.

The difficulty is obviated in this machine in three ways: first, by the movable bottom of the Receiver carrying, as it does, a diamond-shaped protuberance upon its surface; secondly, by the steepness of its sides and front; and thirdly, by a system of "stops," which strike the Receiver every time the seat rises and falls. By these means immunity from sticking is secured, even although fresh damp earth be employed.

The second object is gained since the bucket is within easy reach of the toty's hand, and is at a convenient elevation.

The third point has been discussed when describing the working of the apparatus.

The fourth thing to be desired is obtained by placing the bucket upon a slope, and fitting it into a groove so arranged that the bucket will not enter at all, unless it be in its right place. The slope is such that the upper part of the front of the vessel touches the under side of the seat, so that no accident can happen, while there is no difficulty in the withdrawal. The same arrangement effects the fifth object.

The sixth is very important. It is certain that no scheme can succeed in the long run which shall always demand such care in the preparation of the earth as nothing but constant attention can ensure.

It will be observed that, in this apparatus, all apertures and passages are large enough to permit the free exit of any lumps as far as an inch in diameter, while the action is powerful enough to crush any ordinary lump that might fix itself at the one point where its stay would interfere with the working of the machine.

The apparatus that has been at work in this Institution has only been supplied with earth just as it has been dug by our lads, who water the ground daily where they are about to dig in order to render their work easier.

It will be observed, with regard to the seventh and eighth points, that the parts are so simple, yet so massive, that both construction and repair are extremely easy. For the very same reason it is almost impossible for the works to get out of order.

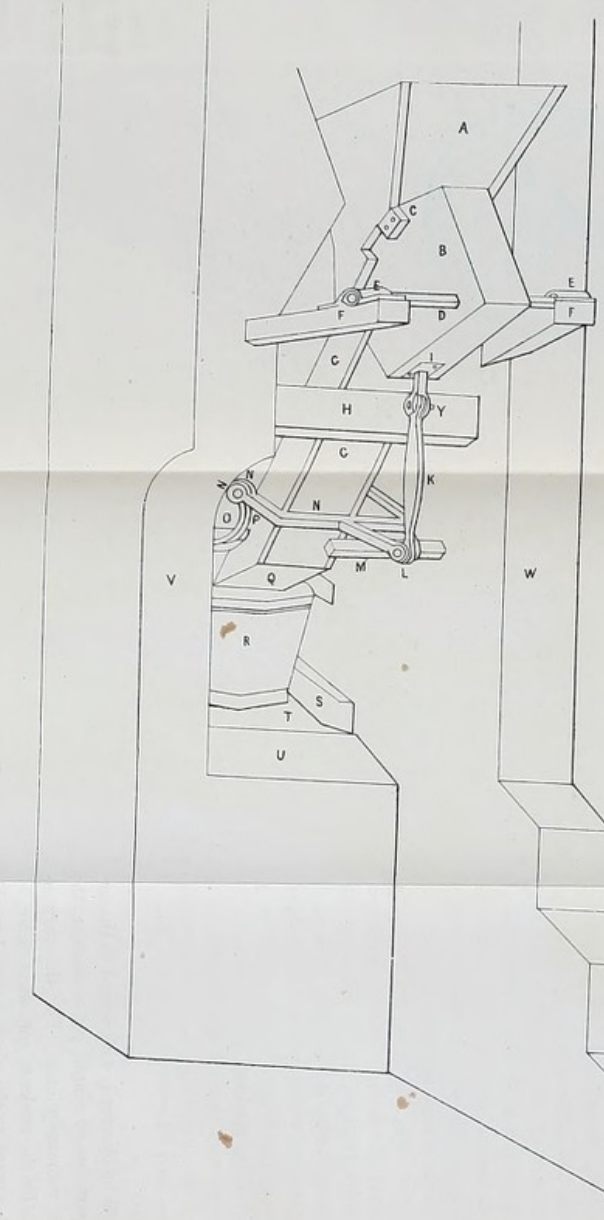
With regard to the ninth point, I would observe that the native blacksmith has offered to make any number of sets of the iron work for Rupees 6 per set complete; while the wood-work will not cost more than 5 Rupees, so that the whole cost of the apparatus will not be more

PLAN IN PERSPECTIVE

OF A

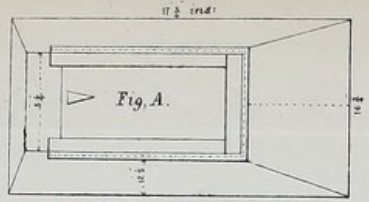
SELF ACTING EARTH CLOSET

By Charles. E. Gover Esq

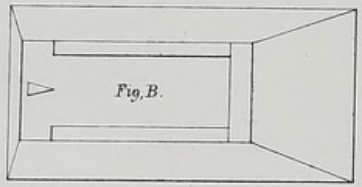


A Earth Receiver
B Charger
C Stop to prevent B's descent
D Spindle of B. Very strong
E Socket of D
F Wooden arms to support B.D.E
G Spout for descending earth
H Support to G
I Joint of lever with charger
K Lever
L Joint of K with horizontal lever
M Fulcrum of do
N Horizontal lever communicating power from L. to L.Y. and thence to Charger
O Seat
P Iron joining O with
Q Iron bottom of G
R Bucket
S Side of groove in which R fits
T Base of do
U Slope for withdrawing R
V W Side walls
X Steps
Y Joint
Z Joint.

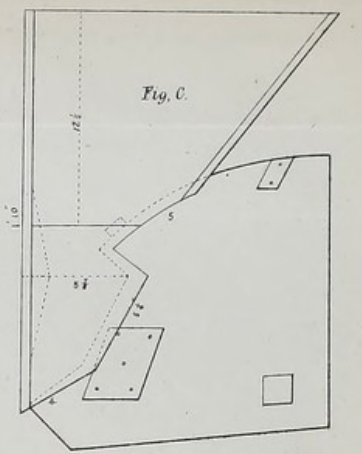
TRANSFER BY M. JACOBS. AND LITHS BY R.J. SALDREY, GOVT LITHS PRESS FORT ST GEORGE MADRAS 1869



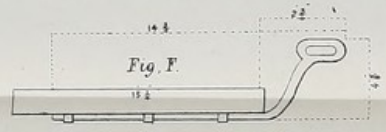
Bird's eye View of Receiver when charger is open



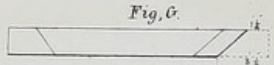
Bird's eye View of Receiver when charger is closed



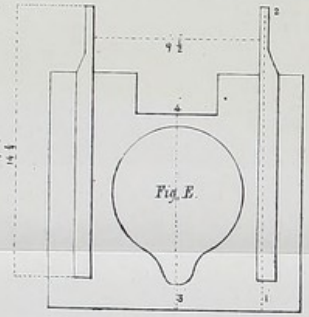
Side View of Receiver & charger when the latter is open The dotted lines show interior



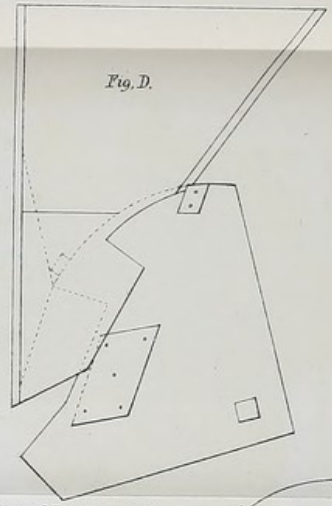
Section of Seat from 1 to 2 of Fig, E.



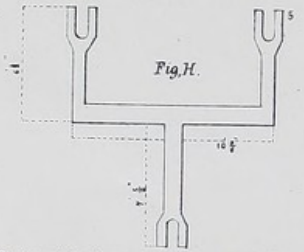
Section of Seat from 3 to 4 of Fig E



Under side of Seat, showing struts & opening for Spout



Side View of Receiver and charger when the latter is closed



Horizontal lever enclosing spout & Connecting Seat with upright iron connected with charger

Fig K

Front of Joint 5 ins: Fig, H

Fig L

Side Elevation of Working apparatus when the seat is down

TRANSFER BY W. JACOBS AND LITHO BY R. J. BALDREY, GOVT LITHO PRESS FORT ST GEORGE MADRAS 1869

than Rupees 11. Doubtless the cost would be less if made in the most advantageous manner.

I must not omit to mention that the peculiar shape of the Receiver, as shewn in Fig. M., is due to the necessity that exists for avoiding friction. If small particles of sand were allowed to work between the sides of the Receiver and Charger, they would at once rapidly wear out the machine, and enormously increase the difficulty of working. To avoid this, an interval of at least the eighth of an inch should be allowed between the Charger and Receiver, while strips of soft leather should be fastened to the latter, so as to overlap the upper surface of the former by three-quarters of an inch, as shewn in Figs. A. and B. The leather will prevent all but a very little earth from reaching the edge of the Charger, while whatever does arrive at that point immediately falls through without causing friction.

Awaiting your instructions, I will cause the model to remain until a decision has been come to with regard to the future application of the apparatus.

(Signed) CHARLES E. GOVER.

APPENDIX E.

REPORT ON DRY EARTH CONSERVANCY IN THE LATRINES OF THE 2ND REGIMENT NATIVE INFANTRY AT VEPERY.

From Colonel W. K. WORSTER, Barrack Master, to the QUARTER MASTER GENERAL, Fort Saint George, dated 7th September 1867, No. 1,327.

SIR,—I have the honor to enclose a statement of the cost of the six months' experimental earth conservancy in the Native latrines (male and female), in use with the 2nd Regiment Native Infantry at Vepery.

2. As the Report on this conservancy will be submitted by the Officer Commanding the Regiment, to whom the conduct of the experiment was transferred, it seems scarcely necessary for me to enter on the subject, further, than to state, that the expenditure of earth in these or similar latrines must be disproportionate to the numbers resorting to them.

3. This will be evident from the fact, that it is necessary to cover the floors of the channels with earth, for the absorption of fluids and for facility in cleansing. For a channel twenty-four feet long, by nine inches wide, a layer of earth of an inch in thickness will be about 120 lbs. This quantity, therefore, has to be added to that expended for shutting in emanations.

4. With four of these channels cleared three times a day, 1,440 lbs. will be required, and supposing 500 persons resort to the latrines daily, and that the quantity of earth for each application is 2 lbs., the total amount will be 2,440 lbs, or 4·88 lbs., each person.

5. An efficient pugmill was in use from the 4th April, and with the comparatively large quantities of earth in the mill, the incorporation was at all times effective in regard to coherency.

VEPERY.

Cost of Establishment and supply of Dry Earth for six months.

No.		Rate per mensem.	Actual total per month.	Actual total for the last six months.	Remarks.
		RS. A. P.	RS. A. P.	RS. A. P.	
	Cost of making and repairing a pugmill ...	... ...	... ...	233 5 9	
	March 1867.				
2	Box Carts, &c.	17 8 0	35 0 0	35 0 0	
2	Male Toties	4 6 0	8 12 0	8 12 0	
62	Cart loads of earth at 5 Annas per cart load.	... ...	... ...	19 6 0	
	April 1867 *to August* 1867, *Extra Establishment entertained.*				
2	Box Carts, &c.	17 8 0	35 0 0	175 0 0	Pugmill used on the 4th April 1867.
4	Male Toties	5 0 0	20 0 0	100 0 0	
2	Female Toties	4 6 0	8 12 0	43 12 0	
216	Cart loads of earth at 5 Annas per cart load.	... ...	... ...	67 8 0	
				682 11 9	

(Signed) W. K. Worster, Colonel,

Barrack Master.

7th September 1867.

From Colonel JOHN KITSON, Commandant, 2nd Regiment, N. I., to the DEPUTY ASSISTANT QUARTER MASTER GENERAL, Centre Division, dated Madras, 14th January 1868, No. 3.

SIR,—I have the honor to acknowledge the receipt of your letter, No. 72, of the 7th instant, enclosing copy of one from the Sanitary Commissioner to the address of Major-General Sir R. Smyth, K.C.B., No. 5, of the 4th idem.

2. In accordance with your instructions, I now report on the points on which information is especially required by the Sanitary Commissioner.

(a.) The latrines in the lines of the Regiment under my command appear to be duly appreciated.

(b.) The daily average number of males using them is 223, of females 177.

(c.) The quantity of earth daily used is 1,320 pounds; of mixed earth and soil 1,634 pounds.

(d.) The pugmill perfectly incorporates the earth with the soil, leaving hardly any perceptible smell, but the quantity of earth required for this makes the mill very hard to work. It has been five days out of working order since it has been in use, *i. e.*, since March 1867.

(e.) The information required under this head is, I understand from your letter under acknowledgment, to be furnished by the Barrack Master. I have no means of affording it.

3. I should add that, as far as concerns the daily average attendance, I think it will gradually become much greater, but the latrines have been several times out of use in consequence of alterations going on in them. In consequence, the people using them have at times been driven, of necessity, back to their old habits. The latrines too are so far removed from the Right Wing that they are hardly used at all by it.

4. I have been compelled to delay this report, in order to have accurate measurements of the earth and soil made for a few days so as to give a fair average.

The foregoing papers are certified as True Copies.

By order,

HOWARD B. MONTGOMERY, M. D.,
Secretary, Sanitary Commissioner for Madras.

APPENDIX F.

RULES EXPLANATORY OF THE OBJECT AND WORKING OF THE DRY EARTH SYSTEM OF SEWAGE IN ITS ADAPTATION TO BARRACKS, HOSPITALS, AND PUBLIC INSTITUTIONS.

FRAMED UNDER ORDERS OF GOVERNMENT, No. 1,376, OF 10TH APRIL 1865.

PREAMBLE.—The power of dry earth to render dormant decomposition in excrementitious matters and to keep latrines and urinals free from smell is almost absolute. But certain conditions are necessary to the full deodorant power of earth, and these are—

I.—Dryness.
II.—Its application in sufficient quantity.
III.—Its *immediate* application.
IV.—Its reduction to powder.
V.—The [illegible]ction of a suitable earth.

DRYNESS.—To secure dryness it is only necessary to procure and store the earth in dry weather, and to protect it from wet. A certain amount of moisture, as that taken up from the atmosphere, is not of practical importance.

QUANTITY TO BE USED.—The quantity necessary to deodorize each evacuation of a healthy adult is two and a half pounds. *Less* than this may fail in its objects; *more* adds to the labor and cost of supply and removal, and interferes with the proper working of the pugmill, if that machine be provided.

To deodorize the urine passed into the urinals, a much larger relative quantity is required, and which may be stated at thirty-six pounds for each imperial gallon, or six and three-quarter pounds for each man, assuming the urine of twenty-four hours to equal thirty fluid ounces (one and a half pints) in excess of that voided with each solid dejection. So that the total quantity of earth required to deodorize the whole excreta of an adult will be nine and a quarter pounds, of which two and a half pounds will be required in the latrines, and six and three-quarter pounds in the urinals.

METHOD OF APPLICATION.—The application must be *immediate* (by means of a scoop provided in latrines for the purpose, capable of taking

up two and a half pounds) so as at once to envelop the solid and absorb the fluid feculence; the object being not so much to correct or remove the fætor of decomposition after it has once set in, as to arrest or put in abeyance decomposition itself, for a period necessary to the removal of the earth and ordure from the premises.

Reduction to a state of powder.—The state of division to which the earth is brought is of importance. The more it is pulverized the better, especially if it be required for use in self-acting closets. For general use in latrines this fine state of division is not so necessary. Still screened and sifted earth is more efficacious than that which has not thus been prepared. Sufficient division is generally attainable without the use of sieves.

Kind of earth to be selected.—Earths vary in their deodorizing powers. Hence selection is necessary. Soils rich in organic matter possess the property in a high degree. Clays act better than loams, and loams, than sand. The mixture of earth and ordure removed from the latrines, if dried and kept dry, may be used over and over again. But omitting that compost, the following soils may be enumerated in order of eligibility:—

I.—Rich garden mould.
II.—Peaty soils.
III.—Black cotton soils.
IV.—Clays.
V.—Stiff clayey loams.
VI.—Red ferruginous loams.
VII.—Sandy loams.
VIII.—Sands.

Other conditions are essential to the efficient working of the system. The most essential is *dryness* not only of the earth, but of the system. No water must be used in or about the latrines. Any accidental dripping of fluids must be covered and absorbed by dry earth. The privy pans and other utensils must be cleaned and scoured with dry earth—the floors of the latrines dusted with earth and swept—*never washed.*

Pugmill.—If the pugmill be supplied, complete incorporation of the mass of earth and excrement must be effected before it be removed. But to the efficient use of this mill its principles of construction must be scrupulously adhered to, and a certain methodical system be followed in the preparation of the mixture of earth and soil for the mill, in its transfer to the mill, and in the working of the mill itself. This will be explained hereafter.

The milled mass can be removed without offence in an open cart; but covered carts, to meet different states of the weather, are necessary, as *wet* will set up putrefactive changes in the stuff.

Receptacles for contents of Privy pans.—Receptacles, and preferably of iron, are necessary in the latrines to receive the contents of the privy pans from time to time, and for removal of the compost to the carts.

Disposal of Poudrette.—The disposal of the mixture is generally by burial in pits, the object being to get rid of it under ground as speedily as possible, an alternative forced upon us by the fact that no commercial value attaches to the compost in this country.

But actually it constitutes a most valuable manure, capable (so far as the weight of evidence goes) of being immediately applied to the soil. It is, therefore, the duty of the authorities charged with the conservancy of Barracks, Hospitals, and Public Institutions, to impress upon those interested, the value of this compost as a manure, and so far as lies in their power to bring about its use as a fertilizer of the soil, instead of wasting it by burial in pits.

Its utilization in soldiers' gardens may be sanctioned under supervision. It should be ploughed or dug into the soil rather than spread on the surface. But the safest plan will be to prepare lines of shallow trenches, such as the furrows made by the plough, to deposit the manure in them and then to cover it over. On irrigation, or after rain fall, the water will dissolve out any soluble matter and convey it to the roots of the growing plants, while the gases given off by decomposition of the stuff will be absorbed by the soil, and appropriated also by the plants. Utilization of the contents of the pits in this way will not, it is believed, be attended by any risk. The fallow and manured land might be made to alternate each year, and thus the soil would never be exhausted.

Sites for and conservancy of filth pits as they are termed.—The selection of sites for deposit of the 'Poudrette,' must be made not only with reference to distance from Lines and Barracks, but also with regard to the nature of the strata composing the subsoils and rocks.

The '*dip*,' or inclination of the beds with reference to the direction of lines of drainage of sub-soil waters, should be especially noted, and in all instances sites on which the 'dip' of the strata is away from the lines should be selected. This is necessary to secure the wells from contamination.

The levels and conformation of the surface do not always indicate the inclination of the lower strata, so that it is necessary that some skilled knowledge should be brought to bear upon the subject of selec-

tion of sites for deposit pits. This knowledge will be possessed by Engineer and Medical Officers.

In regard to the *conservancy* of the pits, if the mixture of the earth and night-soil is pugged in the mill, or if a sufficiency of earth is used in the latrines, nothing further is required than to deposit the compost in the pits till they are filled to within three feet of the top, and then to cover them over with fresh earth.

If it be, however, desired to keep the mixture in a condition fit for utilization, as required in soldiers' gardens, or for disposal by sale as manure, it will be necessary to protect the pit from the entrance of rain by surrounding it with a low wall, and surmounting it with a roof. Thus protected and kept dry, decomposition is arrested.

Having explained the general principles of the dry earth system of sewage, and of the utilization of the compost as a manure, I proceed to give in detail the working of the system in latrines, and first—

A.—European Latrines.

The following appliances are necessary :—

I.—A suitable store, at the latrines, of sifted earth.

II.—Scoops capable of holding two and a half pounds of earth.

III.—Iron receptacles to receive contents of privy pans.

IV.—A toty in constant attendance to apply the earth as required.

Detail of Operations.

I.—Place half a scoopful of earth in each privy pan.

II.—Half fill each urinal with dry earth.

III.—On a privy pan being used, add *immediately* a scoopful of earth.

IV.—Inspect the urinals from time to time and see that there is a sufficiency of earth.

V.—At regular intervals of twelve hours remove the privy receptacles and urine tubs to pugmill.

VI.—Place about seven pounds of earth at bottom of the mill, then transfer the contents of the vessels one by one to the mill, making a few revolutions of the handle each time. In this way transfer the contents of each vessel, adding as much earth as may be necessary. Work the mill for quarter of an hour.

N. B.—If the earth bears a proper proportion to the soil, the mass will well out as a stiff paste. If too little earth is added, the mass will be too thin and not properly deodorized. If too much, it will be too stiff

and great difficulty will be experienced in working the mill. The proper quantity can only be learned by experience.

VII.—Open door of mill, receive the compost in any convenient vessel, and transfer to cart.

VIII.—Scrub out each receptacle, privy pan, and urinal, with dry earth while the milling is going on.

IX.—Clean the mill itself in the same way with a little dry earth.

X.—Add the requisite amount of dry earth to each privy pan and urinal before putting them back in the privies and urinaries.

If these detailed instructions are carefully attended to (and very little practice on the part of those charged with supervision is all that is necessary,) the system will prove an entire success.

The privies will be without odour, the contents of the receptacles and urinals can be transferred to the mill, the milling process be carried out, and the mill stuff removed without any offensiveness.

Coal tar should be applied to all utensils used. It is not a constituent part of the dry earth system, but it is an important adjunct, and its use should not be neglected. All works in the privies, and the walls themselves to the height of three feet, should be painted with it.

B.—Native Latrines.

The requirements provided for in standard plan privies for Natives are :—

I.—An earth store.

II.—Troughs or trenches for defæcation.

III.—A cistern for water.

IV.—Asphalte pavement for ablution, but any suitable place can be converted into a dry earth latrine for Natives if the above essentials are attended to.

Detail of Operations.

I.—Place two inches of earth in the trenches or troughs.

II.—Add earth in the proportion of two and a half pounds to each evacuation passed into the trough.

III.—Transfer the contents of the troughs twice in twenty-four hours to the pugmill if one be provided, or to carts for removal.

The system sometimes followed of filling the troughs at one operation nearly full of earth must be interdicted. It leads to a much larger use of earth than is necessary, renders the mixture incapable of being worked in the pugmill, and adds much to the cost of carriage.

Particular attention must be paid to the ablutions practised. They must be performed, in the standard plan privies, over the pavement provided for the purpose, or in other latrines at a place specially set aside—*never over the troughs.*

The foregoing rules are applicable to any buildings used upon the dry earth system, and do not restrict themselves to standard plan privies and urinaries.

Indeed, the system is a most elastic one, and by attention to the essential principles already given, any latrine can be converted into a dry earth latrine. All that is necessary to secure freedom from smell in the building is—

That earth be added in sufficient quantity to cover and absorb solid and fluid feculence.

That the application be immediate.

That the mass of earth and ordure be periodically removed.

This being understood, considerable latitude is given in the adaptation of existing buildings to dry earth latrines. In fact, in the absence of privies specially designed for the purpose, the system is capable of being applied to any convenient building.

J. L. RANKING,
Sanitary Commissioner for Madras.

The foregoing Report was forwarded to the Quarter Master General, Fort Saint George, with the following letter, No. 245, dated 23rd March, from the Sanitary Commissioner.

"I have the honor to forward, for the information of His Excellency the Commander-in-Chief, and for submission to Government, copy* of a further report upon the dry earth system of sewage.

* With five spare copies.

2. "Instead of simply replying to your Memorandum, No. 1,445, of 27th September 1867, (received prior to my appointment to the office of Sanitary Commissioner,) giving cover to Colonel Worster's report upon the experiments undertaken in the latrines of Fort Saint George, I have thought it better to submit a comprehensive report upon the whole subject, with reference to the Proceedings of Government, noted in the margin, in which such report was called for, and which it has not been possible to submit earlier. Indeed, even now, as noted in the body of the report, I am not in a position to give definite information upon the important question of expense attending the introduction of the system, neither have I yet received the report, so long due,

No. 389, dated 11th March 1867.

of the results of experiments undertaken at Secunderabad under the Orders of Government, No. 2,205, dated 28th June 1866.

3. "There can be, I think, no further question of the great superiority of the system over that which preceded it, and of its important sanitary bearings upon the health of the troops, and I am justified in recommending that it be authoritatively introduced throughout the Army of this Presidency."

Under date the 17th April 1868, the Quarter Master General addressed the following letter, No. 3,164, to the Secretary to Government, Military Department.

"Adverting to the Order of Government, dated 28th June 1866, No. 2,205, I have the honor, by order, to forward for submission to Government, a letter from the Sanitary Commissioner, giving cover to his report on the dry earth system of conservancy. Appended to this document is the Barrack Master's report on the trial of that system, carried out in the privies of the European Regiment in Fort Saint George, as directed in the above quoted Order of Government.

23rd March 1868, No. 245.

2. "The advantages of the dry earth system of conservancy have been so generally admitted, that it is scarcely necessary for the Commander-in-Chief to say that he advocates its introduction in the latrines of all European Corps as soon as possible. The extra expense involved in the adoption of the system cannot, apparently, be at present determined as a general question,* but it may be inferred from the 77th paragraph of Mr. Ranking's report, that the additional cost for establishments will not be very considerable, and as the benefit that will be derived from the system will be so great, it is inexpedient, in His Excellency's opinion, to postpone its adoption pending full particulars of cost.

* *Vide* paragraph 19, page 32.

3. "Independent of establishments, the Commander-in-Chief observes, that the following charges must necessarily be incurred, viz., sheds for storing dry earth to meet the requirements of the latrines during the monsoon; and carts with boxes with air-tight lids for the conveyance of the contents of the latrine vessels to the deposit pits, not only during the rainy season, but at all times.

4. "The application of dry earth for the deodorization of urinaries would obviously involve so great an expense, that the substitution* of either McDougall's Disinfecting Powder or Carbolic Acid for it seems very desirable.

* *Vide* paragraphs 93 and 94, page 33.

5. "With respect to the 'Pugmill,' the results of Colonel Worster's and Mr. Gover's experience as to its efficiency for the purpose for which it is intended are so much at variance, that it is for Government to determine whether the Chemical Examiner should be referred to for his report on the subject. The Commander-in-Chief observes that the 'Mill' is not absolutely requisite for the working of the dry earth system *per se*, and its use would doubtless add to the expense; His Excellency, therefore, thinks that mills should not be constructed until at least their efficacy is placed beyond question.

6. "With regard to latrines for Natives, the Commander-in-Chief considers it very desirable that the dry earth system should be carried out in them also. From the Sanitary Commissioner's report, page XXXVIII. it will apparently be unnecessary to erect buildings for the system upon the expensive standard plan approved of in the Order of Government, No. 2,538, dated 20th August 1867, Public Works Department. The sanction of Government will hereafter be asked for the erection of suitable buildings for the purpose in the vicinity of Regimental lines, whenever Commanding Officers recommend their construction.

7. "In concluding this letter, the Commander-in-Chief directs me to invite the special attention of the Right Honorable the Governor in Council to the practice which obtains at the Male Asylum of burying the compost taken from the pugmill in pits in the Asylum premises. This seems to His Excellency to be very objectionable; for the Sanitary Commissioner himself admits (paragraph 88) that decomposition most likely does take place in the milled mass in the pit, and that thus there is a measure of danger of contamination of neighbouring springs of water. Is it then prudent to run so serious a risk in such a locality?"

On the 9th June 1868, the following Order was passed by Government in the Military Department:—

"No. 2,258.

"The Governor in Council concurs with the Commander-in-Chief, that it is expedient to authorise the introduction of the dry conservancy system into the latrines of all European Corps, as soon as possible; before doing so, however, His Lordship in Council considers it advisable to request His Excellency to cause Government to be furnished with an approximate estimate of the extra expense, which will necessarily be incurred at each station, both in buildings and establishments.

2. "The erection of pugmills will be deferred, until it is satisfactorily established that they are necessary for the efficient working of the dry earth system.

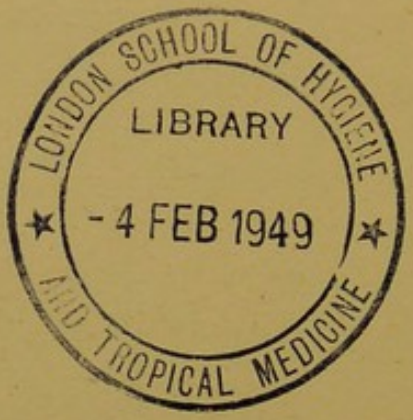
3. "As it appears from the Sanitary Commissioner's report, that the use of McDougall's Disinfecting Powder is as efficacious and more economical than dry earth for urinaries, the cost of the quantity required should be included in the estimate.

4. "The Governor in Council will also be prepared to authorise the introduction of the dry conservancy system into the latrines of Native Regiments, whenever His Excellency the Commander-in-Chief may recommend it, and on being furnished with a detailed estimate of the extra expense which it will entail.

5. "With reference to the last paragraph of the Quarter Master General's letter above recorded, the Sanitary Commissioner will furnish Government with his opinion regarding the practice which obtains at the Military Male Asylum of burying the compost taken from the pug-mill in pits on the Asylum premises."

(True Extract.)

(Signed) C. S. Elliot, Major,
Offg. Deputy Secretary to Govt.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