Printed reports by Lieutenant Colonel A.M. Davies, RAMC, in connection with local investigations at stations in Britain where there seemed to have been undue prevalence of preventible illness

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RAMC 604

It is requested that in any further communication on this subject, the above Number may be quoted; and the Letter addressed to—

The Director-General,
Army Medical Service,
18, Victoria Street,
London, S.W.

WAR OFFICE,
LONDON, S.W.,
January, 1903.

SIR,

I am directed to acquaint you that certain reports have been made from time to time by Lieut-Colonel A. M. Davies, R. A. M. C., in connection with local investigations at stations where there seemed to have been undue prevalence of preventible diseases.

These reports, which are very thorough and complete, and upon which action has, or is, being taken, have been printed with a view to circulation, as, in addition to their value for the purposes for which they were prepared, they have an educational value, and it is considered that they would be useful as guides to Medical Officers when carrying out similar enquiries.

A supply is accordingly sent for distribution to Station Hospitals and to Military Medical Officers generally.

I have the honour to be,
SIR,
Your obedient Servant,
W. TAYLOR,
Director-General.

The
Principal Medical Officer.

Capt. S. W. Hardy
Khartoum

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499

Report on Prevalence of Sore Throat at Woolwich, in connexion with the Dockyard Basins.

I have the honour to report that, in accordance with instructions, I have during the last few weeks visited Woolwich in order to inquire into a recent prevalence of sore throat amongst men working in the Royal Dockyard. It had been suggested that this prevalence had been due to bad smells arising from a sheet of water known as the *Inner Basin*,* and it was especially with a view to trace out any such connexion that my inquiries have been directed. Some delay has occurred in arriving at facts, on account of the existence of five different and independent jurisdictions, or spheres of employment, within the Dockyard, and some dozen or more different military units in the garrison, necessitating repeated visits to get hold of the men concerned.

2. It appeared to be most convenient, first, to ascertain definitely whether there had recently been any marked prevalence of cases of sore throat, and if so, its nature and extent; and secondly, if any definite connexion could be traced between these cases and the Inner Basin. At the very beginning of the inquiry I found two "general impressions" existed in the neighbourhood: that there had been a good deal of sore throat amongst the dockyard workers in July and August; and that "sore throat" was, if not always present in Woolwich, at any rate so common that any one arriving there for duty might naturally expect to get an attack, as it were, by way of becoming acclimatised. On inquiry from the Medical Officer of Health for the Borough (Dr. Sidney Davies), I was informed that during the last summer there had been no special incidence of throat illness in Woolwich generally, and that diphtheria and scarlet fever had been below the average. Sore throat is not a notifiable disease, but there can be little doubt that, if there had been any well-marked outbreak in the borough, the Medical Officer of Health would have become aware of it.

3. In regard to the civilian employés in the Dockyard, it appears that from the beginning of July to the end of the first week in September, 13 cases of sore throat, tonsillitis, or quinsy, reported themselves to the Medical Officer in charge. Two of these cases I could not trace: the remaining 11 I was able to see personally; 3 belonged to the Army Ordnance Department, 4 to the Department of Inspection of General Stores, 3 to the Building Works Department, and 1 to the Supply Reserve Depôt. Of these men, two habitually worked around, or near to, the Inner Basin: the remaining 9 either worked indoors, or in a part of the Yard away from the basin, or else all about the Yard, and not specially connected with the basin. None of these men attributed their sore throat to bad smells, arising from the basin or elsewhere. Although such a possibility cannot be denied, there seems to be no evidence of any connexion between any condition of the basin and these cases of sore throat. One man only (of these cases) complained of any offensive smell from the basin, but his work did not have any connexion with it.

4. There is, however, very definite testimony on all sides as to the occurrence of very bad smells in the Yard during the past summer, as well as in previous years. By some people the stench was definitely attributed to the basin, by others to the river itself. As to the latter there can be no

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* The *Outer Basin* has had its water changed several times during the past few months, and no complaint is made regarding any bad smells arising therefrom.

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562

doubt. The Medical Officer of Health for Woolwich states that "the river was very foul for some weeks": several men, constantly employed at the wharf, stated that the smell was frequently offensive and sickening; several officers employed in the Dockyard said the same thing. As to the basin, the officers employed in the Inspection of General Stores Office, and in the Chief Ordnance Officer's Office, complained strongly of the very offensive smell that had arisen from it during the hot weather. Dr. Donald, medical officer in charge, also testified to the formation of gas bubbles on the surface of the water (no doubt sulphuretted hydrogen), indicating decomposition of organic matter in the mud at bottom.

5. Two other cases came to my notice, on particular inquiry. (1) The caretaker of the Ordnance Office lives in a quarter overlooking the basin: he stated that it was necessary to keep the front windows of the house closed, on account of the bad smells; his wife said the same thing, and attributed a severe sore throat of some weeks back to this cause. I detected a marked "sewer-air" smell in the water-closet of this quarter, which possibly might account for this sore throat (especially if the windows were habitually kept shut: the w.c. ventilates into the house-passage). There is, however, no reason to doubt the statements of Mr. and Mrs. Curtis that a bad smell is very frequently to be observed coming from the basin in front of their house. (2) Mr. Marrable, clerk of works, stated that he himself, and his family, constantly suffered from sore throats, which he believed to be due to the bad smells, originating from either the river or the basin—so bad that the windows had to be kept shut. This house is at some distance from the basin, and several buildings intervene, so that the river-origin appears to be the more likely of the two.

6. On the whole, as regards the civilian employés, though there is decided evidence as to the occurrence of bad smells in the Dockyard, and good reason to believe that these originate in some degree (but not altogether, and perhaps not principally) from the Inner Basin, there does not seem to be definite evidence that these bad smells have caused sore throats; though there is a possibility, and in two instances almost a probability, that such has been the case.

7. With regard to soldiers employed in the Dockyard, on fatigues, or going through courses of instruction, or otherwise engaged there, I found it impossible to obtain any complete list of these men: I accordingly extracted from the attendance books of the Auxiliary Hospital the names of all men who had reported sick with sore throat, tonsillitis, or quinsy, from July 1st until September 10th (the date of commencement of this inquiry), and acertained from the men personally whether they had been employed at the dockyard or not. The total number of these cases of sickness between the dates named was 168. I was able to interview all of them personally, with the exception of about 20, who had left the station. Of the total number, 16 only had been connected in any way with the Dockyard: 3 men had worked in the collarmaker's shop, 3 in the smith's shop, 2 in the wheeler's shop, 3 in the Ordnance College workshops, 1 in the saddler's shop, and 1 in the Royal Artillery Records Office. None of these men worked alongside of, or even near to, the Inner Basin: three other men, who had been to the Dockyard occasionally, on fatigues, &c., stated that they had not been anywhere near to this basin. Several of these men had noticed a bad smell during the hot weather, but not one attributed it to the basin; it was generally supposed to come from the river. In no instance was the sore throat attributed to any bad smell: it was generally thought to be due to "a bit of a cold"; in two instances, to chill on coming out from a heated workshop.

8. In regard to soldiers, therefore, just as in regard to civilians, employed in the yard, I can find no evidence that sore throats were caused by, or connected with, any condition of the Inner Basin.

9. The chief facts arrived at in the present inquiry are as follows:—

(1.) There has been a considerable prevalence of sore throat and allied

affections amongst the troops at Woolwich and (to a much less extent) in the civilian employés at the Royal Dockyard during the past summer. I am not able to give any statistical comparison with regard to previous years, because it is not only (or principally) admissions to hospital, but *all cases* of men complaining of throat ailment that have been investigated; and of such no record for previous years is obtainable. The medical officers in charge of the Auxiliary Hospital, and of the Dockyard, are both of opinion that there has been more throat illness during the past summer than usual.

(2.) There is definite (though not widespread) testimony to the occurrence of bad smells arising from the Inner Basin during the past summer; also that gas bubbles formed on its surface, denoting, there is little doubt, the formation of sulphuretted hydrogen, due to decomposition of the mud in the basin. There is a more general testimony to the occurrence of bad smells in the Dockyard, without definitely attributing them to this basin. There is no doubt the river was often very offensive in this respect.

(3.) There is no evidence to connect the occurrence of the cases of sore throat with the emanation of bad smells from the basin. Sore throat was prevalent throughout the garrison, not specially among men working in the Dockyard. Of the soldiers that suffered from sore throat none were specially connected with the basin, indeed all were employed at some distance from it, and none attributed their sore throat to this cause. Of the civilians only two out of eleven worked near the basin, and none attributed their sore throat to this cause. In the case of Mrs. Curtis such an origin is possible, but I incline to the belief that a badly ventilated drain was a more likely cause: in the case of Mr. Marrable's family, if bad smells were the cause of the sore throats, the river was at least as likely a source for the bad smells as the basin.

10. I am unable, therefore, to recommend that the basin should be cleaned out an account of illness having resulted from its offensive condition. Neither do I consider that any improvement is practically to be obtained from the free use of disinfectants. The area of the basin is 2 acres, 2 roods, and 2 perches, or 109,444 square feet; the depth of water and mud is 12 feet; the cubical content is therefore 1,313,328 cubic feet, or 8,208,300 gallons. No disinfectant could be usefully applied to such a large volume of fluid without very great expense; and, in my opinion, no permanent improvement would result.

11. While unable to trace any connexion between the throat affections (or any other illness) of the past summer and the condition of this basin, I cannot help thinking that it is unadvisable that this large sheet of water should remain stagnant—for ever. It can hardly be beneficial, it may some day be prejudicial, to health, and it has certainly been a nuisance already. The large space which it at present occupies to no purpose might probably be turned to good account, if the basin were emptied and cleansed.

A. M. DAVIES,
Lt.-Col., R.A.M.C.

24th October, 1901.

Report on Sanitary Investigations at Shoeburyness.

I.—On the Sanitary Condition of Shoeburyness Barracks.

1. *Water Supply.*

1. The water supply for Shoeburyness Barracks is derived from a deep well, 9 feet in diameter, the property of the War Department, and situated within War Department boundaries; for a depth of 80 feet the well is lined with cast iron "tubbing"; below this there is brick steining for a depth of 89 feet, down to the bottom of the well; below this is the London Clay, in which a bore-pipe is carried down to 434 feet, at which depth the water-bearing strata (sand and pebbles of the Lower London Tertiaries) are entered; the bore-pipe is "blown in" at 438 feet. This well is therefore a *bonâ fide* deep well, and should furnish a water free from all organic contamination. It contains, however, a large quantity of chloride of sodium (33 per 100,000 of chlorine), and the total solids are excessive (94·2 per 100,000); the hardness is very slight (total being only 2·5), and in all other chemical respects it is a good water, free and albuminoid ammonia and nitrites and oxidisable matter being either absent or only present in minute proportion (analysis at Netley, August, 1899). The deposit was stated to be very small, consisting only of sand and vegetable débris; and bacteriological examination revealed no signs of sewage contamination.

2. The water is distributed in the usual way to cisterns in the different barracks; these are provided with wooden covers, and are periodically cleaned out. They are placed in what are called "cleaning rooms," some of which are occupied as battery offices, some as store rooms; in the former there are clerks engaged during a great part of the day, and often six or eight persons are present in a comparatively small space; in the latter, arms, kits and stores of various kinds are deposited. In either case, though not called "barrack rooms," they are "inhabited spaces," and the air of the rooms would contain human effluvia and dust, which should on no account gain access to a drinking-water supply. The wooden covers to the cisterns are not, from the nature of the case, close-fitting; and besides, there is a large hole in each to give place to the ball-valve; the water is therefore liable to receive dangerous organic pollution. Either a tight-fitting iron cover should be provided, or (which would be much to be preferred) the storage cisterns should be done away with altogether.

3. The village of Shoeburyness is supplied from a similar well of about the same depth, the property of the Urban District Council; this was completed, and the new supply laid on, in 1897; previous to this, the inhabitants were dependent on shallow surface wells. This has an important bearing on the health of the civil population in the neighbourhood (and of the military who live in lodgings outside barracks). The village proper of South Shoebury has been efficiently sewered for many years; therefore, though shallow wells were used for water supply, they were not in such danger of grave contamination as if cesspools had still been in use; this, however, was the case at Cambridge Town, where a drainage system was only introduced in 1898: before this date the shallow wells and cesspits were sunk within a few yards of each other, with the natural consequence that enteric fever was endemic in this district.

2. *Drainage.*

4. The drainage arrangements of the barracks are satisfactory in their general plan, but faulty in several points of detail. This has long been

(Wt. W. 2459 1500 7|02 H & S 9080) P. 02
562

known to be the case, and the whole system is now in process of relaying, as funds are available. The chief difficulty has been the small amount of fall; a necessity of the case, owing to the situation at the sea level. Another difficulty has arisen from the nature of the soil, which is sand and gravel at the surface, with clay or loam beneath; it has been ascertained in several instances that the drains have sunk in their length, due to settlement of the soil on which they rest. Some years back manholes were constructed at all points where it was desirable to have them, and since then it has been possible to locate obstructions and apply the necessary measures in good time. I examined a considerable portion of the drainage system; at one place there was a partial stoppage, and at several points there was to be noted some sluggishness in the flow, and a tendency to deposit. Nowhere, however, was there any offensive smell, or sewer-gas under pressure, to be detected; and I do not think that the drains, although defective, are likely to have had any bad effect on the health of the troops hitherto. There are adequate arrangements for ventilation, and the drains have been frequently flushed; so that, as there have been such excellent means of examining them (owing to the large number of manholes) the general condition has been satisfactory.

5. The outlet of the drainage system is into a tide-locked tank on the beach; this is ventilated by a 12-inch shaft carried up the wall, and above the eaves, of a lofty building occupied as officers' quarters; from the tank a sewer-pipe leads into a tidal "swin" or channel in the sand, the pipe being carried out to a point where the "swin" always contains water. The tank is emptied twice in every 24 hours, about 1 hour after each high tide. This arrangement is quite satisfactory.

6. The latrines are water-closets of the "Jennings' continuous pipe" pattern; they are flushed out once a day. It would be better if this flushing were done more often, twice or three times daily; it would also be desirable that more water should be let into the closet pans; in the *Drainage Manual*, para. 261, it is stated that the pans should ordinarily be about half-full of water; they appear to be actually filled only up to about one-third. Although it is stated in this paragraph that the discharging should be done by hand, my opinion is that it should be done automatically (and at more frequent intervals), there being several good patterns of automatic discharge now available. Any attempt at economy in the provision of water for flushing is likely to have bad effects; a full and abundant supply is necessary.

3. *General Sanitary Condition of Barracks.*

7. There is nothing in the situation or construction of the barrack buildings, or in their surroundings, of an insanitary nature; with the exception of the foul odours and possibly infected dust arising from some large collections of refuse along the shore; these lie on ground belonging to the Brickfields Company, to the north of the barracks and village, and will be referred to more particularly in a later part of this report. A part of the barracks consists of huts; it would be desirable to substitute proper buildings for these timber erections as soon as practicable.

II.—Summary of Results of Bacteriological Examinations.

8. The only samples examined were two specimens of water, one from the barrack supply, and one from the supply to a house in the village (No. 4, Hinguar Street), where a case of enteric fever had recently occurred. Both samples gave satisfactory results, there being no indications of excremental or of surface contamination.

No cultivation experiments were made on cockles; there had been no enteric cases either in the garrison or in the village for several weeks previous to my visits, and I did not consider such an investigation would be of any practical use at the present time.

III.—Enteric Fever at Shoeburyness.

9. The accompanying table shows the admissions for enteric fever amongst the troops from 1895 up to the end of 1901, amounting to 25 cases; besides these, there have been 2 cases among the officers (one each in 1899 and 1900), 5 among the women (2 in 1896, 1 in 1898, 2 in 1900), and 9 among the children (2 in 1895, 5 in 1896, 1 in 1898, 1 in 1900).

Admissions for Enteric Fever. 1895–1901.

	Name.	Barrack or lodging.	Date.	Remarks.
1	Gnr. Barrett.. ..	Hut 11	25.6.95	Origin doubtful. The flooring of the hut was foul.
2	„ Webb	L. 2	20.7.95	These men were both recruits of one month's service. They had eaten shellfish obtained near the sewer exit.
3	„ Roberts ..	K. 2	20.7.95	
4	„ Osborn ..	4, Smith Street ..	3.8.95	Water supply from surface well, bad and insufficient.
5	„ Warwick ..	B. 2	4.3.96	Recently on furlough. Frequents Southend. ? Infected shellfish.
6	„ Smith	B. 1	13.4.96	Employed in officers' mess.
7	Serjt. Littlewood ..	P. 1	14.7.96	
8	„ Goble ..	P. 3	1.8.96	
9	Gnr. Merritt.. ..	B. 3	13.10.96	Employed on Maplin Sands.
10	Drvr. Cowling ..	Drivers' hut ..	28.7.97	Daily passes through the swin, into which the sewage of the village is discharged; this swin is land-locked at low tide.
11	Gnr. Edwards ..	F. 4	5.10.97	Recruit of three months' service. Had been on pass 1st to 4th October.
12	„ Mott	F. 4	19.10.97	
13	„ Denny	Lodgings	6.2.98	
14	„ Cox	C. 18	11.7.98	Had eaten shellfish a week before.
15	Bombdr. Wadsworth	P. 2	10.8.98	Had eaten cockles gathered by himself about 2,000 yards from the shore.
16	Drvr. Montague ..	Drivers' hut ..	10.9.98	Daily passes through a land-locked swin, which receives sewage of village.
17	„ Mansfield ..	3, Smith Street ..	19.9.98	Passes through swin before mentioned. Had eaten shellfish, but not taken within 2,000 yards of shore. Probably had drunk surface well water, owing to temporary stoppage of artesian supply. Three other cases of enteric fever in same street.
18	Gnr. Greenwood ..	J. 2	26.7.99	Waiter in serjeants' mess.
19	„ Nicholls ..	E. 4	27.7.99	
20	Serjt. Kerr	N. 7	6.8.99	Had just previously been cleaning out an old gun emplacement, in which was a collection of very foul water and mud.

	Name.	Barrack or lodging.	Date.	Remarks.
21	Drvr. Watson ..	Camp	August 1899	3rd Kent Volunteer Artillery. Diagnosis doubtful.
22	Gnr. Clifford ..	?	Sept. 1900	Probably had eaten shellfish taken locally.
23	,, Robertson ..	Cambridge Road..	6.8.01	Blocked drain at the house. Three other enteric cases in same street.
24	,, Williams ..	West Road, Cambridge Town	12.8.01	Probably connected with last-mentioned cases.
25	Corpl. Hersey ..	4, Hinguar Street	16.8.01	Had eaten shellfish on the shore just before his attack.

10. It is probable that no one cause, or manner of propagation, will explain all these cases; the following are varying modes of infection that have been suggested, and that call for enquiry :—

(1.) Eating infected shellfish.
(2.) Connexion with sewage outfall.
(3.) Infected water supply in village.
(4.) Defective sewerage in village.
(5.) Infected refuse heaps in the brickfields.

There has been nothing to throw suspicion on either the water supply in barracks nor the milk supply, neither have any important defects been found in the drainage arrangements within barracks.

11. (1)—The eating of infected shellfish, especially cockles, has been shown to have been the most probable cause of an epidemic of 23 cases occurring in the occupants of a row of houses in Wakering Road (about a quarter of a mile from the barrack gates) during August and September, 1899. This outbreak was enquired into by Dr. J. C. Thresh, County Medical Officer of Health, and Mr. E. R. Walter, Medical Officer of Health for the Urban Sanitary District (see *British Medical Journal*, December 16, 1899). The reasons for ascribing the cause to infected cockles were: (1) No evidence tending to implicate water supply; nor (2) Milk supply; (3) Drainage arrangements unusually good; (4) Subsoil free from polluting matter; (5) Cockles were eaten by nearly all the persons attacked, and were obtained from a source known to be polluted with sewage; (6) Cockles from the beach are consumed chiefly by new-comers to the district—the residents in the infected houses were all recent arrivals in the town. Bacterial examinations were made of cockles gathered both on the beach near the town, and further out, near the sewer outfall. *Bacillus coli communis* and spores of *Bacillus enteritidis sporogenes* were found (*a*) in the mud adhering to the shells; (*b*) in the fluid in the shells; and (*c*) in the pulped body of the cockles, in each case; there can be no doubt that all were sewage-contaminated.

12. The result of this enquiry has naturally led to the idea that the eating of shellfish gathered off Shoeburyness affords the most reasonable explanation of the enteric cases that have recently occurred. The following facts bear upon this question :—

(i.) Cases 2, 3, 14, 15, 25 admitted having eaten cockles gathered on the beach or banks of sand and mud opposite the village. Case 22 was a married man, whose father-in-law was a fishmonger, and it is extremely likely that he had been in the habit of eating shellfish gathered locally. But it is very likely that others had also eaten shellfish procured in a similar way, but denied it, owing to the practice being contrary to a Garrison Standing Order issued in 1895: "Non-commissioned officers and men are cautioned against eating shellfish gathered within 1,000 yards of the shore, as they are very poisonous."

(ii.) A portion of the foreshore is let out for the purpose of cultivating cockle beds; this is in the immediate neighbourhood of the outfalls of the main village sewer and of the barrack sewer. There is therefore little doubt that the cockles gathered in this neighbourhood are contaminated with sewage. As enteric fever has prevailed among the civil population every year (at any rate since 1895), the sewage certainly *may* have contained *Bacillus typhi* during certain seasons in these years.

(iii.) Cockles are to be found all over the Maplin Sands, across which the drivers pass almost daily, as well as other men employed in the School of Gunnery; though a long distance from the outfalls, it is not unlikely that these cockles should also have been fouled with sewage.

(iv.) The same danger attends eating shellfish at Southend, which is a place of frequent resort for the troops.

(v.) Drs. Thresh and Walter note that cockles from the beach are chiefly consumed by new-comers to the place (older residents being aware of the bad effects to be anticipated from eating them): the Wakering Road cases were all new-comers; amongst the military cases, Nos. 2, 3, 11, 15 had only very recently joined the station.

13. (2)—It was noted in two cases (Nos. 10 and 16) that, being drivers of the Royal Artillery, they had every day to pass through the "swin" into which the sewage of the village was discharged, this being land-locked at low tide.* A "swin" is a channel in the mud and sand of the foreshore, not permanent, but varying slightly day by day according to the tides and currents. As far back as 1891 complaints had been made as to the objectionableness of the particular swin into which the sewer discharged, and the attention of the Local Government Board was invited to the matter; no action, however, appears to have been taken either at that time or in 1895, when the representations were repeated. In 1897 the village was provided with a new and ample water supply, one result of which was that the collecting sewage tank became quite inadequate; the military authorities reopened the question, and in 1898 the sewer was extended to a point further off the shore, so that the condition complained of does not now exist. As far as I could judge, there is now nothing dangerous or offensive in connexion with the outlets either of the village or of the barrack sewers, which are far out from the shore. As enteric fever prevailed in the village in each of the years (1897 and 1898) when these cases (10 and 16) occurred, it is possible that there may have been some connexion between these facts, though it can hardly be said to have been likely.

14.—(3) and (4) It has always been the custom for numbers of the men, married off the strength, to reside in private houses in the village, owing to insufficiency of quarters. The sanitary state of South Shoebury has therefore a closer connexion with the health of the troops than is perhaps generally the case. Six of the 25 enteric cases lodged in the village, viz., Nos. 4 and 17 in Smith Street, just outside the barrack gates; No. 25 in Hinguar Street, also quite near the barracks; and Nos. 23 and 24 in Cambridge Town, a new district recently laid out for building, about half a mile to the west; another case (No. 13) lived in lodgings, but I am unable to state in what part of the village these were situated.

15. The following statistics, kindly furnished me by the Medical Officer of Health for Shoeburyness Urban District (Dr. E. R. Walter) show that the place has been severely visited by enteric fever in recent years:—

Year.	Cases of enteric fever.
1895	80
1896	45
1897	30
1898	33
1899	37
1900	22
1901	11

* Another case (17) also passed through this swin; but a more likely channel for infection existed in the drinking water.

The population in 1891 was 2,290, but is now about 4,000; even with the higher figure the attack-rate is markedly excessive, ranging from 3 to 11 per 1,000 (not counting the epidemic of 1895); the average attack-rate in town populations is somewhere about 1 or 1·5 per 1,000.

16. Of the 80 cases in 1895, nearly all occurred in Cambridge Town, which at that time disposed of its excreta in cesspools and derived its drinking water from shallow wells; the season of prevalence was, as usual, the autumnal period from middle of September to middle of December. In 1896 also, the cases were mostly in Cambridge Town, beginning earlier in the year (July), and ceasing about November. In 1897, the cases were still mostly in Cambridge Town, distributed throughout the year. In 1898, there were cases in South Shoebury village to about the same extent as in Cambridge Town; the village had been sewered for many years, but until 1897 the water had been derived from shallow wells, which of course were liable to contamination, though not so dangerous as those in Cambridge Town. During 1897 distribution of water from a deep well belonging to the Local Sanitary Authority was effected throughout the whole district; and in 1898 Cambridge Town was sewered. There were 37 cases in 1899; but of these, 23 formed a localised and distinct outbreak due to eating shell-fish, as already mentioned; if these be deducted, it is seen that there has been a considerable improvement since the adoption of the sanitary measures of sewering and providing a pure water supply; this improvement may probably extend to the military portion of the inhabitants. Two cases (among soldiers), however, occurred in August of the present year, one at any rate in all probability connected with a blocked drain in Cambridge Road; in the same road there were three other cases among the civil population; a drainage system that is badly laid is quite as dangerous as no system at all, and in property of this description all the drainage details require to be very carefully looked after to prevent such ill consequences as these.

17.—(5) *Infected Refuse Heaps in the Brickfields.*

For more than 10 years past the nuisance arising from the deposit, screening, and burning of ashpit refuse, used in the brickworks of Messrs. Eastwoods immediately adjoining the War Department land, has been a subject of complaint amongst the Shoeburyness garrison. In 1892, the Commandant, School of Gunnery, addressed the Local Government Board on this matter, and a long correspondence resulted, but no essential improvement in the condition. What happens is shortly as follows:—At very frequent intervals barges arrive from London loaded with "ashpit refuse"; this is unloaded at high tides at the eastern end of that portion of the shore that is *not* War Department property near the spot known as Black Gate, and carted to the adjoining ground, where it is stacked in enormous heaps; the accumulation at the present time (as always) is very large, amounting probably to some thousands of tons. The stuff consists of cinders, bones, rags, paper, old shoes, old tins, and rubbish generally. It is first hand-picked to separate the larger objects, such as broken kettles, sardine tins, &c., the residue is then screened to separate the "breeze" (small coal and cinders) from the "soft core" (rags, paper, old shoes, and all kinds of filthy rubbish); the coarse part of this organic rubbish is then burned in the open, while the finer part and the "breeze" is used for brick-making, in the process of "clamp-burning."*

18. During the unloading and carting of this ashpit refuse from barges to rubbish heaps, during the screening, during the burning of the discarded organic filth (rags, &c.), and during the burning of the bricks themselves, offensive effluvia are given off which are described as most sickening. The odour from burning the bricks is unpleasant, but is probably not actually

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* "Clamp-burning consists in building the bricks into a pile, 8 to 10 feet high, with alternate layers of fine breeze (cinders), air-passages being left at suitable intervals. When a clamp (or pile) of sufficient size has been made, which may mean half a million to a million and a-half bricks, fires are lighted around it, by which the breeze is ignited, and by this means the combustible matter in the bricks themselves is also put into a state of slow combustion. When this has all been consumed, the combustion ceases."—(Stevenson and Murphy's *Hygiene*, i, 949.)

hurtful to the garrison, nor can it be regarded, legally, as a "nuisance." The worst smells are stated to occur during the burning of the coarse discarded organic filth; this is carried on very crudely and imperfectly in the open, and on windy days a great quantity of the offensive material is blown about the shore; it is not at all unlikely that in this way disease-germs might be disseminated for some distance in the neighbourhood of the barracks and ranges; the same thing might also occur during the carting of the filth from the barges to the rubbish heaps, when some of it is of course unavoidably dropped on the shore, and in windy weather blown about.

19. There can be no possible doubt, but that a very large quantity of offensive filth is brought to this spot on the shore, between the barracks and the ranges, and there deposited, the accumulation being literally enormous; and that the methods of its ultimate disposal, whether in the manufacture of bricks or in the destruction of the useless portion, are offensive and a "nuisance." There is also, in my opinion, a great probability, amounting to actual danger, of infectious material of one kind or another forming a part of this foul stuff; in which case, owing to the way in which it is handled, and the imperfect manner of its destruction, the "nuisance" would not only be offensive but dangerous to health. It is probable that the poisons of diphtheria and of plague are those that would be the ones most likely to be present in, and to be disseminated from, such rubbish heaps; if plague were to gain a footing in London, I should consider there would practically be a great danger in this method of dealing with the ashpit refuse. Outbreaks of diphtheria have been reported, due apparently to emanations from this sort of material spread on the ground as manure (the late Dr. Hubert Airy, Dr. J. C. Thresh). I do not know that enteric fever cases have actually been traced to such a source; in the Wakering Road outbreak in 1899, already referred to, Drs. Thresh and Walter considered that it was possible that the persons might have handled, and been infected by, the "soft core," but did not consider it probable; neither was it probable that the contagion was carried in the effluvium from the brickfields.

20. In my opinion it is not probable that any of the cases amongst the troops were due to aerial propagation from this source; but there is still a possibility that this may have been the case, and the offensiveness and danger resulting from this condition of things are so marked that a more particular reference to steps that may be taken for its discontinuance will now be made.

IV.—Nuisance arising from Refuse Heaps at the Brickfields.

21. The actual condition of these refuse heaps has been shortly described in the preceding paragraphs; it is necessary to go into this matter somewhat more fully, in order to show (as I think may be shown) that action can, and should, be taken to abate what, in my opinion, is a serious and dangerous "nuisance."

After (i) a *résumé* of former correspondence, and (ii) a statement of the law on the subject, (iii) reasons will be given for taking fresh steps in the matter.

22.—i. Résumé *of former Correspondence.*

(1) On 5th September, 1892, the then Commnadant, School of Gunnery, acting on the advice of the Medical Officer in charge of troops, wrote to the Secretary to the Local Government Board, complaining in forcible terms of the nuisance arising from these refuse heaps.

(2) The Local Government Board communicated with the Rochford Rural Sanitary Authority, and on 5th October, 1892, replied to the Commandant, with copy of letter from this Authority, to the following effect:—"That the deposit in question is only such as has been usual for many years past, long before the range land was purchased by the War Department; that the deposit consists of 'breeze' brought to the spot by water by Eastwood & Co.

in the ordinary course of their business as brick manufacturers; and there appears to be nothing unusual or exceptionable in the way the material is carried or dealt with. The heap is considerably more than 100 yards from any dwelling. It is admittedly objectionable, but the Rural Sanitary Authority do not appear to have any remedy open. No complaint has been made by any member of the civil community."

(3) On 13th October, 1892, the Commandant again wrote to the Local Government Board, stating that the so-called "breeze" consists of foul rags and paper, bones, old shoes, &c.

(4) The Local Government Board again wrote to the Rural Sanitary Authority on 2nd October, 1892, enquiring if the accumulation referred to was not a nuisance injurious to health (*sic*), and if so, why did not the Authority take proceedings?

(5) On 26th October, 1892, the Rural Authority wrote to the Local Government Board (the letter being forwarded to the Commandant) stating:— (a) The deposit consists of rubbish formed outside the district and imported into it to be used in making bricks. (b) The rubbish is necessary for the effectual carrying on of the brick trade. (c) The heaps are more than 100 yards from any building. (d) The rubbish is not kept longer than is necessary or usual for the purposes of the brick trade. (e) All steps available for preventing injury to the public health have been taken.

(6) On 21st November, 1892, the Commandant wrote to the Adjutant-General, enclosing photographs showing the condition of the foreshore, and the screening places; all kinds of filthy matter, instead of being burned or buried, are allowed to be washed along by the sea; the troops have to be employed in cleaning it away and burying it.

23. A very great deal of additional correspondence took place during the next year or so, much to the same effect, but with little result. Some steps were taken to prevent the rubbish being blown about the shore. In a similar case near Southend, where the Coastguard complained of the nuisance from screening filthy rubbish, the Medical Officer of Health for the Port of London took action, the practice was given up, and Mr. Smith, Manager to the Brickfields Building Company of Southend, stated that it was cheaper to bring the breeze to the brickfields ready screened. (It was this that the Commandant wished to have done at Shoebury.) Dr. R. J. Duffin, a civil medical practitioner at Shoeburyness, wrote on 10th July, 1893, that he considered the noisome odours to be a source of danger, and that scarlet fever, diphtheria, and severe sore throats were possibly due to them.

24. Without delving deeper into this voluminous correspondence, it appears from the above that a decided nuisance has been in existence, and that this has not been denied, but that no active measures have been taken to bring about an improvement. The condition at the present time is much about the same; the offensive odours are complained of by everyone; even as far away as Ness Road, nearly a mile off, the windows (so I am informed) have to be kept shut when the wind blows in that direction at the time the rubbish is being burned; and with regard to dirty paper and foul matters being blown about the shore, this still occurs, and may have a bad effect on the parties of men who have to remain (at Black Gate) very near to the heaps, while on duty.

25.—ii. The *Statute Law* bearing on the matter is contained in the Public Health Act (1875), Sections 114 and 91.

Section 114. *Duty of Urban Authority to complain to Justice of Nuisance arising from Offensive Trade.*

Where any . . . . manufactory, building, or *place used for any* trade *business* or manufacture *causing effluvia is certified to any urban authority* by their Medical Officer of Health, or by any two legally qualified medical practitioners, or *by any ten inhabitants* of the district of such urban authority, *to be a nuisance* or injurious to the health of any of the inhabitants of

the district, such urban authority *shall* direct complaint to be made before a justice, who may summon the person by or on whose behalf the trade so complained of is carried on to appear before a Court of Summary Jurisdiction.

The Court *shall* inquire into the complaint, and if it appears to the Court that the business carried on by the person complained of is a nuisance or causes any effluvia which is (*sic*) a nuisance or injurious to the health of any of the inhabitants of the district, and unless it be shown that such person has used the *best practicable means for abating* such nuisance, *or preventing* or counteracting such effluvia, the person so offending . . . . shall be liable, etc.

Section 91. *Definition of Nuisances.*

Sub-section (1). Any premises in such a state as to be a nuisance or injurious to health. . . . .

(4) Any *accumulation or deposit* which is a nuisance or injurious to health . . . . shall be deemed to be nuisances liable to be dealt with summarily . . . . provided that a penalty shall not be imposed . . . . if it be proved to the satisfaction of the Court that the accumulation or deposit *has not been kept longer than is necessary* for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health.

26.—iii. *Reasons for taking Fresh Action.*

(1) The position at the present time is different from what it was in 1892, when complaint was originally made. At that time the health authority was the Rochford Union Board of Guardians, acting as a rural sanitary authority, to whom the powers under Section 114 did not belong: within the last few years the Shoeburyness Urban District Council has been created, to whom these powers do belong; and who are bound to take action (*shall* direct complaint to be made) on receiving certified statement as to the alleged nuisance.

27.—(2) In a small place where the chief business and source of employment for most of the civil inhabitants is a source of complaint, there might be a difficulty in obtaining evidence as to nuisance resulting therefrom; the local medical practitioners also might not be anxious to move in the matter; but under Section 114 it is sufficient if "any ten inhabitants" certify as to the existence of the nuisance. As this nuisance is, and always has been, a great subject of complaint amongst the officers of the garrison, it can hardly be difficult to get at least 10 persons to put their complaint in writing, definitely and decidedly, but without exaggeration or bias.

28.—(3) It should be clearly understood how much and how little is required to be proved in stating or certifying to a nuisance. In the first place, it is not necessary to prove that the effluvium, or whatever it is, has actually been injurious to health; a nuisance *may be* injurious, and *vice versâ* something injurious to health may *not* be a nuisance; it is necessary to prove *either* the one or the other.

Mr. Justice Stephen gave his opinion (Bishop Auckland Local Board *v.* Bishop Auckland Iron and Steel Company, 1882) that "even if the nuisance were not shown to be precisely injurious to health, yet if shown to be injurious to personal comfort, and possibly injurious to health" it would be a nuisance under this Act. The natural sense of the words is "a nuisance either interfering with personal comfort or injurious to health." The law was meant to strike at "anything which would diminish the comfort of life, though not injurious to health, and at anything which would, in fact, injure health." Mr. Justice Field concurred. This was a case in which the Medical Officer of Health had stated that the alleged nuisance (effluvia from smouldering heaps of cinders), though a nuisance to some people, was not "a nuisance injurious to health"; and the local justices dismissed the case on this ground. On appeal Justices Stephen and Field reversed this judgment.

Sir John Simon, formerly Medical Officer to the Privy Council, stated (Royal Commission on Noxious Vapours, 1877): "I think the expression 'injurious to health' in many of these discussions has been used in a sense to impose upon the person who is charged with the duty of protecting health an obligation to prove that some named and catalogued disease, such as typhoid fever, or small-pox, or dysentery, or epilepsy, or something of the kind, is produced by these vapours. I do not think we are bound, when it is a question of sanitary injury, to show injury of that circumscribed kind. To be free from bodily discomfort is a condition of health."

See also Mr. d'Eyncourt's decision, below:

It appears to me that, although it may not be possible to prove actual injury to health in any particular case, there can be no reasonable doubt that a very considerable interference with comfort has been caused by the effluvia complained of; the numerous written statements in the correspondence already referred to, and the many verbal expressions of opinion made to me in November and December last, must have some basis in fact.

29.—(4) Proceedings might also be taken under Section 91, Sub-sections (1) or (4). A case bearing on Sub-section (4) is quoted by Mr. Wynter Blyth, in his *Manual of Public Health*, p. 245. There was a deposit of manure at a manure merchant's premises in Chelsea. The defence was that being a manure merchant (a necessarily unsavoury business) he could not be interfered with; and that at the particular time of the alleged nuisance the accumulation was larger, and had remained longer than was ordinarily the case, for certain reasons beyond his control. The magistrate, Mr. Tennyson d'Eyncourt, decided that the accumulation did constitute a nuisance: he said that the manure collected should not be allowed to accumulate in this way, but should be at once carted into barges, this being only a question of expense. He made an order for abatement with costs. Notice was given for appeal, but the appeal was not proceeded with.

30.—(5) It will be necessary to show that "the best practicable means for abating such nuisance, or preventing or counteracting such effluvia" have not been taken. Here it should be clearly understood that it is not the effluvia caused by *brick-making* (although they are offensive) that are complained of, but the effluvia caused by burning the organic rubbish that is not required for the making of bricks, and the bad smells and dispersion by wind of foul dust caused in the unloading and screening of this foul organic matter. There is no desire to interfere with the industry of brick-making; but can it be reasonably maintained that it is necessary for the successful carrying on of this business that foul ashpit refuse should be brought to, and accumulate in, this plot of ground in close proximity to the barracks and ranges? The foul rubbish that is brought here is *not* used for brick-making; it is destroyed by burning, or rather it is supposed to be so destroyed; a good deal of it blows about the shore (paper, rags, &c.). What is necessary for brick-making is the "breeze," or small coal and cinders, which forms a part only of the rubbish brought here; the burning of this does not constitute the nuisance. The best means for abating the nuisance or preventing the effluvia would be for the brickfields company only to bring screened rubbish; there would then be no nuisance from the unloading, screening, or burning of the organic filth, neither would the trade of brick-making be interfered with. It is possible that the profits would be less, but with that we have nothing to do; insanitary conditions are not to be allowed to continue in order to increase profits if it can be shown that the business can be well carried on if these conditions are removed. It is not even certain that the Company would suffer any loss; as already mentioned, the manager of the Southend Brickfields Building Company stated that it cost less to bring the breeze to the brickfields already screened.

31. I consider that, for the health of the Shoeburyness garrison and of the village or town, now become a somewhat populous urban district, the offensive and dangerous part of this business (which is not a necessity for its successful carrying on) should be put an end to, and only screened rubbish brought here, such as is required for brick-making. If, however, some con-

cession is to be made (which, from a sanitary standpoint, I would not recommend), at least the offensive rubbish should be effectually and innocuously destroyed in a closed destructor; this would obviate the bad smells and the danger of infective matters being blown about the beach during the present imperfect method of slow burning in the open; it would not obviate the danger of unloading, depositing, and screening the possibly infective matter. It might perhaps be regarded as "the best practicable means of preventing" the effluvia arising from the present burning process (which is the most offensive, though not the most dangerous, part of the whole process); but it would not, in my opinion, "abate the nuisance" altogether. While there is a possibility of employing such a means of preventing the effluvia, it cannot be maintained that the present crude methods of handling and destroying this foul matter (by which it is allowed to be dispersed in the air and blown about the shore) are "the best practicable."

32.—(6) It is to be noted that under Section 114 there is no limitation as to time of establishment of the business or process complained of. It will therefore be no reply to state (as has been stated by some) that the brickfields were in existence here, and worked as at present, long before the War Department bought the neighbouring land and established the ranges. It can hardly be said that the brickfields were here before the barracks were originally built. But that is not the point; it has already been admitted that it is not the business of brickmaking that is objected to, but the carrying on of certain processes connected with, but not essential to, this business.

33. I beg to recommend that proceedings be commenced by obtaining certified statements from 10 inhabitants of the urban district of Shoeburyness that a "nuisance" (in the sense previously explained) does exist; which statements should be forwarded to the Urban District Council, and that the War Office authorities provide legal assistance, so that the case be properly conducted; presumably the local military authorities would be guaranteed any expenses to which they might be put in taking legal proceedings.

V.—Conclusion and Recommendations.

34. The sanitary condition of Shoeburyness barracks is on the whole satisfactory; certain defects exist in the drainage system, which are now in course of being remedied, and as to which no recommendations are needed. The latrine pans should be filled to the amount laid down in the *Drainage Manual*, para. 261; and I recommend that an automatic system of discharge be adopted. I also recommend that the storage cisterns within barracks, which are at present exposed to contamination, be done away with; if this is impracticable, that close-fitting iron covers be provided.

35. From a bacteriological examination of water samples, taken in the barracks and in the village, it appears that the drinking water is not contaminated; no indications were found of any pollution.

36. As to the probable causes of the cases of enteric fever that have occurred, five modes of infection have been thought to occur (1) eating infected shellfish; (2) infection from the sewage outfall; (3) polluted water supply in the village; (4) defective sewerage in the village; (5) infected refuse-heaps at the brickfields. Eating infected shellfish (cockles) has been shown to have been the most probable cause in an outbreak of 23 cases among the civil population in 1899; it has probably been the cause in five or six of the military cases, and very possibly in other cases as well, which after a lapse of time it has not been found practicable to thoroughly investigate.

The village or town of Shoeburyness has suffered severely in recent years from enteric fever; and as many men, married off the strength, live outside barracks in lodgings, they have naturally been exposed to the same liability to infection as the civil population: six cases have occurred among the troops living in lodgings in the village; these have probably been due to insanitary conditions connected either with the water supply or the drainage, which have now been remedied.

I do not consider that the sewage outfall has been the cause of any enteric cases among the troops.

Neither do I consider that the refuse-heaps—though dangerous—have been the cause of any enteric cases.

37. The chief recommendations that I have to make (in addition to those mentioned in para. 34) are that the danger of eating shellfish should continue to be insisted on; and should be brought to the notice of the troops even more explicitly than hitherto, and especially that all new arrivals at the station should be very urgently warned against the practice: that a careful look-out should be kept on the sanitary state of all houses occupied as lodgings by troops in the village: this might be done in conjunction with the local medical officer of health: and that steps be taken to remedy the nuisance arising from the brickfields' refuse heaps, as detailed in paras. 26 to 33.

APPENDIX

Detail of the Bacteriological Examinations.

No. 1.—*Water supplied to Shoeburyness Barracks.*

Sample taken 20th November, 1901, from tap in Dispensary at Station Hospital.

Numeration.—(a) In agar at 37°·5 C.; 96 colonies per cubic centimetre.

(b) In gelatine at 20° C.; 175 per c.c.

Examination for B. typhi *and Coliform Bacteria.*

Into two tubes of glucose-formate broth were sown 1 c.c. and 5 c.c. of the water respectively, and incubated at 37°·5 C. anaerobically. No growth at all resulted in either tube.

Examination for B. enteritidis sporogenes.

Into a tube of litmus milk was sown 1 c.c. of the water; the culture was kept at 80° C. for half an hour, and then incubated anaerobically at 37°·5 C. No growth resulted.

Examination for Spores.

One c.c. water was sown into a gelatine tube, kept at 80° C. for 10 minutes, and then incubated at 20° C. The only growth consisted of three or four mould colonies: these may have been due to accidental contamination.

No. 2.—*Water supplied to Shoeburyness Village.*

Sample taken 20th November, 1901, from scullery tap at No. 4, Hinguar Street, South Shoebury.

Numeration.—(a) In agar incubated at 37°·5 C.; 185 per c.c.

(b) In gelatine at 20° C.; 240 per c.c.

Examination for B. typhi *and Coliform Bacteria.*

Same procedure as No. 1; no growth resulted in either tube.

Examination for B. enteritidis sporogenes.

Same procedure as No. 1; no growth resulted.

Examination for Spores.

Same procedure as No. 1 ; no spores developed.

Remarks.—Neither of these samples of water show signs bacteriologically of contamination either with excremental matters, or from surface washings : the number of germs present in the village sample is much larger than in the barracks sample ; and in both of them the germs are more numerous than should be the case in a deep-well water. The physical characters in each case are good, and there is no sediment obtainable for microscopic examination. Both samples are fit for drinking purposes.

(Signed) A. M. DAVIES,
Lt.-Col., R.A.M.C.

17*th January*, 1902

Report on Sanitary Investigations at Pontefract, October 3rd to October 14th, 1901.

I.—Report on the Sanitary Condition of Pontefract Barracks.

1. *Water Supply.*

1. The water supply for the barracks is, and for many years past has been, derived from the municipal supply to the borough of Pontefract.

2. The source of this is a deep boring at Roall, about 10 miles to the east. The works consist of a brick well, carried down 20 feet, below which is an iron tube sunk a further distance of 65 feet, and to this succeeds a boring in the rock carried down about 40 feet, making the whole depth of the "well" 120 feet (approximately); at the bottom of this "well" is a heading, in which are 4 bore holes, whose total depth (including that of the well) varies from 154 to 225 feet. The uppermost portion of the well, in brick, is not cemented, but I was informed that it is always perfectly water-tight; as is the iron tube. The rock below this is the New Red Sandstone, which is the water-bearing stratum, and is extremely porous. The water is raised to the surface by 2 sets of steam pumps, and conducted in closed mains to Pontefract.

3. Water from such a source should be of very good quality, being derived from a genuine deep well; the Rivers Pollution Commissioners reported (*Sixth Report*) that the New Red Sandstone yields a wholesome and palatable water, good for drinking and cooking; and this water has been examined with favourable results at various times, except that the fixed hardness is somewhat excessive. In 1895, the Netley Examination showed total solids 40; total hardness 18; fixed hardness 8·5 (parts per 100,000). In February, 1901, the same constitutents were 30·5, 32·5 and 12 respectively; in all other points the chemical examination was satisfactory, and no pathogenic germs or sewage organisms were found to be present.

4. An inspection of the well itself, and of the country immediately surrounding it, however, suggest some doubt as to the quality of this water being above suspicion. First, as to the well and borings: it may be taken, I think, as certain that no contamination can enter through the masonry wall or iron tube that reach down to 85 feet from the surface. Below this is the sandstone rock from which the water is extracted by pumping. This "Bunter Sandstone" is highly porous and extends for some hundreds of square miles around the site, affording a most abundant gathering ground, and apparently a pure water. The Rivers Pollution Commissioners stated (*Sixth Report*,

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p. 130) that "when the rock is uniformly porous, or nearly so, like the chalk, oolite, green sand or new red sandstone, the organic matter, at first present in the water, is gradually oxidised and transformed into innocuous mineral compounds." At the time this Report was written (1874), nothing was known about the transmission of disease by pathogenic organisms present in drinking-water, but its conclusions are not, in this regard, invalidated; for the passage of water through a uniformly porous rock for a considerable distance will deprive it of all its contained germs (by mechanical filtration) as well as oxidise and render innocuous the organic matter. The important point is, that the rock, though porous, should be firm and homogeneous, not soft or crumbly, shaly, or liable to fissures. The New Red Sandstone is generally described as being a firm rock of this character, and when the well was sunk at this site, no doubt such was expected to be the nature of the water-bearing rock. There is, however, great doubt as to this being the case. I was informed that when the well was first sunk, it entirely collapsed, the ground round about it sinking in to a considerable extent; this seems to point to the rock being soft (at any rate at that particular spot). Another well (the present one) was then sunk some 50 or 100 feet away from the first one; when the heading was being driven horizontally, a great rush of water occurred at one place, which was only got under with some difficulty; this also points to a soft condition of rock in the immediate neighbourhood, or, it may be, to an underground stream. Moreover, there are certainly fissures in the rock: after heavy rains a quantity of sand gets washed into the borings; this could not happen unless there were some channel or channels to give it passage, that is, one or more fissures. It is impossible to surmise their number or extent; but the two facts of (1) the collapse of the first well, and (2) the access of sand to the present borings after rain, furnish, in my opinion, strong indications that the rock in this particular spot is not firm, uniformly porous, and to be relied on as an efficient filter for removing organic matter and organisms from the water.

5. The Report already quoted (p. 130), referring to deep wells, states that "where the rock is much fissured, or permeated by caverns and passages, like the mountain limestone for instance, the effluent water differs but little from surface drainage, and retains most of the organic impurities with which it was already charged." It would, or might, also retain any disease-germs which might have gained access to it.

6. Secondly, as to the surroundings of the well: supposing fissures to exist in the rock, these are of as much importance as in the case of a shallow well. There are no dwellings, except the house of the superintendent, in the immediate neighbourhood, and the nearest hamlet is nearly ½ mile distant. But (except for an area of 5 acres immediately around the well that has been recently acquired by the Corporation) the whole of the surrounding country is ordinary agricultural land, partly arable, partly pasture, and manured, according to the crops sown, with privy-midden manure, that is, human excrement. The city of Leeds had proposed to erect sewage disposal works within a distance of about 1 mile to the north of this well, but their Bill was successfully opposed by the local authorities of Pontefract and Goole. It may be doubted, however, if even that soil pollution, if it had been allowed to take place, would have been worse than the continual application of what is practically crude sewage to the land, such as happens at the present time. If the rock were uniformly porous even this would be of little consequence; but, from what has been stated above, it is seen that this is not the case.

7. It may be objected that, if this condition has really existed for some years past, chemical analysis would have shown the water to be bad, or at any rate suspicious; and some outbreak of water-borne disease must have resulted before now. I do not think these objections can be sustained. In the nature of the case, supposing a fissure to exist, it may not be every week, or every month, that water passing through it is derived from a spot contaminated by manure; but there is no security against such a contingency happening, and the point is, that, under the assumed condition of things (if allowed to continue) it cannot be guarded against. As to there having been no outbreak of disease to cast suspicion on the water—enteric fever has been

prevalent in Pontefract for the past 2 years; it may not be, and probably is not, due to the water, but this cannot be stated with certainty.

8. I have to state, therefore, that although the municipal water supply is derived from a *bona-fide* deep well, properly constructed and worked, and from a formation considered by the Rivers Pollution Commissioners to furnish, as a rule, a good and wholesome water; yet, owing to the special local circumstances of (1) fissures in the sandstone, and an apparent softness in the rock immediately near the well, and (2) the practice of manuring the land round about with privy-midden stuff, in my opinion a considerable degree of suspicion must attach to this source of supply.

9. *Distribution.*—From the pumping station the water is conveyed in closed mains to a covered reservoir in Pontefract Park, and thence distributed by gravitation throughout the town and to the barracks. The head is not enough to force the water to the upper storeys of the barrack buildings; it is therefore received into an underground tank and pumped thence up to three tanks on the roof of a lofty building known as the Armoury, whence there is sufficient head to distribute it everywhere in barracks. The underground tank is cemented and covered in, the high-level tanks are covered in, and the pipes and fittings are all of the best description. Small covered cisterns are provided under the roofs of the barrack buildings; the service is constant, and the water is laid on to each ablution room. There seems to be no liability to any risk of contamination at any point in the system of distribution.

2. *Drainage and Conservancy.*

10. The arrangements for sewage removal at the barracks are on a double system: (1) dry-earth closets are provided for the troops; (2) water closets are provided for officers' quarters, for married quarters, for the station hospital, and for serjeants' mess; urinals for the troops, and drains to carry away waste water from cookhouses, ablution and bathrooms, also surface-drains to carry off rain-water, are connected with the same system of pipes, which discharge into the sewerage system of the borough.

11.—(1.) *Dry-earth Closets.*—At the time of my visit these were all in good order, and showed no sign of any neglect, either then or previously; the mechanism worked, dry earth was present in all the closets, and in sufficient quantity, and the closets were all clean. The mixed earth and excreta is removed by a contractor once a-day, and got rid of, probably as manure. Though I do not think that dry-earth conservancy is the proper method to adopt, when a water-carriage system of removal exists and water is abundant, I cannot say that the dry-earth system appears to have had any bad effect in Pontefract.

12.—(2.) *Drainage System.*—This dates, in the main, from the time when the barracks were built (about 30 years ago), but alterations have been made from time to time, and quite recently a new length of main drain has been constructed, as well as the relaying of several lengths of branch drains. There are three main sections—(i.) Eastern: draining the officers' quarters and stables, the soldiers' quarters and their cookhouses, ablution and bath-rooms and urinals, and the canteen and serjeants' mess. (ii.) Western: having two subsections, (*a*) draining Station Hospital and B block, married quarters; (*b*) draining A and C blocks, married quarters; these unite at a manhole in front of the quartermaster's quarter to form (*c*), which drains this quarter, the stores and offices, and also carries away rain-water from the hut barracks. (iii.) Southern: draining commissariat serjeant's quarter and guard room (W.C.), and carrying off rain-water from the back of the stores. Nos. ii. and iii. unite near the S.E. corner of barracks, and a few yards further on their combined channel joins with No. i. in a large disconnecting manhole, whence the main drain runs outside the barrack wall to another disconnecting manhole, and from this point starts the municipal sewer.

13. I examined the whole of this drainage system in detail, in conjunction with the Medical Officer in charge and the Clerk of the Works, on two successive days, 3rd and 4th October, 1901.

14. *Water Closets.*—These are all of a new and good "wash-down" pattern, and the connexions appear to be all of good construction and in good order.

15. *Soil Pipes.*—These are all 4-inch pipes, carried outside the walls of buildings, and taken up full-bore to the full height of buildings above the eaves as ventilating pipes; in some cases there seem to be more angles in the pipes than is necessary or desirable; the pipes might preferably be carried up *through* instead of *round* the eaves.

16. *Drains.*—Speaking generally, the drain pipes appear to be in all cases of good materials, properly laid, and with proper disconnexions, except as now to be mentioned.

(i.) *Eastern Section.*—At the back of soldiers' quarters, opposite Tudor and Minden blocks, the fall is defective; this had previously been found to be the case, and a length had recently been taken up and relaid. Manholes have been provided at frequent intervals, so that it is possible to locate any stoppage or partial obstruction. It was found (October 3rd and 4th) that the drain, in manhole opposite 51st depôt cookhouse, when flushed ran very slowly; also in the next manhole lower down, opposite the drill shed; while in the next manhole higher up, opposite 65th depôt cookhouse, it was running freely. At the drill-shed manhole there was obviously some considerable obstruction; immediately below this manhole is a siphon trap, and this was found to be filled up with deposit; it was cleared out as much as possible (though this could not be done completely), but the flow was still rather sluggish. Some deposit was found in the length of drain between this manhole and the manhole next above it, opposite 51st cookhouse; this deposit was no doubt due to the retardation of flow owing to silting up of the siphon just mentioned. The length of drain between 51st and 65th cookhouses had just been relaid, and was quite clear; but stoppage is sure to occur again unless either a greater fall is given or more frequent flushing carried out. I could not ascertain the exact fall in this section; the size of the drain is 9 inches in diameter from near its head at officers' mess to the manhole opposite drill shed; below this it is a 12-inch drain. As far as I could gather, the fall is less than 1 in 90, and with a drain as large as this, the depth of fluid running is very shallow, and the scouring effect very slight.

(ii.) *Western Section.*—(*a.*) The drain that serves the Station Hospital and B block, married quarters, is an *old* drain, of 9 inch diameter; it is not self-cleansing, owing to defective fall. It can be flushed (along part of its length only) from a 2,000-gallon tank, which is let off once a week. At the manhole, where the flushing pipe joins this drain, an accumulation (not amounting to a stoppage) was found; from this it appears most probable that the length of drain *above* this (leading from Hospital), which is not accessible to this large flush, would also suffer from retardation of flow and gradual obstruction.*

(*b.*) The manhole opposite quartermaster's quarter, where the two sub-sections unite, was also found to be partially clogged with black deposit,† and here, when flushed, the flow was very sluggish, pointing to some deposit in the length of drain below. The new drain, running between A and C blocks, married quarters (which has only quite recently been laid) was found to be partially stopped. The diameter is 6 inches, the fall 1 in 70; but the flow is so scanty that it does not give sufficient scour; when flushed with clear water the velocity was only about 1 foot per second (instead of 3 feet per second, the desired rate). The drain in front of A and B blocks was also found to run very slowly. The flow was satisfactory in the rest of this section.

(iii.) *Southern Section.*—The fall is defective between the new manhole at back of quartermaster's store, and the gateway into yard belonging to the guard room; above and below these points it is satisfactory.

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* A 100-gallon tank is let off daily along this hospital drain.

† The black colour is due to sulphuretted hydrogen, evolved in decomposition of sewage matter; the black substance is *not* particles of small coal, or ash, as often thought to be the case.

17. On the whole, I regret to say that, in my opinion, the *fall* of the drains throughout the greater part of their course is defective, and their *size* in many places too large for the amount of fluid to be carried off: consequently the *flow* is sluggish, and gradually a deposit occurs. This was found to be actually the case in five different places on October 3rd and 4th. The reason for the drains having been laid with such a slight fall is, I understand, the necessity that was supposed to exist for connecting the *new* drains with the previously existing system without interfering with the level of the latter. I think that, granting this necessity, it would have been better to have raised the new drains, even up to or above the ground level, if required, in order to secure a proper fall. The reason for the size—6 inches and 9 inches—is, I suppose, in order to carry off storm water. The volume of sewage to be removed is, I feel sure, not sufficient to adequately cleanse them.

18. Another hindrance to rapid flow along these drains results from the insertion of siphon traps below manholes at two points (possibly at others also), viz., below the manhole in front of drill shed, and in front of quartermaster's quarter. They are no good in a length of unventilated drain, and interfere both with flow of sewage and circulation of air.

19. *Ventilation.*—The outlets for drain-air are provided by carrying soil pipes up to roof above eaves. Special ventilating pipes (not soil pipes) are provided for No. 1 section, running up walls of soldiers' quarters. These do not reach quite to the top of the roof, therefore the aspirating effect of wind is lost. The one at the north end of Minden block has a Y-junction inserted about two feet above the ground, therefore the rest of the pipe is useless. Inlets are provided to manholes when practicable; but this could not be done safely in the course of the drains through barracks, as a rule. The manholes are therefore inspection, not ventilating or disconnecting, chambers.* There is an inlet at ground level near the serjeants' mess. The manhole at junction of flushing-pipe with hospital drain (western section, sub-section *a*) has a lateral 9-inch pipe leading outside the barrack wall, and opening at ground level to act as *inlet* for fresh air. On examination, this was found to be completely choked up with sods of turf and earth, evidently done on purpose. I would suggest that a pipe of the same diameter carried about four feet up the wall, with a wire dome, would perhaps be better than the present opening at ground level (which is useless unless kept clear). I would also suggest that a similar inlet ventilating pipe be carried laterally from the same boundary wall to the manhole in the *new* drain at back of C block, married quarters, near south-west corner, which is at present unventilated.

20. *Flushing.*—There is a 2000-gallon tank at the upper end of the drainage system, in rear of Officers' mess. This has hitherto been usually discharged once a week along the eastern section, and once a week along sub-sections (*a*) and (*c*) of the western section. The branch of the latter serving the hospital, which cannot be flushed by this large tank, is flushed daily by a 100-gallon cistern in the mortuary. At the north (upper) end of A block, married quarters, is a 300-gallon tank, which flushes the part of sub-section (*b*) of this western section which runs in front of A and B blocks: the part that runs between A and C blocks cannot at present be properly flushed at all, though this is urgently required. As the drains are laid at present, with defective fall in some places, and slight flow of sewage in proportion to size of drain nearly everywhere, more frequent flushing is certainly necessary.

21. *Connexion of Surface Drainage with Foul Drainage.*—The surface drains throughout barracks lead into gully traps, from which underground pipes lead into the foul drains. In many cases it has been found that during the past exceedingly dry summer these gully traps had become untrapped, and offensive smells were perceived, these untrapped openings naturally acting as drain ventilators. This was especially noticed outside the windows of No. 14 room, Minden block, where three rain-water pipes discharged directly over these gullies. The gullies were removed on recommendation of the Medical Officer in charge, the rain water collected in surface channels, and

* I was informed that these manholes were only put in about twelve months ago, before which time stoppages could only be rectified by breaking open the pipes.

discharged into the drain through an improved form of gully trap, giving a better seal than in the old pattern previously in use.

22. *Connexion of Waste-water Pipes and Urinals with Foul Drainage.*—All the pipes leading from ablution rooms, bath-rooms, and cook-houses discharge over open gratings, with properly trapped connexions with the foul drainage system: the urinal connexions are also properly trapped. At the junctions of these pipes with the main drains, inspection manholes have been constructed in nearly every case.

23. *Care and Supervision of Drainage Arrangements.*—A pioneer serjeant has been detailed to look after the drains generally, and to attend to the flushing: he reports to the Royal Engineer Department when any stoppage occurs. As prevention is better than cure, it would be well if this serjeant were to take more particular note of the signs of *commencing* stoppage, *i.e.*, sluggishness of flow and deposit in pipes. As a matter of fact, the Medical Officer in charge has himself personally exercised a minute supervision over the whole drainage system.

3. *General Sanitary Condition of Barracks.*

24. The barracks stand at the top of a hill, 275 feet above sea level, with a good slope in all directions, and about half a mile from the town. The situation is unexceptionable. The subsoil is magnesian limestone (upper beds), here about 50 feet in depth: on the eastern side the ground has been made up to produce a level surface.

25. The soldiers' quarters are arranged in four blocks of two storeys each: they appear to be well built and in good sanitary condition in every respect. I more particularly examined No. 14 room in Minden block, whence several cases of enteric fever had been admitted to hospital. It is on the ground floor, and apparently in perfect sanitary order. The floor had been taken up a few weeks previously, also in the early part of the present year: the ground beneath had been found quite clean and dry on each occasion. There is a properly ventilated space between the ground level and the floor of the room in all the barracks.

26. The cook-houses and subsidiary buildings, and the married quarters, all appear to be in a good sanitary condition.

II.—Summary of Results of Bacteriological Examinations.

27. Samples of water were examined, taken (1) from the pipe as it enters the tank on top of Armoury tower; and (2) from a tap in ablution room of No. 14 barrack room, Minden block. The distance between these two points is only a few yards, and no probable source of contamination exists between them, therefore they may be considered as practically two specimens of the same water.

28. The examination was directed to find out (*a*) presence of the bacillus of enteric fever, (*b*) presence of coliform bacteria, (*c*) other indications of sewage pollution, (*d*) indications of surface contamination (as shown by presence of spores and *streptococci*) in the water, which is derived from a deep well.

29. The *number* of germs growing at incubation temperature was found to be 1 per c.c. (about 20 drops) in the first sample; while in the second none at all developed from $\frac{1}{2}$ c.c. of the water. At room temperature also the samples agreed fairly well together, the number varying between 140 and 400 per c.c.

30. The bacillus of enteric fever was not detected.

31. *Bacillus coli communis* was found in No. 2 sample, but in small numbers only; it was present in a cultivation of 5 c.c. water, but absent from a cultivation of water concentrated so as to equal 400 c.c.; its presence therefore appears to be due to a chance contamination.

32. *Bacillus enteritidis sporogenes* was not detected.

33. No organisms indicating contamination by surface washings were detected; no *streptococci*, and only a relatively small number of spores.

34. The only unfavourable points in this water are the occurrence of *B. coli*, and the excessive number of germs growing at air temperature, considering the water to be one derived from a deep well, and therefore naturally almost free from germs. It does not seem likely that they should have gained access, or increased materially in number, either in the covered reservoir at Pontefract Park, or in the closed tank at the barracks. Too much importance must not be given to either point, as the presence of *B. coli* was probably due to casual contamination, and the germs present, though numerous, are not in themselves of any consequence. The water is not quite satisfactory: a watch should be kept, and bacterial examinations made from time to time.

III.—Enteric Fever at Pontefract.

35. The accompanying table shows the admissions for enteric fever at this station from 1899 to present date. The only previous cases in recent years have been one child in 1894, and one man in 1897. The cases of invalids from South Africa were all men who had returned home convalescent, had then gone on furlough, and on return from furlough had been admitted to hospital for a longer or shorter time, merely on account of temporary unfitness for duty, not because of any symptoms of enteric fever. It is, I think, highly improbable that they in any way introduced the specific poison into the barracks. Two cases were contracted in hospital: Private Thorpe (admitted 22.3.00) was orderly over Private Flannery, who had died 21 days previously: probably transmission was direct in this case; the attack was a slight one, and patient was discharged within 6 weeks. The other hospital case, Private Palmer, was admitted 30.5.01 with "Debility": the diagnosis of enteric fever was made 7.7.01, previous to which date there had been no signs of the disease; death occurred on 16.7.01, the case being a severe one; the causation of this case remains obscure. One case, that of Private Wright, admitted 18.1.01, was contracted at Dewsbury, whence the man had arrived immediately before admission to hospital.

Admissions for Enteric Fever, Station Hospital, Pontefract.

Name.	Date of admission.	Result.	Barrack whence admitted.
Shaw	25.9.99	Died	Minden.
Flannery	7.2.00	Died	Tudor.
Cornett	15.3.00	Recovered	Minden.
Maskell	19.3.00	Recovered	Minden.
Thorpe	22.3.00	Recovered	Hospital.
Holland	20.5.01	Recovered	Minden.
Simms	11.7.01	Recovered	Minden.
Palmer	7.7.01	Died	Hospital.
Wright	18.1.01	Recovered	Minden (from Dewsbury)
Wraith	19.12.00	Recovered	From furlough, after return from South Africa.
Ross	16.1.01		
Mitchell	9.5.01		
Ward	1.10.01		

36. I have endeavoured to find an explanation (1) for the fact that 5 cases have been admitted from one barrack (not counting Private Wright), while only one case has been admitted from the rest of the soldiers' quarters; and (2) for the occurrence of the series of cases at this particular military station.

37.—(1) The only suspicious circumstance specially relating to the Minden block, that I have been able to trace, has been the faulty gully traps immediately outside the windows on the west side of No. 14 room on ground floor (from which 2 cases have been admitted during the present year). There is no doubt that these traps were of a bad pattern, that they became unsealed during the long spell of dry weather last summer, that drain air did escape from these openings, and that deposition of fæcal matter to some considerable extent did take place in the main drain thus ventilated, whereby the drain did become, to some extent, a kind of elongated cesspool. I would not assert that this was the cause, though it might have been a predisposing factor.

38.—(2) As regards Pontefract barracks generally, their situation and construction are from a sanitary standpoint satisfactory. It has been already mentioned that the water supply is not quite satisfactory, though hitherto it had been considered excellent and uniformly well reported on. The local drainage conditions are also far from what should be the case, in spite of the great attention that has been given to their improvement. There is, however, as far as I have been able to discover, no *definite* cause for enteric prevalence to be found in the barracks themselves.

The troops are of course in some degree exposed to the general health conditions obtaining in the neighbourhood; their own circumstances of housing, water supply, and drainage are no doubt much better in the barracks than those under which the bulk of the neighbouring population habitually live. As, however, the soldier does not spend the whole of his time within the barrack enclosure, it is necessary to enquire into the health statistics of the general population round about.

39. The Medical Officer of Health, Dr. A. Hillaby, has kindly furnished me with information as to enteric prevalence in the borough:—

	Cases notified.	Deaths.
1891	9	3
1892	8	0
1893	26	2
1894	5	1
1895	11	3
1896	2	0
1897	11	3
1898	7	0
1899	24	6
1900	26	12

The deaths include all deaths from enteric (workhouse and brigade depôt included); the notifications do not include the depôt. During 1901, 15 cases have been notified up to middle of October.

The following figures are extracted from the Report of the County Medical Officer of Health for the West Riding (Dr. J. R. Kaye) for 1900:—

	Population.	Total death-rate.	Zymotic death-rate.	Enteric cases notified.
Total of West Riding	1,451,991	18·3	2·2	1,625
Total of Urban Districts	1,110,229	17·9	2·2	1,322
Pontefract Borough	13,099	20·5	3·4	26
Featherstone Urban District ..	16,671	19·5	2·9	44

The attack-rate of enteric fever for the whole population of the West Riding is 1·12 per 1,000, for the urban districts is 1·19; while for Pontefract it is 2·0, and for Featherstone, 3·76 per 1,000. There has therefore been an undue prevalence in this neighbourhood in 1900, and a prevalence higher in 1899 and 1900 than for many years past in Pontefract. Featherstone is a mining village, in population not much smaller than Pontefract, and distant about 1¼ miles from the barracks; it possesses a theatre, and probably offers as many attractions of a certain character as the town of Pontefract itself. I was informed as a matter of fact that the troops do frequent Featherstone almost as much as the town. With an epidemic of enteric fever in this village, it is not surprising that some cases of the disease should occur among the soldiers frequenting its public-houses and places of entertainment.

40. As to the causation of this epidemic, and of the prevalence in Pontefract, the same factors are probably at work as in the town districts of the West Riding generally; the privy-midden system, defective scavenging, badly paved streets, alleys, and yards, which become fouled during the removal of the midden stuff, and in which children play, taking into the dwelling-room faecally polluted soil (possibly specifically infective matter)—these are considered by the Health Authorities of the West Riding to be the conditions favouring enteric prevalence. The troops are in a better state, sanitarily, than the general population, because they are not exposed to the soil and air-pollution inseparable from the filthy privy-midden system, but it is not to be wondered at that they to some extent share in its dangers. On the whole, I consider that it is principally to connexion with the epidemic at Featherstone, and the prevalence at Pontefract, that the occurrence of the enteric cases at the barracks is to be ascribed, although the exact mode of propagation of the disease cannot be traced; the faulty drainage conditions of the barracks, and the somewhat unsatisfactory character of the water supply have to be borne in mind, but are not so likely, in my opinion, to be the explanation of the cases.

IV. Conclusion. Summary and Recommendations.

41.—A. The chief results of my investigation into the sanitary conditions at Pontefract Barracks are as follows:—

(*a.*) *Water Supply.*—Although derived from an undoubted deep well, and not near any collection of dwellings, there are grounds for suspicion as to the purity of this water, on account of (1) the extremely porous and soft nature of the sandstone whence it is drawn, and the presence of fissures in it; and (2) the fact that the soil in the neighbourhood is manured with privy-midden matter. The methods of storage and distribution are quite satisfactory.

(*b.*) *Drainage.*—It may be stated that the principles governing the construction of drains are mainly that (1) they should rapidly and effectively remove the sewage; (2) they should not pollute the soil through which they pass; (3) they should be self-cleansing; and (4) their contained air should be kept in such a condition as to be inoffensive, or as inoffensive as possible, or at any rate innocuous. The second of these conditions has been complied with, but numbers (1), (3), and (4) cannot be said to have been effectually carried out. Owing to insufficient fall (combined probably with too large a size in relation to volume of sewage transmitted) in several places the drains are not self-cleansing, and do not rapidly or effectively remove the sewage; a partial stoppage results, leading to decomposition and generation of foul gases. The lengths of drain where this partial stoppage has occurred (and where it will certainly continue to occur unless some alteration is made) are: (1) at back of Minden block, and thence to manhole opposite drill shed; (2) the "old" drain serving Station Hospital and B block, married quarters; (3) between manhole opposite quartermaster's quarter and manhole near to serjeants' mess; (4) "new" drain running between A and C blocks, married quarters; (5) between new manhole at back of quartermaster's stores and the gateway

into yard belonging to guard room. Flushing tanks are provided at three points, and bath room water also helps very considerably in flushing; but this has been found to be insufficient. Surface drainage has (until lately) been led into the foul drains through a form of gully trap that readily becomes unsealed, and foul smells have been perceived in consequence; an improved form of trap is being substituted throughout the barracks.

(*c.*) The situation and *general sanitary conditions* of the barracks are satisfactory.

42.—B. The bacteriological examination of the drinking water did not give very satisfactory results. Whereas it is derived from a deep well, and should therefore be almost free from germs, a rather large number (varying from 140 to 400 per c.c.) were found growing at room temperature, though practically none grew at incubation temperature; *B. coli* was found, but the details of the examination point to its presence being due merely to some casual contamination. Bacteriologically, the water is not above suspicion.

43.—C. As regards the causation of the cases of enteric fever that have occurred, my opinion is that although water supply and drainage conditions are not satisfactory, it is on the whole more probable that the troops have suffered (though in a lesser degree) from the same general defective sanitary conditions as the surrounding population: enteric fever is epidemic at Featherstone, a large mining village near by, frequented by the soldiers for recreation, and is prevalent at Pontefract; the incidence of the disease at Featherstone is more than three times as severe as in the West Riding generally. The most probable cause is the existence of the privy-midden system, with its accompanying pollution of soil and air. One particular barrack block (Minden) suffered most; the only defective sanitary condition specially affecting this block that I could discover was, that during the last summer some rain-water gully traps had become unsealed, and had acted as drain ventilators, just outside the windows on the ground floor of this building; this may have acted as a predisposing cause.

44. *Recommendations.*—1. The nature of the rock in which the well and borings furnishing the water supply are situated, the manured ground round about, and the somewhat unsatisfactory results of the bacterial examination of the samples, combine to throw some suspicion on this supply. I recommend that further examinations be made, both of the well site, and of water samples. I should not condemn the water, but I consider the matter requires attention.

2. The drainage system being such as it is, I recommend that the condition of the drains be very carefully watched, to detect any signs of commencing stoppage; that flushing be carried out throughout the whole system frequently, and if necessary, every day; that a 300-gallon flushing tank be provided for the drain running between A and C blocks, married quarters, without delay; that the manhole ventilator outside western boundary wall (paragraph 19) be cleared, and a short vertical pipe affixed to the wall; that a similar ventilator be provided for the manhole at junction of flushing pipe with hospital drain; possibly also a similar lateral ventilator might be provided for one or more of the manholes on the eastern section of drain, none of which are at present ventilated; that the new pattern gully traps for surface drains be provided all through the barracks.

It is to be borne in mind that, speaking generally, the present drainage system is not "self-cleansing"; therefore there is always liability to stoppage, evolution of foul gases, and possibly dissemination of pathogenic organisms. To increase the fall and make the drainage system self-cleansing would not be impracticable, though expensive. Meantime the greatest care is necessary to keep the drains in a good state.

3. While enteric fever is epidemic at Featherstone it is for consideration whether it would be advisable to put this village out of bounds. The troops might be warned of the prevalence of infectious disease in the neighbourhood. Beyond this, it does not appear to be practicable for the military authorities to take any measures towards the improvement of the general sanitation;

especially the abolition of privy-middens, which I consider to be, indirectly, the most likely cause of the enteric cases in barracks at this station.

(Signed) A. M. DAVIES,
Lieut.-Col.,
R.A.M.C.

London, 6th November, 1901.

APPENDIX.

Detail of the Bacteriological Examinations.

No. 1. Water Supplied to Barracks.

Sample taken, 7th October, 1901, from pipe supplying tank on roof of the Armoury; the water was collected *before* it entered the tank.

Numeration.—(1) 0·5 c.c. sown into agar, and incubated at 37°·5 C. (= 99° F.).

After 24 hours there was no growth. After 48 hours, one colony had developed. No more colonies appeared.

(2) 0·5 c.c. sown into a tube of gelatine and kept at air temperature (from 50° to 65° F. = 10° to 18° C.).

After 45 hours, about 35 dots; after 3 days, about 140 colonies; after 4 days, 200 colonies.

(3) 0·5 c.c. sown into gelatine, plated, and kept at air temperature.

After 45 hours, 15 dots; after 3 days, 60 colonies; after 4 days, 150 colonies, none liquefying, none coliform.

The number of germs growing at incubation temperature is 2 per c.c. at air temperature, about 350 per c.c.

Examination for B. typhi *and Coliform Bacteria.*

Parietti Test.—Water concentrated by Klein's method—4,000 c.c. water were passed through a portable Pasteur-Mallie filter, the deposit on the filter collected and worked up in 10 c.c. of the water under examination, and 1 c.c. of this mixed deposit and water sown into each of two broth tubes to which had been added 0·1 c.c. and 0·2 c.c. respectively of Parietti's solution (forming a nutrient medium containing 0·05 and 0·1 per cent. phenol respectively). The tubes were incubated at 37°·5 for 4 days. No growth at all occurred in either tube.

Pakes' Test.—Water unconcentrated. Into two tubes of glucose-formate broth were sown 1 c.c. and 5 c.c. respectively of the water; they were then incubated at 42° C. (= 108° F.), anaerobically, the oxygen being got rid of by a mixture of pyrogallic acid and caustic soda in a Buchner tube. After 3 days no growth had occurred.

Water concentrated by Klein's method (as above). 1 c.c. of the mixed deposit and water was sown into glucose-formate broth, and incubated anaerobically at 42° C. for 3 days. No growth occurred.

By neither Parietti's nor Pakes' method was any indication given of the presence of any coliform bacteria even in water concentrated.

Examination for B. enteritidis sporogenes.—Water concentrated (as above). 1 c.c. of the mixed deposit and water was sown into 10 c.c. sterile milk, heated to 80° C. for 10 minutes (to destroy all non-sporing organisms),

and incubated at 37° C. anaerobically in a Buchner's tube. No clotting resulted; therefore no *B. enteritidis sporogenes* was present.

Examination for Spores.—Water concentrated (as above). 1 c.c. of the mixed deposit and water was sown into gelatine, heated to 80° C. for 10 minutes (to destroy all non-sporing organisms), and, having been plated out in a Petri dish, was kept at room temperature (10° to 18° C.).

After 48 hours there was no growth; after 3 days, 12 small colonies; after 4 days, 66 colonies, that is, 66 spores in 400 c.c. water, or 0·16 spores in 1 c.c., the total number of germs present and growing at this temperature being about 350 per c.c.

Examination for Streptococci.—Water concentrated (as above). An agar tube having been melted, plated in a Petri dish, and allowed to solidify, 1/10 c.c. of the mixed deposit and water was spread over the surface, and the preparation incubated at 37°·5 C. for 3 days. No growth resulted.

Microscopic Examination of Sediment.—This was very small in amount, and contained nothing of any consequence.

No. 2. *Water supplied to Minden Block.*

Sample taken 9th October, 1901, from tap in ablution room on ground floor; this is supplied from a covered cistern in the roof.

Numeration.—(1.) 0·5 c.c. sown into agar and incubated at 37°·5 C. for 4 days. No growth whatever resulted.

(2.) 0·5 c.c. sown into gelatine tube and kept at air temperature.

After 48 hours, 34 colonies; after 3 days, 110 colonies; after 4 days, the same. No liquefying colonies.

(3.) 0·5 c.c. sown into gelatine, plated in a Petri dish, and kept at air temperature.

After 48 hours, 16 colonies; after 3 days, 72 colonies; after 4 days, the same. No liquefying colonies.

No germs develop from this sample at incubation temperature; at air temperature there are about 180 per c.c.

Examination for B. typhi *and Coliform Bacteria.*

Parietti Test.—Water concentrated by Klein's method. 4,000 c.c. were passed through a portable Pasteur-Mallie filter, the deposit on the filter collected and worked up in 10 c.c. sterile water, and 1 c.c. of this mixture sown into each of two broth tubes containing respectively 0·1 and 0·2 c.c. Parietti solution. These were incubated at 37°·5 C. for 3 days. No growth resulted.

Pakes' Test.—Water unconcentrated. Two tubes glucose-formate broth sown with 1 c.c. and 5 c.c. of the water respectively, and incubated at 42° C. anaerobically in Buchner's tubes. No growth appeared in the tube containing 1 c.c., even after 3 days' incubation.

In the tube containing 5 c.c. slight turbidity and gas formation occurred after 23 hours. From this tube gelatine plate cultivations were made (with two dilutions), and kept as near 20° C. as possible.

After 20 hours several dots appeared in each plate; after 48 hours each plate showed a considerable number of dots in the depth of gelatine, and small, thin, irregular, filmy colonies on the surface, apparently a pure culture and typically coliform in aspect; after 50 hours the sub-cultures mentioned below were made. The aspect of the colonies remained typically coliform for 10 days.

Subcultures.—(a.) *Agar Stroke.*—After 48 hours, a thin, pale, colourless growth, not linear; but this may have been owing to the presence of moisture in the tube.

(b.) *Potato.*—After 48 hours, a thin, almost colourless growth, but with faint yellowish tinge; after 4 days the yellowish tinge was more pronounced, but still slight.

(c.) *Litmus Milk.*—After 48 hours (not incubated), no change; after 3 days, slight reddening; after 24 hours' incubation the reddening was marked. No clotting occurred.

(d.) *Broth.*—After 48 hours, slight growth, which subsequently increased; after 5 days, still slight turbidity, no pellicle. No formation of indol.

(e.) *Gelatine Stab.*—After 4 days, a thin grey growth; no subsequent change.

(f.) *Agar Shake Culture.*—After 24 hours' incubation, considerable formation of gas bubbles.

Microscopic Examination of Broth Culture, × 1/12 o.i.—Bacilli with rounded ends, twice or three times as long as broad, motile, some in pairs, decolorised by Gram's method.

Water concentrated by Klein's method (as above). 1 c.c. of the mixed deposit and water sown into glucose-formate broth and incubated anaerobically. No growth occurred after 3 days at 42° C.

The organism isolated by the above test from 5 c.c. water was *Bacillus coli communis*, differing from the type only in absence of indol formation and failure to coagulate milk.

Examination for B. enteritidis sporogenes.—Water concentrated (as above). 1 c.c. of the mixed deposit and water was sown into 10 c.c. sterile milk, heated to 80° C. for 10 minutes, and incubated at 37° C. for 48 hours anaerobically in a Buchner's tube. No clotting resulted; therefore no *B. enteritidis sporogenes* was present.

Examination for Spores.—Water concentrated (as above). 1 c.c. of the mixed deposit and water was sown into gelatine, heated to 80° C. for 10 minutes, plated in a Petri dish, and kept at room temperature for 3 days. No growth resulted; therefore no spores were present.

Examination for Streptococci.—Water concentrated (as above). 1/10 c.c. mixed deposit and water spread over a solidified agar plate and incubated.

After 24 hours, 12 colonies, all of considerable size; after 48 hours, 15 colonies, all large, thin, and when examined microscopically seen not to consist of *Streptococci.*

There was no sediment available for *microscopic examination.*

Remarks.—These two samples of water may probably be considered as practically one and the same drinking water examined on two different days. The distance between the points where the two samples were taken is only about 50 yards, and no recognisable danger of pollution exists between these points. The main supply tanks on top of the Armoury tower, and the small cistern in roof of the Minden block, are covered in, and in the best possible positions.

As regards number of germs present, the two samples agree fairly well, there being practically no organisms in the water capable of growing at incubation temperature when a small quantity is submitted to examination, and at the room temperature a number varying from 140 to 400 per c.c. With a larger quantity (obtained by examining the deposit on a Pasteur filter), it was found that a moderate number of colonies grew on agar at incubation temperature, but less than 1 per c.c. in No. 2 sample. The water is therefore of good quality so far as regards *number* of germs *possibly pathogenic* in character; but the number of *ordinary aquatic* germs is larger than should be present in

a *bonâ-fide* deep well water, and raises a suspicion of some leakage into the well or boring.

As regards indications of surface contamination, neither *B. mycoides* nor *Cladothrix* were detected in either sample ; the number of spores present was very small in No. 1 sample (less than one spore for every 2,000 germs present, approximately ; according to Houston, of the micro-organisms of soil, one-tenth or more are spore-bearing) ; in No. 2 sample no spores were found. *Streptococci*, which are considered by Houston to indicate excrementally polluted soil-washings, were not found in either sample.

To detect signs of sewage pollution, special search was made for *coliform* bacteria and for *B. enteritidis sporogenes*. The latter was not found in either sample ; of the former, an almost typical *B. coli communis* was found in 5 c.c. of No. 2 sample, but no such growth was obtained either from 1 c.c., or from 1 c.c. of the concentrated filter deposit (representing 400 c.c. original water) ; neither was any growth found in the phenolated broth tubes (Parietti test). The occurrence of a limited number of *B. coli* in one particular quantity of 5 c c. must therefore be looked on as a casual occurrence ; it cannot be held to be actually condemnatory of the supply, but indicates that a watch should be kept on the sources, and bacteriological examination made from time to time.

Bacillus typhosus was not detected.

On the whole, these two samples (which I look upon as practically two specimens of the same water) might be considered as of good quality, except for the presence of *Bacillus coli* even casually and accidentally, but as the water is a deep well water (which should be germ-free or almost germ-free), the presence of from 140 to 400 organisms per c.c. is not satisfactory, even though at the time of examination no organisms indicating excremental or surface soil contamination were found.

(Signed) A. M. DAVIES,
Lieut.-Col.,
R.A.M.C.

London, 6th November, 1901.

Report on Sanitary Investigations at Canterbury.

I.—On the Sanitary Condition of Canterbury Barracks.

Section 1. *Introductory.*

1. The barracks at Canterbury are situated to the north-east of the city, between Sturry Road and Military Road, on low lying ground in the valley of the Great Stour. The subsoil is brick-earth, a loamy deposit, varying from a clayey sand to a sandy clay, which is practically impervious; this, though more absorbent than clay, holds up the water to such an extent that the *maneges* in winter are sloughs, 4 to 6 inches deep in mud; while in the hot, dry months of summer the surface becomes (so I am informed) a bed of dust of about equal thickness. I do not know whether the stratum under the brick-earth is of gravel (as is usually the case) or of clay; but at any rate there is no doubt that the situation of the barracks is damp and cold, and liable to fogs during the winter months. There is a fair slope from St. Martin's Hill on the south, towards the Stour on the north; the hospital, at the highest part of the barracks, lies at 71 to 81 feet above sea level; the barrack buildings themselves vary from 43 feet on the north to 64 feet at the south-east; while the river banks, about 200 yards north of Sturry Road, are 22 feet only above the sea. In spite of this fairly good slope, the alluvial soil of the Stour Valley (which within historic times was under water almost up to this point*) is so retentive that the climate is very considerably colder and damper than on the higher ground that surrounds the city in other directions.

2. The barracks consist of three portions; to the west are the infantry barracks, also called the "Buffs Square," being the Depôt Barracks for the 3rd Regimental District; in the middle are the so-called artillery barracks, now occupied by cavalry; to the east are the cavalry barracks proper, the largest and newest of the whole group of buildings. During the last 2 years, on account of the large numbers of recruits passing through the Cavalry Depôt, one or more blocks in the infantry barracks also have been occupied by cavalry.

Section 2. *Water Supply.*

3. *Source.*—The water supply for the barracks is derived from the Canterbury Waterworks Company, who have a deep well at Wincheap, to the south-west of the city; it is pumped up to a reservoir on St. Thomas's Hill, and thence distributed by gravitation. The deep borings reach down to the chalk, from which the water is obtained; the borings are two, 11 feet apart, and are lined to a depth of 36 feet with cast-iron tubes; their total depth is 490 feet. The following analysis is given in the *Sixth Report* of the Rivers Pollution Commissioners† :—

Total solids	.. ..	33·60	parts per 100,000
Organic carbon	.. ..	0·012	,, ,,
,, nitrogen	.. ..	0·012	,, ,,
Free ammonia	.. ..	0	,, ,,
Nitrogen as NO_3 and NO_2		0·426	,, ,,
Total combined nitrogen	..	0·438	,, ,,
Chlorine	.. .. ..	2·10	,, ,,
Temporary hardness	..	22·1	,, ,,
Permanent hardness	..	4·2	,, ,,

* Fordwich, "the town on the ford," or arm of the sea, a mile and a half to the north-east, was the seaport of Canterbury.

† Another analysis, received since this Report was written, is given in Postscript, p. 15.

(Wt. W. 2459 1500 7/02 H & S 1979) P. 02/502

"The water is clear and palatable . . . . It is perfectly wholesome, and well fitted for dietetic and all domestic purposes . . . . The quality is unsurpassed by that of any other in Great Britain."

After softening by Clark's process, the total solids are reduced to 11·94, and the total hardness from 26·3 to 4·9 per 100,000.

4. *Distribution.*—The water mains run along Military Road to the south of the barracks, and enter the barrack enclosure at various points. The supply, as delivered by the Company, is on the constant system, and as there is ample pressure, there is no necessity for storage, even for fire purposes. There are, however, cisterns, as follows :—

Infantry Barracks.—Outside A block, south wall, supplying A and B ablution rooms.

Outside E block, supplying E ablution room and the school latrine.

Cavalry Barracks.—Outside west wing, over the ablution room.

A block, cistern under the roof.
B block, ditto.
Waterloo block, ditto.
Balaclava block, ditto.

There are also cisterns in both cavalry and infantry officers' messes, and in staff sergeants quarters.

There are no cisterns in the artillery barracks.

The hospital is supplied through a separate large covered cistern on the top of hill at back.

There are no others, except for the supply of latrines and urinals, the above being the only ones whose water can be used for drinking purposes.

The cisterns outside E block, infantry barracks; outside west wing, cavalry barracks; and those in the officers' messes are properly covered in.

The cistern outside A block, infantry barracks, has a cover, fairly well-fitting; but into this cistern, besides the pipe-water, rain-water enters from the roof of the barrack; not only is this dirty in itself, but it washes in large quantities of dead leaves and dust; the sediment in the tank is manifestly dirty, and contains worms; later on in the year, when the weather is warmer, no doubt there would be a large amount of insect life, and of small animal organisms. The sediment found on March 12th is described in the Appendix.

5. All cisterns under the roof in the cavalry barracks (A and B blocks, Waterloo and Balaclava blocks) are provided with wooden covers, but in no case, on the days when I visited the barracks, were these covers placed in position. It is my experience that these covers are very seldom, if ever, properly fixed; in the present case, it was evident, from the accumulation of dust and cobwebs on the covers, that they had not been in position for many months, perhaps years. In A and B blocks, the lofts under the roof in which the cisterns are placed were dirty; in Waterloo and Balaclava barracks they were clean (these are newer buildings). In each cistern was a thick whitish sediment, averaging about $\frac{3}{4}$ inch in depth; on examination this was found to consist of carbonate of lime.

6. As to the cleaning out of these tanks or cisterns, it appears doubtful whether it should be the business of the troops or of the Royal Engineer Department; according to King's Regulations, para. 337, and Royal Engineer Regulations, para. 895, tanks are to be cleaned by the Royal Engineers, and cisterns "where accessible" (according to King's Regulations; Royal Engineer Regulations express it "where readily accessible") by the troops. But there is no distinct understanding what receptacles are "tanks" and what are "cisterns"; or what are accessible and what are not accessible. The Royal Engineers do not, as a rule, undertake this work in barracks, unless they are called upon to do so; the troops, on the other hand, when cisterns

are out of sight and out of mind (particularly when the water supply is spoken of as a constant service), often omit to take charge of them. All the tanks now referred to are "accessible," but they cannot be reached without ladders, and those in the four cavalry blocks are out of sight under the roof. Whatever may be the explanation, it is the case that these tanks have been exposed to contamination by dust, &c., and that they have not been cleaned out for a very long time; the good water supplied by the Company has been to some extent fouled; and in one case (the tank outside A block, infantry barracks), the water has been mixed with washings from the roof.

7. *Intermittency of Service.*—The water as delivered by the Company is a constant supply; but in barracks it is converted from a constant to an intermittent supply, by being turned off at 7 p.m. every evening until 6 a.m. next morning; it is also turned off from 2 p.m. until 4.30 p.m. every day except Thursdays and Saturdays, when it remains on all the afternoon in order that the men may have hot baths; at the hospital it remains on every afternoon until 7 p.m. This arrangement has been in force by order of the General Officer Commanding, South-Eastern District, since 6th November, 1897, the order having been issued in consequence of an excess consumption that had existed for some time previously. I did not find that any inconvenience had resulted from the intermittency, except perhaps occasionally at night. But it is for consideration, whether the only way, or the best way to obviate waste (that is, unnecessary consumption) of water is to revert to the admitted evils of intermittency of supply. These evils are chiefly two: (1) the likelihood of contamination by storage in cisterns; and (2) the danger of insuction of foul gases, or solid or liquid impurities, into pipes which are sometimes full and sometimes empty. All authorities are in favour of constancy of supply. Dr. Thomas Stevenson wrote (Stevenson and Murphy's *Hygiene*, 1892):—"In no distant future an intermittent supply will, it may be hoped, be regarded as an anomaly." Dr. George Wilson states (*Handbook of Hygiene*, 1898):—"The constant system should always be adopted wherever it can be carried out. . . . . With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred." Soldiers are undoubtedly careless, but surely "strict regulations and efficient supervision" might be established in the Army, if anywhere; proper fittings are always provided as far as I have seen. Hitherto, whenever there has been an excess consumption, it seems to have been thought that the best remedy would be to cut off the supply. I submit that it is not the best remedy, but perhaps the worst, and that it should never be done without trial of other measures first; of which efficient supervision would be the most important.

8. In the present instance, during the last 2 years (January, 1900, to December, 1901) the consumption has been considerably *under*, rather than *over*, the allowance, in every quarter except two; thus (in gallons):—

	Under consumed.	Over consumed.
1900, March quarter	2,437,800	
June ,, ...	783,900	
September ,, ...	..	54,480
December ,, ...	1,334,920	
1901, March ,, ...	1,683,350	
June ,, ...	156,680	
September ,, ...	..	687,680
December ,, ...	617,560	

Whatever reason, therefore, there may have been for cutting off the supply at the end of 1897, there does not appear to be any need for so doing now. All hard and fast rules require sometimes to be modified, simply because circumstances alter cases; and although the regulation allowance is perhaps on the whole, and generally, sufficient (20 gallons per head for each

man, woman, and horse, 10 gallons for each child), there are occasions when more is required. I was informed by the Officer Commanding Cavalry Depôt that in dry weather it was absolutely necessary to water freely the *maneges*, on account of the enormous quantities of dust produced, due to the nature of the soil; this expenditure is not contemplated in the 20 gallons for each horse (probably it has been the cause of the excess consumption during the 3 months, July to September, in the 2 years, 1900, 1901). The use of a warm bath, say once a week for each man, is most salutary, but it implies a daily additional consumption of 6 or 7 gallons per head, which was not contemplated when 20 gallons were allowed for all purposes.

9. I would therefore recommend that greater attention be paid to supervision, and that a more liberal interpretation be placed on King's Regulations, para. 400. If it be recognised that to cut off the water (even for a few hours daily), not from necessity, but because the amount consumed has been in excess of regulation, is to go contrary to all sanitary experience, other measures would be adopted instead. No waste should be countenanced, but if efficient care is taken to prevent this, if the fittings are certified to be in good order, and no leakage exists in the course of the pipes, any excess consumption would probably be found to be necessary, and due either to increased cleanliness on the part of the troops, or to better flushing of drains; it can hardly be the intention of the authorities to check either of these tendencies.

I recommend that the water be now turned on constantly.

10. *Storage Cisterns.*—If the supply is made a really constant supply, as in the rest of the city, there is no need for cisterns (except *possibly* for fire purposes); and from a sanitary point of view they are objectionable, and had better be done away with. If this is considered unadvisable on general grounds, I recommend that steps be taken (1) to clean them out carefully at short intervals, the responsibility for this work being clearly defined; and (2) to provide close-fitting covers; those at present supposed to be used would not efficiently keep out dust, even if in position.

I recommend that the ingress of rain-water from the roof of A block, infantry barracks, into the cistern outside west wall of this block, be prevented, the cistern being used only for pipe-water, if it is to be used at all.

Section 3. *Drainage.*

11. The present system of underground drains was constructed, I understand, about 7 or 8 years ago; on the whole it is satisfactory.

The surface drainage and storm-water system is entirely separate from the foul drainage system throughout.

Both systems lead into the town sewers to the north of the barracks, either in Sturry Road or in Alma Street; this being in the direction of the natural fall of the ground, from south to north; the ultimate disposal of the foul drainage is by application to land at the Corporation Irrigation Works, near Sturry, but within the city boundary; the storm-water and surface drainage is led into the River Stour.

12. *Foul Drainage. Infantry Barracks.*—There are three drainage sections; one serving the south and west sides of the square, a second the north side, and a third the east side.

First Section.—This commences at a w.c. and urinal near the guard room (Military Road Gate), and running westwards in rear of A and B blocks, receives drainage from A block ablution room and cookhouse, and from serjeants' w.c.; then turning northwards at the south-west corner, serves the latrine for A, B, and C blocks, the cookhouse and ablution room for B and C blocks, and passing in rear of C and D blocks and staff serjeants' quarters, leaves the barrack enclosure at the racquet court, near north-west corner. Here is a disconnecting manhole, into which is also received a short branch from E block latrine.

This drain is of 6 inches diameter, from its commencement to its termination; the pipes are of stoneware, well laid and jointed, but laid in the clayey or loamy soil, not on cement. (This description applies generally to all the drains.) It is well ventilated; there being either 4-inch or 6-inch ventilating pipes carried high up at the head of the system, at A cookhouse and at B latrine. There are several inspection pits or manholes along the length of the drain, and where it changes its direction, so that its condition can be very well looked after. The fall is approximately 1 in 50, which ought to be sufficient to make the drain self-cleansing. This, however, has not been the case, the reason being that the quantity of fluid passing along it has not been large enough, in its upper portion, to fill the drain to one-quarter of its diameter; unless this is habitually the depth of sewage or fluid passing along the pipe there will not be sufficient scour. See *Drainage Manual*, para. 11.

I examined the whole length of this drain, and found signs of recent stoppage (fæcal matter lodged on the benching of manholes) at several points in its upper part; also a deposit still collecting on the drain invert; and was informed that there had been a complete choking some two months ago. It must accordingly be admitted that this section is in the habit of getting stopped, the depth of fluid being insufficient to cleanse it. The remedy applicable to this particular case is the provision of a flushing tank (say of 200 gallons capacity) at the head of the section, to be let off once a day.

In the branch drain leading from A block cookhouse into the collecting drain (this branch being also 6 inches in diameter) a complete fracture round the whole circumference of the pipe was found to exist; this was situated immediately under, and only some few inches distant from, the leak in the leaden water pipe that supplies A block ablution room, referred to in para. 4. The soil here is made soil, and not an impervious clay; it would therefore allow percolation; this is what actually took place, and led to the discovery of the leak, it being found that water was passing along this drain when all sources of supply had been (apparently) cut off. Owing to the excellent system of inspection manholes, there was no difficulty in tracing to its source this unexplained flow of water. The importance of these co-existing leaks in water pipe and drain will be considered subsequently (para. 32).

The disconnecting manhole at the end of this section is provided with a large (9-inch) fresh-air inlet, and an intercepting siphon (9-inch) at the junction with the town sewer leading into Alma Street, and thence into Northgate Street.

13. *The second section* commences by two short branches, from the ablution room belonging to E block, and from the serjeants' mess cookhouse and urinal (attached to E block); then, receiving E cookhouse drainage, it turns round the corner of the infant school and passes down in front of the officers' quarters, married quarters, and Royal Engineer office in "Northgate Barracks"; after receiving drainage from urinal next staff-serjeants' quarters, it enters the town sewer in Northgate Street (or Sturry Road), being provided with a disconnecting manhole, the same as first section just mentioned. This section was found to be in good order.

14. *The third section* drains officers' mess and the quarters on either side of it, also the east side of these barracks. Commencing at the south block of quarters, it serves several water-closets at the back of these quarters and the mess block. Some of the officers' quarters have been unoccupied for a considerable time, and the closets therefore unused; on applying the smoke-test a few weeks back, various defects were found in the traps, and in junctions between closet pipes and drains; these were all put right, and at the time of my visit every w.c., soil pipe, and trap appeared to be in good order. The closets are all of good pattern, mostly wash-down, and a few valve closets. In all cases where quarters are unoccupied, w.c. fittings require to be inspected from time to time to see that there is no evaporation of water in the traps, &c. There are several ventilating (outlet) pipes running up the walls of these buildings, and the upper part of this section was in good condition.

On examining the manhole at the corner of "establishment stables," Northgate Barracks (in the lower part of this third section) there was found to be some deposit in the drain and a very bad drain smell: it was evident that the ventilation here was insufficient. Also, lower down in this section, at the manhole opposite provost prison, where a branch from the prison joins the main drain, there was a similar very bad smell: in this manhole there were signs of recent stoppage (faecal matter lodged on the benching); and when the prison latrine was flushed, the issuing fluid was very dirty, showing that in the prison branch deposit was taking place. There had been no prisoners lately, and probably flushing had been neglected.

The outlet of this third section is into the town sewer in Northgate Street (or Sturry Road); here is a disconnecting manhole, with large fresh-air inlet, 4 feet above ground level.

15. The unsatisfactory point in this section is the want of ventilation in the lower part, and a tendency to deposit. The latter might be prevented by extra flushing with a fire hose; extra ventilation is not very easy to provide in this situation, as there are no high buildings near, up which outlet pipes might be carried. The upper part of the section (serving mess and officers' quarters) is well provided in this way; for the lower part, reliance must, I think, be placed on carefully keeping the drain clean; possibly a ventilating pipe might be run up the wall of the latrine near the passage leading to artillery barracks.

It is to be noted that the water main is carried through the manhole just mentioned (near stables): this is a most undesirable practice; it is possible that sewer gases might injuriously affect the water pipes or joints.

16. The *hospital main drain* runs down this same roadway on the east side of infantry barracks: it is quite separate from the barrack drains, *except* that for some reason or other the drain from barrack Warden's quarter, No. 2, leads into it, instead of into the barrack drain; the w.c. of this quarter is inside the house, it is a valve closet of good pattern, and there is a ventilating pipe outside; but it is a pity that this drain should lead into the hospital drain without a complete air-disconnexion. The hospital drain leads into the town sewer in Northgate Street, at the same point as the third section drain, but quite distinct from it; the disconnecting manhole has a large fresh air inlet, but its mouth is 25 feet above ground level, which is higher than need be, even though the hospital stands some 30 feet higher than this point.

17. *Artillery Barracks.*—In these barracks there are three sections of drains.

The *first* section commences on the Military Road side at the infant school latrine and urinal; here is a flushing tank, discharged daily. The drain runs down the west side of the barracks, and at the north-west corner turns eastwards, and, after receiving two branches from stable drains, enters the town sewer in the Sturry Road. There is a disconnecting manhole and fresh air inlet at the corner of the "Buffs Canteen," also at the outlet into the sewer. Here and at two other points the manholes are not provided with proper covers, having only a stone slab, which allows soil and grit to fall into the drain, so tending to cause stoppage. This section is in good order.

18. The *second* section also commences on the Military Road side, at back of the quarters of the Officer Commanding Cavalry Depôt; here is a flushing tank. Outside the quarters of the Officer Commanding Infantry Depôt there is an inspection manhole, in which a branch from urinal at the church, and another branch from w.c. at rear of serjeant's quarter join the main collecting drain. On opening this manhole it was obvious that there was some obstruction in the drain; this had also occurred a few days back, and on the present occasion, though it was cleared temporarily, it again recurred on the following day; probably the siphon trap on the lower side of the manhole was in fault in some way. Unless there is a fresh-air inlet to make a disconnexion (which is not the case here), I think a siphon trap in the course of a drain is useless and liable to lead to stoppage; I found this to be the case also at Pontefract. The upper part of this drain section, behind these two officers' quarters, had

been relaid last summer (1901) in consequence of its unsatisfactory condition, and it is now satisfactory, except for this manhole. The drain pursues a straight course under the parade ground (having a fresh-air communication by grating at ground level, which ensures good ventilation), and after receiving a short branch from the artillery block ablution room, enters the disconnecting pit at outlet of the *first* section.

19. The *third* section is a short length of drain leading from w.c. at warrant officer's quarters, then receiving sewage from the artillery block latrine and urinals, and entering the main sewer at north-east corner, through a disconnecting pit, with fresh-air inlet. I was informed that obstructions frequently occur in the lower part of this section, owing to articles of clothing, &c., being put into the latrine. There are cradles to catch such things in all the branch drains at exit from latrines; but they are not always placed in position, "because they cause a stoppage."

20. *Cavalry Barracks.*—The drainage of these barracks is in two sections, one westerly, the other easterly.

The *westerly* section commences in rear of the officers' mess; here is a manhole into which enters a small drain from urinal and w.c., and into this leads a flushing pipe connecting with a tank fed by a spring just within the War Department boundary. This is a large tank, and gives a good flush; there was, however, at the time of my visit some obstruction in the pipe, which interfered with the proper velocity and flushing power of this volume of water. The gully outside mess cookhouse requires some form of grease trap. The drain runs westwards in rear of the west wing, taking sewage from the latrine and stable drainage from this block; there are three manholes in this part of the drain, so that obstructions can be easily located and complete stoppages prevented.

At the Military Road gate the drain turns north and runs straight down to the north-west corner of these barracks. At the manhole opposite Military Road gate the drainage system of the married quarters enters this section. A 6-inch pipe serves here, as elsewhere, for branch as well as main drains. In its course downwards this drain receives bath water from the hot baths behind the reading room, sewage from B latrine, and ablution water from B block; opposite the canteen there is a disconnecting manhole with fresh-air inlet; this drain is quite sweet and thoroughly ventilated. A few yards lower down it is joined by a branch from Nos. 5, 6, and 7 huts; the junction takes place in a manhole, and in addition there is a manhole on the branch drain with disconnecting trap and fresh-air inlet. In front of the guard room, at Sturry Road gate, is a disconnecting manhole, where the drain goes into the town sewer. All this section is in very good condition.

21. The *easterly* section also commences in rear of the officers' mess, and running eastwards behind Waterloo and Balaclava blocks, takes the sewage from their latrines, and foul water from cookhouses, &c.; at the south-east corner of the barracks, the drain turns north, and in front of Balaclava block receives a branch, conveying stable drainage from these two blocks; the junction is made in a proper manhole. Proceeding north in rear of A block, it receives ablution water from this barrack at a manhole; and a little lower down, foul water from huts Nos. 1, 2, 3, and 4, this junction being in the length of the drain, not in a manhole. A few yards further on, a short branch from A block latrines, and another from the cookhouse, join the main drain in a manhole. At the north-east corner of the barracks the drain receives a branch from the militia barracks (at present empty) and turns westwards, and enters the town sewer in Sturry Road, having a disconnecting manhole and air inlet shortly before leaving the barrack enclosure. In this section of drain everything was in good order; there are numerous manholes, readily allowing inspection, and the ventilation is good.

22. The *married quarters* are situated on the south side of Military Road, opposite the cavalry barracks. There are 7 blocks of buildings, and the drainage is arranged in 4 sections; at the head of the longest section is a 200 gallon flushing tank; in spite of this, it was found that the drain was

partially choked; the deposit consisted of small gravel and stones, and it is possible that children had dropped them down the gratings: so large a quantity could hardly have been washed in naturally. The other sections were found to be in good order, except that on account of the use of thick paper in one of the water-closets, a stoppage had occurred in the closet siphon. These closets are good wash-down closets, but the fittings require constant looking after. There is a disconnecting trap and fresh-air inlet outside the wall at the end of Military Road, so that this system is cut off from the rest of the barrack drainage, before it enters the manhole in cavalry barrack drain, western section, at the Military Road gate.

23. Looking at these drains as a whole, they are of a satisfactory plan and construction, and, as far as could be ascertained, laid with self-cleansing falls; but on account of their size, 6 inches in diameter in nearly every case, they are not in practice always self-cleansing. One man is specially employed by the Royal Engineer department, entirely to keep the drains in order, clear stable gullies, &c.; it is evident that something more is required to ensure that the drainage system is maintained in a proper condition. Three marked instances of partial obstruction were disclosed at my visit, viz.: in rear of A block, infantry barracks; outside Commanding Officer's quarter, artillery barracks; and in the longest section of the married quarters' drain. Besides which the benefit of the flushing tank at head of cavalry barracks' drain, western section, was far less than it should have been, on account of its small velocity, due to obstruction in the pipe. I do not suppose that this was exceptional, the occurrence, I mean, of 4 partial obstructions simultaneously. I was informed also that stoppages had rather frequently occurred in the first two situations.

I submit that stoppages ought *never* to be allowed to occur; and that what is required is such an inspection of the drains that the earliest signs of defective removal of sewage shall be observed, and the necessary measures taken to *prevent* a stoppage taking place. A little experience will soon show what the signs are that should be looked for: a slight deposit of fine sewage-mud on the invert of the drain; diminished velocity of current, as seen when a flush tank is let off, and the rate of flow observed at manholes lower down; any deposit of sewage matter on benching of manholes, showing that there has been a temporary stoppage that has set itself right (but which may recur): these are some of the points to be looked to. Any intelligent non-commissioned officer would soon become competent for the work; but under existing arrangements, as soon as he has learned his duties he would in all probability be drafted away from the station: the present Royal Engineer Staff is already fully engaged in its own work, and could not be expected to carry out this proposed additional duty; but the Quartermaster Sergeant, Royal Engineers, would instruct, and advise, in the case of the drains. I recommend that a pensioner non-commissioned officer be employed for this duty with one or two labourers (as at present) under him; it would be possible for him to thoroughly (not perfunctorily) examine every manhole and trap and sanitary appliance throughout the whole barracks twice a week; if this were properly done, there would be no possibility (humanly speaking) of any length of drain becoming choked, because the earliest signs of retarded flow would be noted, and the defect set right, probably in a few minutes.

Recommendations.

24. A flushing tank is necessary at head of the first drainage section in infantry barracks (near the guard room). One or more flushing tanks would also be desirable at the heads of the subsidiary sections in the married quarters drainage system. The existing flushing tanks might be let off rather more frequently. The flushing pipe at head of cavalry barracks, western section, requires cleaning. The lower part of the infantry barracks drain (third section, between officers' quarters and provost prison) is badly ventilated, and especially so in comparison with the westerly section of cavalry barracks drain, in similar situation; a disconnecting manhole with fresh air inlet, or possibly an outlet pipe, might be constructed. All manholes (not hitherto provided with them) should have the new pattern double Jones'

covers, which prevent earth and gravel getting into the drain and so save much labour and inconvenience. With these slight additions and alterations, I consider that the drainage of Canterbury Barracks would be made satisfactory (though not a self-cleansing system throughout): the excellent provision of manholes renders supervision easy, and all danger of drain stoppage would be obviated if *constant* inspection were carried out by an intelligent non-commissioned officer; an additional man is, however, required for this purpose, as above stated.

25. *Latrines.*—These are all of the usual Jennings' pattern pan latrines. They were in fairly good order, said to be flushed out twice a day, but with hardly a sufficient depth of water in each pan. Some of those in the infantry and artillery barracks are dark, and needlessly so, on account of a partial screen of brickwork in front, which appears to be of no use, and might well be removed.

The *urinals* are flushed for twenty minutes morning and afternoon. They were all in good order.

Section 4. *General Sanitary Condition of Barracks.*

26. The *infantry barracks* are old two-storeyed buildings, but are fairly satisfactory, having good window space, Boyle's extraction ventilators and an inlet arrangement for fresh air, that looks like a large Sheringham valve. There is a space beneath the boarding on the ground floor, which is dry, clean, and well ventilated. A and E blocks are, and for about two years have been, occupied by the cavalry depôt. B, C, and D blocks are occupied by the depôt, East Kent Regiment.

27. The *artillery barracks* are also occupied by the cavalry depôt. There is only one building that is used as soldiers' quarters; this is of three storeys, having A and B passages. The rooms on the lower floor are only 8 feet 6 inches in height, and are therefore rather dark and ill-ventilated, although they are provided with Boyle's ventilators and the "Sheringham-like" inlets: the rooms on the upper floors are 9 feet 6 inches in height.

28. The *cavalry barracks* are the most extensive, and consist of three blocks on the south side, a large block on the east, and a similar large block on the west side, and seven wooden huts.

The blocks on the south side are (1) West Wing, the oldest, consisting of troops' quarters over stables: although old, they are not bad barracks, except for the fact of being over the stables; (2) and (3) Waterloo and Balaclava blocks are of modern construction (1893), and are very good barracks: they have stables underneath, but there is a cement flooring that prevents any effluvium rising into the rooms above. Ablution rooms are provided under the same roof.

On the east side, A block, and on the west side, B block, are two-storey buildings, without stables beneath, dating from 1876. They are good barracks, though not so good as the newer Waterloo and Balaclava blocks.

All these barracks have Boyle's ventilators and Galton's grates. The window space is adequate, and the ventilation generally satisfactory for the regulation number of occupants. For the past three winters, however, it has been ruled that 400 cubic feet should be considered a sufficient space, instead of the regulation 600 cubic feet, and there has in consequence been overcrowding. The artillery barracks have not been overcrowded, having been considered, with good reason, to be unfit to accommodate this increased number of men. In the summer the excess numbers are camped out. The pressure on the cavalry and infantry depôts has been very great during the last two and a-half years, and this measure was no doubt unavoidable: 400 cubic feet is, however, not sufficient space for the average soldier. No ill result can be traced to the overcrowding.

The *night urinal* arrangements, here as elsewhere, are objectionable. Tubs are used, supported on slabs, which are generally sufficiently impervious;

but in the washing of these every morning, the flooring in the neighbourhood always gets wetted with foul water. It would be a great improvement to construct proper impervious urinals, both on ground and upper floors, leading into the foul-drainage system, and properly flushed and trapped. Materials are now available, as is evident in the underground conveniences all over London, and in other large towns. They would, of course, be kept locked during the day time. A and B blocks have the urinal "turrets" usual in this type of barrack; but they are not used, having probably been found to be a nuisance, from want of a proper flush. The present arrangement is complained of as offensive by everyone concerned.

At the back of west wing, Waterloo and Balaclava blocks, cavalry barracks, the latrines, urinals, and cookhouses are crowded together into a very small space: this is particularly the case in rear of Waterloo, where cookhouse and latrine almost adjoin each other. I am unable to suggest any remedy, short of rebuilding.

The *huts*, seven in number, are old, and the floors in many places defective: they are repaired from time to time, but the patchwork is not satisfactory. Here, and throughout the ground floors of the barracks generally, rats are troublesome.

II.—Summary of Results of Bacteriological Examinations.

29. A sample of water was drawn from tap in E block cookhouse, infantry barracks, as representing the drinking water supplied from the waterworks, without passing through any tank or cistern. This was found to contain a very small number of germs (12 per c.c.), and to be free from any objectionable organisms: it appears to be a pure deep-well water.

Another sample was examined, taken from pipe leading from cistern outside A block, infantry barracks, which supplies the ablution room attached to this barrack block (in which two cases of enteric fever had occurred recently). This water contained a large number of organisms (200 per c.c. in agar at blood heat; from 600 to 1,000 per c.c. in gelatine at ordinary temperature). A variety of *Bacillus coli communis* was found in one cultivation (4 c.c. water in glucose-formate broth, grown anaerobically), but not in a similar cultivation with 1 c.c. water, nor in the water concentrated by Klein's method, when the equivalent of 250 c.c. was examined by this test. Probably, therefore, the occurrence of *B. coli* was accidental. No other excremental or objectionable germs were found: there were a few spores. The sediment from this tank contained dead leaves, soot, &c. The water is obviously impure, but the bacterial examination would not condemn it.

III.—Enteric Fever at Canterbury.

30. The accompanying table shows the cases of enteric fever that have occurred in Canterbury Barracks since the beginning of 1900; I was informed that there had been only one case in 1899, and that this patient had contracted the disease when on furlough. With regard to the 11 cases recorded, it is to be noticed:—

1. That cases have occurred in all three barracks—cavalry, artillery, and infantry.

2. That in no instance has more than one case of fever originated in any one barrack block, except cases Nos. 9 and 10 from A block, Infantry Barracks.

3. That in two cases (Nos. 2 and 7) the infection was quite possibly, or probably, contracted outside barracks; No. 2 was employed all day outside barracks, and No. 7 had been on furlough for 9 days shortly before coming sick. In three other cases also the men had been on furlough; but in two instances (Nos. 5 and 9) they had been suffering from diarrhœa before leaving Canterbury, and there is a presumption that the illness commenced while

they were in barracks; in the third case (No. 11) the man had returned to Canterbury 5 weeks before coming sick.

Cases of Enteric Fever. Canterbury Barracks.

1	18th Hussars	Pte. French ..	3.7.00	Hut 6, Cavalry Barracks	Admitted for influenza. Disease changed 12.7.00. Rat-holes near his bed in hut floor. Bad smells complained of.
2	Pensioner's son	Brien	1.8.00	Steward's quarters, Infantry Canteen	Employed in Post Office in City. Disease probably contracted outside barracks.
3	18th Hussars	Pte. Frazer ..	27.8.00	Tents; also Artillery block	No sanitary defects found in the block, but the drains were up for repair.
4	„	„ Leyster ..	28.8.00	Tents, Cavalry Square	Tents were pitched near drains that were open for inspection on account of case No. 1.
5	5th Lancers	„ Ricketts	9.10.00	No. 12, West Wing, Cavalry Barracks	He went on furlough to Westbury-on-Trym, 5.10.00, and was admitted to Station Hospital, Horfield, 9.10.00. He had been ill with diarrhœa for a week before leaving Canterbury.
6	6th Dragoon Guards	Bandsman Gibbs	6.11.00	No. 4, A Block, Cavalry Barracks	Barrack-room floor worn into holes in several places.
7	18th Hussars	Pte. Barfield..	6.1.01	No. 4, B Block, Cavalry Barracks	No sanitary defect in barracks. Recently returned from furlough at Bury St. Edmunds, from 22.12.00 to 31.12.00.
8	Wife of ..	Corp. Epps ..	12.12.01	Infantry Officers' Mess	Several sanitary defects in mess premises.
9	3rd Hussars	„ Jones ..	10.1.02	No. 9, A Block, Infantry Barracks	On furlough at Devonport, 26.12.01 to 3.1.02, but had diarrhœa before leaving Canterbury.
10	19th Hussars	Pte. Ashley ..	6.2.02	No. 9, A Block, Infantry Barracks	Thought to be probably contracted from preceding case.
11	5th Lancers	„ Smith ..	7.2.02	No. 4, B Passage, Artillery Barracks	Was on furlough from 21.12.01 to 3.1.02 at Canning Town.

31.—(4) In regard to case 8, Mrs. Epps, living at the Infantry Officers' Mess, there is, I think, little doubt that her illness was due to, or in some way connected with, the insanitary condition of water-closets in rear of the mess building; several of these were found to be untrapped, allowing drain air to escape freely. All defects had been made good at the time of my visit; but, as noted in para. 14, I found the lower portion of the main collecting drain (third section in infantry barracks system) to be badly ventilated; it also showed some signs of previous obstruction; therefore, supposing these conditions to have existed a few weeks previously, the breathing of such sewer air by a susceptible person may quite reasonably be supposed to have caused the disease.

32.—(5) Coming now to cases 9 and 10, both admitted from the same barrack room in A block, infantry barracks: I conversed with these men, but was unable to elicit any facts of importance, except that I think there is little doubt that Corporal Jones really was suffering from a mild attack of enteric fever *before* he went to Devonport on furlough, and therefore that he contracted the infection in Canterbury.

It has been previously stated that a branch drain pipe was cracked, distant only a few inches from a hole in the water pipe supplying the ablution room attached to this barrack, from the taps in which any man living in this room would procure water for drinking, supposing he wanted it (see paras. 4 and 12). This branch drain does not itself convey sewage, but communicates with a sewage drain a very few feet lower down; this sewage drain had undoubtedly been choked on at least two different occasions recently; and deposit was again collecting on the invert when I examined it; it may be said to have been frequently obstructed. We have, therefore:—

1. A choked drain.
2. Consequent decomposition of fæcal matter and evolution of sewer-gas.
3. This would cause some air-pressure in the drain, the contained air of which would escape through any breach in its continuity.
4. Such a breach actually existed, the drain being cracked completely across.
5. Drain air, therefore, entered the surrounding soil.
6. This soil was "made ground," and therefore porous.
7. A leaden water pipe passing through this soil within a few inches of the cracked drain was broken across.
8. Therefore the drain air had access to the water in the pipe.
9. This pipe water supplied ablution room No. 9.
10. Two men using this ablution room contracted enteric fever.

There is no proof that any specific enteric germs were present in the drain conveying sewage; neither is there any proof that any actual sewage matter (solid or liquid) leaked out of the cracked drain. I am strongly of opinion that the former of these conditions is not a necessary antecedent to the occurrence of a case of enteric fever; I consider that *Bacillus coli* may, under certain conditions, be an effective cause of this disease; *B. coli* would be present in all sewage matter, though not always infective. As to the second condition, it is quite possible that sewage may have backed up in the branch drain and leaked out through the crack; for it is certain that the main drain had been blocked, and the junction was so close (about 5 or 6 feet distant) that such a leakage might easily happen. Without this, however, the sewer air may have contained germs which could find their way into the surrounding soil, and so into the water pipe.

A bacteriological examination of the water passing along this pipe was made. As the pipe was broken, it was not possible to draw water from the tap; so the water was turned on and allowed to escape from the broken pipe for 5 minutes (to wash away any casual impurities at the mouth of the pipe), and a sample taken and examined. A variety of *B. coli* was found to be present, but only in small numbers; it was detected in 4 c.c., but not in 1 c.c.; neither was it found in the equivalent of 250 c.c., when the water was concentrated (see Appendix). It must be supposed, therefore, that it was only accidentally present, and not ordinarily a constituent of the water. This water is different from all other supplies in the barracks, inasmuch as it consists of a mixture of pipe water with rain water flowing off the roof of A block. This mixed supply seems to have been laid on by inadvertence; its existence was unsuspected, and it is certainly unadvisable that it should continue. The tank sediment contained large quantities of leaves and organic matter, also some worms and black stuff (probably particles of carbon, *i.e.*, soot) washed off the roof. Being exposed to dust, of course particles of dung (containing *B. coli*) might gain access to it; the number of germs present was very large in comparison with those in the unmixed pipe supply.

It is possible that the water in this cistern might have been contaminated owing to the direct connexion of its outlet pipe with the contaminated soil around the leak down below; but this is, I think, very unlikely. It is much more probable that the water drawn from the tap should have been con-

taminated by passing through the contaminated soil, or by mixture with some pollution leaking into the pipe when empty.

Whatever may have been the exact *modus operandi* there can hardly be a doubt that the occurrence of the two cases in No. 9 room, A block, has been due to the pollution of the water supplied to the ablution room attached to this barrack.

33.—(6) I have not been able to trace any connexion between the occurrence of cases of enteric fever and the presence of convalescents from this disease returned from South Africa. There is no record of any such men having arrived at this station, though it is by no means unlikely that there should have been some amongst the large number who have rejoined during the last two years. As it is probable that for a long time to come a large number of returned convalescents from this disease will arrive in this country, it would, I think, be desirable that some direct communication should take place between the medical authorities at port of embarkation in South Africa and the medical authorities at station of arrival here, in regard to cases of enteric fever sent home convalescent. At present there appears to be absolutely no "touch" between these authorities in the matter. Perhaps the disembarking medical officer at Southampton, or other port, might forward a certificate to the medical officer in charge of the station to which the man is proceeding. Of course a man who is still ill, more or less, and remains a hospital patient when he disembarks, is not lost sight of; but the number who arrive home convalescent, or at any rate well enough to get away from the transport without being under medical control (which they naturally are eager to escape from) is, I think, considerable; I believe these men arrive at their stations without their medical documents, and are lost sight of medically.

34.—(7) As to the prevalence of enteric fever in the city of Canterbury in recent years, I was informed that it had been endemic to a slight extent. I have not been able to obtain any information from the Medical Officer of Health on this subject.

IV.—Conclusion and Recommendations.

35.—A. From a survey of the present sanitary condition of Canterbury Barracks, it appears that the *water supply* is good and ample, as supplied by the Waterworks Company; owing, however, to the use of cisterns in various parts of the barracks, which are in no case properly protected from dust, there is liability to contamination; in one case (A block, infantry barracks), the pipe water is mixed with rain-washings from the roof of the building. Although a constant supply at its entrance to barracks, it has been made intermittent during the last 4 years, owing to an excess consumption that had occurred in 1897; there appears to be no reason for continuing this practice any longer.

36. The *drainage system* was constructed some 7 or 8 years ago, and is on the whole satisfactory. In one section of the infantry barracks drainage (along the south and west) the drain is not self-cleansing, and stoppage has occurred twice recently; the reason being that the depth of flow (*i.e.*, quantity of sewage) is not enough to furnish a sufficient scour in a 6-inch pipe. In the upper part of this section a branch drain was cracked all across, and within a few inches of it a leaden water pipe was broken. In another section in these barracks (along the east side) the drain is very badly ventilated in its lower part, and shows a tendency to deposit; in the upper part it is well ventilated; here, at rear of officers' mess and quarters some w.c.'s had been found to be untrapped, and did not stand the smoke test a few weeks ago; at the time of my visit all defects had been put right. In the artillery barracks, the manhole outside Commanding Officer's quarter had some defect in construction, leading to frequent stoppage. In the cavalry barracks all drains are in good order. At the married quarters, in the longest drain section, though provided with a flushing tank, partial stoppage was found, due apparently to silt and gravel. Everywhere else the drains were found to be in good order, with plenty of manholes and ventilating pipes. The chief points noticeable seem

to be that, either from insufficient fall or too large a diameter, the drains are not absolutely self-cleansing; and that more flushing and more supervision (to *prevent*, rather than *remove*, choking) are required.

The latrines are in good order, but many of them too dark, on account of a useless brickwork screen in front. The urinals are in good order.

37. The *barracks* are of different patterns and different dates; the infantry barracks are old, but not unsatisfactory; the artillery barracks are also old, and the rooms on the lower floor are low, dark, and not well ventilated. The cavalry barracks are good, except that the west wing is rather old. There has been overcrowding during the past three winters, owing to the large number of troops passing through; on this account the cubic space has been lowered from 600 to 400 cubic feet per head. Under the circumstances this has been unavoidable. The night urinal arrangements are complained of by everyone: though the slabs on which the urine tubs stand are more or less impervious, the tubs themselves and the floor round about become fouled and bad smelling.

38.—B. Bacteriological examination has shown that the water, as supplied direct by the Waterworks Company, is pure. Another sample, taken after passing through the tank outside A block, infantry barracks, was found to contain a large number of organisms, amongst them a variety of *Bacillus coli*; from the details of the examination, however, it appears that this must have been an accidental occurrence; this tank is exposed to obvious contamination by dust and washings from the roof.

39.—C. An inquiry into the circumstances of the 11 cases of enteric fever that have occurred since the beginning of 1900 has not revealed any one particular manner of causation. The cases have been spread all over the barracks, and in no instance has more than one case occurred in the same barrack block, except Nos. 9 and 10 from A block, infantry barracks. I consider that these cases were due to infection of the drinking water, through a leaking drain within a few inches of a leaking water pipe. One other case, at the Infantry Officers' Mess, was also probably due to sanitary defects that existed in the w.c.'s in rear of that building, in conjunction with a foul state of this section of drain. Two cases probably contracted the infection outside barracks. There appeared to be no connexion between the occurrence of enteric fever at this station and the presence of convalescents from this disease returned from South Africa.

40.—D. *Recommendations.* (i.) *Water Supply.*—1. That the cutting off of the water in the afternoons and at night should cease.

2. For consideration, whether the storage tanks should not be abolished, at any rate in connexion with the drinking water supply.

3. If this be considered unadvisable, that (*a*) they be cleaned out frequently, the responsibility for this work being clearly defined; (*b*) that close-fitting covers be provided; and that (*c*) that ingress of rain-water into the tank outside A block, infantry barracks, be prevented.

(ii.) *Drainage.*—4. That a pensioner non-commissioned officer be employed to give his whole time to inspection of the drains and fittings, in order to *prevent* stoppages.

5. Numerous recommendations as to details in the drainage system are specified in para. 24.

(iii.) *Barracks.*—6. That night urinals of modern pattern be supplied on each floor, in place of the present urine tubs.

(iv.) For consideration, whether it would not be desirable that there should be direct communication between the medical authorities in South Africa and medical officers in charge of stations at home, as to despatch and arrival of enteric fever convalescents.

Postscript.

Dated 13.3.02.

Analysis of Canterbury Water. Public Supply. No. 9.

	Grains per gallon.	Parts per 100,000.
Appearance	Clear	
Smell	None	
Chlorine in chlorides	1·47	= 2·1
Phosphoric acid and phosphates	None	
Nitrogen in nitrates	0·38	= 0·54
Ammonia	None	
Albuminoid ammonia	0·0008	= 0·0011
Oxygen absorbed in 15 minutes	Trace only	
,, ,, 4 hours	0·024	= 0·034
Total solid matter	10·43	= 14·90
Microscopical examination of deposit ..	Nominal	

Remarks.—No. 9 is from the Public Supply, and is, as usual, pure.

(Signed) SIDNEY HARVEY,
Public Analyst, City of Canterbury.

Sample received, 11th March, 1902.

The investigations at Canterbury were carried on between 4th and 15th March, 1902; the bacterial examinations were continued subsequently until 7th April.

(Signed) A. M. DAVIES,
Lt.-Col., R.A.M.C.

London,
11*th April*, 1902.

APPENDIX.

Detail of the Bacteriological Examinations.

No. 1. *Sample of Water from Infantry Barracks.*

Sample taken 10th March, 1902, from tap in E block cookhouse, infantry barracks. This water comes direct from the main, without passing through any cistern.

I.—Numeration.

(*a*.) In agar at 37°·5 C. 12 colonies per c.c.

(*b*.) In gelatin at 20° C. 8 colonies per c.c.

II.—Examination for *B. typhi abdominalis* and Coliform Bacteria.

B. *Klein-Parietti Test.*—2,100 c.c. water were passed through a Pasteur-Mallie filter. The deposit on filter removed and worked up in 10 c.c. of the same water: of this mixture 0·5 c.c. was sown into each of two broth tubes, containing respectively 0·1 and 0·2 c.c. Parietti solution, and incubated at 37°·5 C. No growth resulted in either tube.

C. *Pakes' Test.*—Into two tubes of glucose-formate broth were sown

respectively 1 c.c. and 4 c.c. of the unconcentrated water. The tubes were cultivated anaerobically (pyrogallic acid and caustic soda) at 37°·5 C.

1 c.c. tube. No growth.

4 c.c. tube. After 3 days a faint haze and slight growth on glass. A gelatine plate sub-culture from this liquefied in 5 days. An agar stroke culture caused fluorescence in 7 days.

D. *Klein-Pakes' Test.*—Of the mixed deposit and water obtained by passing 2,100 c.c. through a Mallie filter, 1 c.c. (= one-tenth) was sown into glucose-formate broth, and incubated anaerobically at 37°·5 C. No growth resulted.

III.—Examination for *B. Enteritidis sporogenes.*

Of the mixed deposit and water (B), one-tenth (= 1 c.c.) was sown into litmus milk, heated to 80° C. for 10 minutes, and incubated anaerobically in a Buchner's tube—no clotting and no acidification resulted—therefore no indication of *B. enteritidis sporogenes.*

IV.—Examination for Spores.

Of the mixed deposit and water (B), 1 c.c. was sown into gelatine, heated to 80° C. to destroy all non-sporing organisms, then plated and kept at 20° C. No colonies at all developed after 8 days, showing absence of spores.

V.—Examination for *Streptococci.*

A tube of agar having been melted, poured on to a Petri dish, and allowed to set, 1/6th c.c. of the mixed deposit and water (B) was spread over the surface of the agar, then incubated at 37°·5 C. Of the colonies that developed, only one was composed of *Streptococci.*

VI.—*Microscopic Examination.*

Remarks.—The very small number of germs present, the absence of any indication of coliform bacteria, or of other organisms derived from sewage or excremental matters (*B. enteritidis sporogenes, Streptococci*), and the absence of spores (which would probably be present if surface washings had gained access to the water), agree in denoting this supply to be bacteriologically exceedingly pure, as delivered to the barracks. This is what would be expected to be the case from its known origin, a deep well in the chalk, which is not exposed to pollution.

No. 2. *Sample of Water from Cistern, Infantry Barracks.*

Sample taken 6th March, 1902, from pipe leading from cistern outside A block, infantry barracks (see para. 32).

I.—Numeration.

(*a.*) In agar at 37°·5 C. 200 colonies per c.c.

(*b.*) In gelatine at 20° C. In one-quarter of a c.c. 160 colonies developed, = 640 per c.c.: in one-half c.c. the colonies that developed were too numerous to count: there were at least 500 = 1,000 per c.c. Several were somewhat coliform.

II.—Examination for *B. typhi* and Coliform Bacteria.

B. *Klein-Parietti Test.*—2,500 c.c. water were passed through a Pasteur-Mallie filter: the deposit on filter removed and worked up in 10 c.c. of the

same water. Of this mixture, 0·5 c.c. was sown into each of two Parietti broth tubes, containing respectively 0·1 and 0·2 c.c. Parietti solution, and incubated at 37°·5 C. No growth resulted in either tube.

C. *Pakes' Test.*—Into two tubes of glucose-formate broth were sown respectively 1 c.c. and 4 c.c. of the unconcentrated water. The tubes incubated anaerobically at 37°·5 C.

1 c.c. tube. No growth occurred.

4 c.c. tube. After 20 hours, very slight turbidity, and slight formation of gas.

Cx. Gelatine-plate culture from the 4 c.c. tube after 25 hours.

Some liquefying growth was present, and in addition numerous rather coliform colonies, which, however, were rather thicker, and with smoother edges, than is typical.

Cxx. A gelatine-stab culture was made from a coliform colony in Cx. after 6 days. A thin, grey, almost filmy growth resulted that did not liquefy (24 days)—there was slight splitting of the gelatine (gas formation).

Cxxc. Potato culture from Cxx. after 7 days.

After 24 hours no obvious growth. After 3 days, colourless slimy growth.

Cxxd. Litmus-milk culture from Cxx. after 7 days.

After 24 hours, faint pinkish tinge, no clotting. After 3 days the same; also after 11 days.

Cxxe. Broth culture from Cxx. after 7 days.

After 24 hours, slight turbidity. This did not increase.
Indol reaction slight, but distinct after 11 days.

Cxxf. Shake culture in glucose-formate agar from Cxx. after 7 days.

After 24 hours, no gas formation. After 3 days, considerable gas formation. This was evident after 11 days.

Cxxg. Peptone water inoculated from Cxx. after 7 days.

Slight haze after 24 hours. After 3 days, the same.
Indol reaction slight, but distinct after 11 days.

Cxxx. Gelatine stroke plate culture from Cxx. after 7 days.

After 24 hours at 20° C. a copious, thin, but hardly filmy, grey growth in each stroke.

Examined × 1,125. The growth consists of short, stout bacilli, about 2 × 1, with rounded ends, some in pairs, many motile.

Decolorised by Gram-Weigert method.

No change in character of growth after 17 days.

D. *Klein-Pakes Test.*—Of the mixed deposit and water, obtained by passing 2,500 c.c. through a Mallie filter, one-tenth was sown into glucose-formate broth and incubated anaerobically. No growth resulted.

III.—Examination for *B. Enteritidis sporogenes.*

Same procedure as in No. 1 sample. No growth.

IV.—Examination for Spores.

Same procedure as in No. 1 Sample. 23 colonies resulted, *i.e.*, 23 spores in 250 c.c. water.

V.—Examination for *Streptococci.*

Same procedure as in No. 1 Sample. No colonies containing *Streptococci*

VI.—Microscopic Examination of Sediment.

There was no obvious sediment in the water sample. At the bottom of the tank, however, there was a considerable depth (about ¾ inch) of greyish deposit, looking like lime, mixed with dead leaves and twigs, washed down off the roof of A block. On microscopic examination this was found to consist chiefly of calcium carbonate, with a good deal of black amorphous stuff, probably particles of carbon (soot); a few diatoms and small infusoria, and some red worms.

Some sediment from a tank under the roof of cavalry barracks, B block, was also examined. This consisted entirely of calcium carbonate.

Remarks.—This water differs bacteriologically from the former sample, delivered direct from the main, in the large number of organisms it contains, some of which are spore-bearing. The presence of *Bacillus coli*, as shown by the glucose-formate test with 4 c.c. of the water, must be considered to be accidental, as it was not found in the much larger quantity examined in D (viz., one-tenth of 2500 c.c., or 250 c.c.) by similar tests. No indications of surface pollution (the number of spores being small), or of excremental pollution, other than the probably exceptional occurrence of *B. coli*, were found. The explanation of the difference between this sample and No. 1 is to be found in its exposure to dust, and to washings off the dirty roof of A block: the occurrence of *B. coli* is probably due to dust.

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Report on Sanitary Investigations at Portland.

I.—On the Sanitary Condition of the Verne Citadel.

Section 1.—*Water Supply.*

1. *Source.*—The water supply for the Portland garrison is derived from the Weymouth Company's Waterworks, which supply a population of about 20,000 persons in the borough of Weymouth and Melcombe Regis and its neighbourhood. This water is obtained from springs in the Upper Greensand (below the Chalk), near Sutton Poyntz, a village situated on the Downs, about 3½ miles north-east of Weymouth. The daily yield of these springs varies from 2,000,000 gallons in summer to 8,000,000 gallons in winter. The water is impounded in an open collecting reservoir, which together with about 4 acres of the gathering ground is enclosed by iron fencing: thence it flows in an open channel for about half a mile to the village, where it is pumped up to a reservoir at Chalbury (about a mile off), covered in, and holding 300,000 gallons. From this it descends to Weymouth by gravitation. There is another reservoir, also covered in, at Rodwell (between Weymouth and Portland), which is filled by pumping from Sutton Poyntz, and holds 175,000 gallons: another reservoir, holding about 500,000 gallons, has been recently completed at Wyke Regis, still nearer to Portland, but this is not yet (as far as I know) taken into use. The total consumption of water from the Sutton Poyntz Springs is about 700,000 gallons daily.

2. In 1898, Mr. B. Browning, Medical Officer of Health for the borough of Weymouth, considered that there was some possibility of contamination at the source of this supply, from some farms at higher points on the Downs, and situated a mile or more distant from the springs; also from the millstream below the pumping station at Sutton, which he thought had "a tendency to percolate through the clay superstructure to the intervening belt of greensand, and thence to the chalk" at the springs. It does not seem likely that impurities would percolate through clay; and repeated analyses of this water have been most favourable: moreover no death from enteric fever or simple continued fever has occurred in the borough during the ten years, 1891—1900. This population of from 15,000 to 20,000 has been free from apparent waterborne disease for ten years; which fact is in itself a testimony to the goodness of the supply.

3. The following are chemical analyses of this water by different observers, the results being brought to parts per 100,000 for the sake of uniformity.

No. 1.—*By Dr. Bernard Dyer, of London.*

From Weymouth Water Works, 12th October, 1897.

Total dissolved solids	28·4
Volatile solids	2·8
Chlorine	2·57
Saline ammonia	0·0014
Albuminoid ammonia	0·0014
Oxygen absorbed at 80° F.—	
In 15 minutes	0·013
In 4 hours	0·026
Nitrates (NO_3)	1·581

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No. 2.—By F. W. Stoddart, of Bristol.

Sample taken at Weymouth Water Works, 31st October, 1899.

Total dissolved solids	28·5
Total hardness	22·4
Temporary hardness	16·0
Permanent hardness	6·4
Chlorine	2·4
Saline ammonia	0·0006
Albuminoid ammonia	0·0013
Oxygen absorbed in 4 hours at 80° F.	0·021
Nitrates (NO_3)	1·063
Nitrites	0

No. 3.—By Professor R. H. Firth.

Taken from Reservoir in Verne Citadel, 10th April, 1901.

Total dissolved solids	32·5
Total hardness	18·0
Temporary hardness	10·5
Permanent hardness	7·5
Chlorine	2·4
Saline ammonia	0
Albuminoid ammonia	0·0048
Oxygen required (140° F.)	0·0190
Nitrates (NO_3)	1·2254
Nitrites	0

4. The bacteriological examination of No. 1 showed 3,750 colonies of aerobic bacteria per c.c. on ordinary gelatine medium, of which 2,000 are (said to be) capable of growing at blood heat (but this refers presumably to another culture on agar): 180 colonies withstand the action of weak phenol, "being of the various kinds of organisms ordinarily classed under the *coli communis* group." As the sample was, however, not sent direct to the analyst, and the time that elapsed between drawing it and setting the cultivations is not stated, these numerical results can hardly be said to have any value. Dr. Dyer reported that "the water might advantageously be filtered, or if it has been filtered already, that the filtration might be better conducted. The chemical results, however, do not appear to indicate any actual sewage contamination."

5. Mr. Browning made a chemical and bacteriological examination in March, 1898, resembling No. 1 in its results; he found 368 colonies per c.c. (at what temperature is not stated), of which 40 resembled *B. coli communis*, "probably derived from sheep's and rabbits' dung on the Downs": no details as to procedure are given, and no inferences can safely be drawn from the report.

6. The bacteriological examination of No. 2 showed 20 colonies per c.c. in nutrient jelly: no germs of disease or microbe organisms indicative of sewage pollution were discoverable by appropriate methods. Neither time after taking sample, nor temperature of cultivation, is mentioned.

7. The bacteriological examination of No. 3 "indicates this sample to contain none but ordinary water micro-organisms."

8. While Dr. Dyer and Mr. Browning considered that the water required filtration, Mr. Stoddart classed it "amongst those of the highest degree of organic purity," and Professor Firth considered it "a pure and good water."

9. The results of my own bacterial examination are given in an Appendix, and are summarised in para. 35; they corroborate the favourable opinion of the water previously expressed.

10. *Distribution.*—From the Weymouth Water Company's mains on the mainland a special main is conducted across the "Ferry Bridge" (which joins the island to Weymouth), and along the Chesil Bank to Castleton, the hamlet at the northern extremity of the island. Here is the pumping station for raising the water to a height of 487 feet, which is the level of the Main Reservoir in the Verne Citadel. This is divided into three compartments, is completely covered in, and lined with cement, and holds 600,000 gallons (about three weeks' supply). This tank supplies the whole citadel by gravitation, except one section, comprising married quarters, officers' mess and Commanding Officer's quarters, for which there is a separate iron tank of 45,000 gallons, placed on roof of Infant School, and filled from the Main Reservoir by pumping.

11. The distribution system is designed to furnish a constant supply, and there are no drinking-water cisterns in barracks, except in the Officers' Mess, at the Commanding Officer's quarters, and in the coffee bar, all of which are covered in. There are no other cisterns except those for the hot-water apparatus for baths (of which there are three), for hot water at the hosital, for the laundry and for the latrines. Assuming that the supply is really a constant one, that is, one in which the pipes are constantly kept full of water, the distribution system appears to be very well designed; there are no chances of contamination during storage, as is so often the case in barracks; and the good fittings provided ought to prevent waste.

12. In reality, however, the water has not always been laid on as a constant supply, and for the last few months has been only supplied intermittently twice a day; so that, on account of the absence of cistern accommodation, considerable inconvenience, and even hardship, has resulted. To account for this, it is necessary to explain the arrangements as regards supply, which are rather complicated.

13. It has been said (para. 1) that the water for the citadel is derived from the Weymouth Water Works Company; it is not, however, obtained from this Company direct, but through the Portland Urban District Council,* who obtained it from the Weymouth Company under an arrangement by which the Council took over all the obligations of an agreement which had been made between that Company and the Admiralty; so that the Company supply the Urban Council, the Council supply the Admiralty, and the War Department obtain it from the Admiralty on repayment, the pumping being done by the War Department, and with their own machinery. To still further complicate matters, the War Department have agreed to supply the Home Office authorities with 10,000 gallons weekly for the use of the Convict Prison.

14. As far back as January, 1900, the Urban District Council expected to be in a position to supply all the Government Departments in Portland, within a few weeks; but I understand that at the present date there is no immediate likelihood of their being able to furnish any water to the Citadel, or to the other Government departments concerned. Two years ago the question of duplicating the pumping machinery was raised by the Royal Engineers, it being pointed out that in the event of any breakdown of the engine or pumps, there would be great inconvenience, as there is nothing to fall back on. The average daily amount required (when the Citadel is fully occupied) being 20,000 gallons for the military, with an extra 10,000 gallons weekly for the prison, or say 150,000 gallons weekly; the pumping capacity at 44 hours per week and 3,300 gallons per hour, was only 145,000 gallons. By pumping 64 hours a week, a weekly yield of 211,000 gallons may be given; and this was actually done recently in order to refill the reservoir, on which the garrison had been obliged to draw, during a stoppage of pumping for repairs.

15. The necessity for economy in consumption of water was therefore made evident, and a second engine and pump was estimated for at a cost of £500. In the middle of 1901, however, there was a considerable reduction in

* It is to be noted that the Urban District Council have another, and totally different, supply of their own, which they distribute to the civil population of the island.

the strength of the garrison (from a full battalion to about 350 details, and it was intimated that this reduction would probably be permanent. Under these circumstances, the duplication of the pumping machinery was not considered urgent, and the estimate was struck out.

16. Attention having been drawn to the need for economy, it was found that from beginning of May to end of October, 1901, there had been an over-consumption of 526,000 gallons, which could not be accounted for. A Board of Officers inquired into the matter, and found that, after making every allowance, 338,000 gallons should be charged to the occupants of the barracks as excess consumption. The General Officer Commanding approved; and in order to prevent such apparent waste in the future, also approved of any experimental cutting off of the water, which the Commanding Royal Engineer and the Army Service Corps Officer might think desirable. After consultation, it was decided, as an experimental measure, to turn on the water twice daily, allowing only the exact amount to which the troops are entitled by Regulations; half the amount to be run through in the morning, and the supply then cut off; and the remainder run through in the afternoon.

17. This is what has actually been done since the latter part of last November; but much inconvenience and some hardship has resulted in consequence of the almost entire absence of cisterns. It has been the case that men have been unable to get a drink of water in the afternoon, or have had to store water in open pails or other unsuitable vessels in the barrack rooms: they have also been unable to get a wash after afternoon parade, and have had to wash two or three in the same basin. It has been impossible to use the hot bath accommodation provided, as each bath requires from 45 to 50 gallons, an amount that is out of the question when the allowance for all purposes is 20 gallons per head. Lastly, the people in the married quarters, and the women who do the regimental washing, have been put to great inconvenience. On this section of the distribution system are situated married quarters and laundry, Officers' mess, and Commanding Officers' quarters; the two latter are provided with cisterns. There is also a large cistern at the laundry, but as this and the married quarters are at a considerably higher level than the Officers' mess and Commanding Officer's quarters, and as the water has been only turned on for about half an hour morning and afternoon, the water has always run down to fill the cisterns at the *lower* level, and the people at the *higher* level have been unable to draw off the quantity of water (to which they were entitled) in the short time available, and their cistern (at the *higher* level) has not been filled. Consequently they have had to go very short of water for domestic and laundry purposes.

18. In consultation with Lieutenant-Colonel E. S. E. Childers, C.R.E., Weymouth; Major the Earl of Westmorland, commanding details, Verne Citadel; Lieutenant and Quartermaster Browne, Army Service Corps Officer; and Dr. Henley, Civil Surgeon in medical charge, it was agreed on the 30th and 31st January, that the quantity hitherto supplied was insufficient; and, pending sanction of the General Officer Commanding, it was agreed that, as an experimental measure, for (*a*) sanitary purposes, and (*b*) hot baths, 20,000 gallons a week, and for (*c*) laundry purposes, 1,000 gallons a week, should be allowed in addition to the 20 gallons per head per day provided by regulation. This extra allowance is recommended to be supplied, as an experiment, and it will be carefully watched. It may be that a smaller quantity will be sufficient for the purposes named; but I consider it not unlikely that even more may have to be allowed. The reasons for the necessity of this (or some similar) amount in excess of regulation are chiefly as follows:—(1) There are certain "fixed charges," as it were, that must be supplied in barracks, and that cannot be reduced proportionately with reduction in the strength of the garrison. The flushing of latrines, urinals, and drains is the most important of these: for December quarter, 1900, the average total daily consumption was 14,260 gallons; for December quarter, 1901, it was reduced to 7,840 gallons; but it is impossible to diminish the amount *absolutely needed* for sanitary purposes in so great a proportion as this. (2) Hot-water apparatus is provided for baths in the ablution rooms, and it is most desirable on every ground that the regimental order—that each man should have a warm bath

once a week—should be carried out; but it is obviously impossible to do this (implying about 7 gallons per head per day) out of the regulation allowance of 20 gallons for all purposes. When this total quantity was fixed upon as sufficient for all purposes, a general bath of about 50 gallons once a week was not contemplated. But as to its desirableness there can be no question, and the necessary apparatus has been provided.

19. The above two reasons are of general application; but at this station there are two special circumstances that furnish additional reasons for the necessity of an ample water supply. (3) The drains being in some instances of large size, and in particular, the main drain being 2 feet 6 inches in diameter, a copious flush is necessary to prevent choking or deposit; probably one or more automatic flush tanks will be the most economical means of securing a proper condition of the drains: the present allowance is quite insufficient, on account of the large diameter of the main outfall sewer. (4) At this station there have been large numbers of returned convalescents from South Africa, many of whom had suffered from enteric fever; it is known that in some cases of convalescence from this disease the urine remains infective for a considerable, but uncertain, length of time; it is necessary, therefore, that it should be rapidly and completely carried off into the drains, and not allowed to evaporate and possibly become disseminated through the air of urinals and latrines. To do this a much better flushing arrangement than now exists is required. At present the urinals are flushed for a few minutes twice a day; for the greater part of the day they are dry, or almost dry, and of course a sediment collects; this, even if not infective, is unpleasant and unwholesome. It is laid down in Army Service Corps Regulations, Appendix 22, para. II, *f*. "That unless specially ordered to the contrary, urinals are flushed through the perforated pipes for about 20 minutes once a day in spring, autumn, and winter; and if specially ordered, disinfected with a little carbolic powder. In dry summer weather they may be flushed twice a day for about 15 minutes at a time. In wet weather very little flushing is necessary." I do not think that this sparing use of water can possibly be defended from a sanitary point of view; and I recommend that either the urinals should be flushed continuously, or better, that automatic flushing cisterns should be provided, adjusted to discharge one gallon at a time to each stall every half-hour while in action (as recommended in *Drainage Manual*, para. 277) or at even shorter intervals, as is the case in all public conveniences of a modern type in London and other large towns.

20. In addition to the above-mentioned water supply derived from the Weymouth Company's Waterworks, there are within the Verne Citadel rain-water tanks, having an aggregate capacity of 400,000 gallons. The rain-water is caught on the grass-covered earthworks above the casemates, and sinking through the earth flows into the spandrils (hollows between the semi-circular arches), from whence it is conveyed by pipes into tanks beneath the barracks. There are three of these beneath the south-west range, two being under ablution rooms and one under the cookhouse; beneath the south-east range there are two, one under the ablution room, and one under the tailor's shop. The overflow pipes of these tanks, until recently, led direct into the main drain. These overflows were stopped up last year, and now the tanks will require to be pumped out at intervals, until fresh overflows leading into the outer air are constructed.

21. These tanks were presumably made to store water for drinking and domestic purposes, but I am unable to state when their use was given up. The Citadel would seem to have used rain-water at one time, as in the 5th Edition of Parkes' *Hygiene* (1878) Professor de Chaumont referred in a note (p. 18) to the impure composition of stored rain-water at this place. But for many years the water in these tanks has not been used apparently for any purpose; and their direct connexion with the main drain would have rendered the contained water dangerous for drinking. In fact, it was found that an actual overflow of sewage into one of these tanks had taken place. Provided all such communications with the drain are cut off, it would seem advisable that this water should be used for flushing purposes, in case of fire, &c. But special pumping arrangements would have to be made. It is perhaps a point worth noting, whether this storage capacity can safely be neglected, from a

purely military aspect (the citadel presumably being intended to be impregnable), but as the main reservoir contains a three weeks' supply, perhaps this is considered sufficient.

I think, however, that if the tanks are to remain in their present position, and to receive rain-water, measures should be taken to clean them, and keep them clean; and that an extra flushing of the drainage system should be carried out at regular intervals with this surplus water, as by means of the fire engine. This has been done occasionally, but not systematically.

22. There is another (open) tank near the south-west latrines, which receives rainfall and some surface drainage, and is used for flushing these latrines and urinals; at the time of my visit there was very little water in it. In wet weather this tank forms an appreciable addition to the water supply for flushing purposes; but in dry weather (as latterly) practically the whole amount required has to be supplied from the main reservoir; the gathering ground is not large enough to make it a supply that can be depended on in dry weather, when drain-flushing is most needed.

Section 2.—*Drainage.*

23. The arrangement of the drainage system at the Verne Citadel is, in its main points, as follows:—

The principal drain commences at the western end of the southern part of the citadel, in front of the south-west range of casemates, and pursues a straight line to the east, across the parade ground, as far as the Racquet Court (a little to the east of the south-east range of casemates): here it bends slightly northwards, and leaving the citadel, falls sharply down the east face of the hill into the sea. This main drain begins as a 15-inch stoneware pipe, which about opposite the middle of the south-west range becomes a 2-foot 6-inch brick culvert, continuing thus to its outlet.

Commencing from the top, this main drain receives:—

(1.) Several small surface drains, and the drainage from the cookhouse and ablution rooms of the south-west range.

(2.) A 9-inch drain bringing (i) foul drainage from the principal latrine and urinal, that belonging to the south-west range; (ii) foul drainage from the canteen; (iii) foul drainage from staff quarters; (iv) surface drainage from the western portion of the citadel generally.

(3.) A 9-inch drain bringing foul and surface drainage from the Royal Engineer Office and premises and central part of the Citadel.

(4.) Foul drainage from hospital latrine and urinal.

(5.) Foul drainage from hospital cook-house and ablution room, and surface drainage from near hospital.

(6.) A 9-inch drain bringing (i) foul drainage from married quarters' latrine; (ii) Royal Engineer quarter; (iii) laundry; (iv) Officers' mess; and (v) Officers' quarters, block A; also (vi) surface drainage from the northern and eastern parts of the citadel.

(7.) Foul drainage from cook-house and ablution room of the south-east range, and surface drainage from the neighbourhood.

(8.) Foul drainage from Officers' quarters, B block.

(9.) Foul drainage from latrine and urinal belonging to south-east range of casemates, stables, &c.

(10.) Foul and surface drainage from Commanding Officer's quarters.

These branches are 6-inch drains, except those mentioned as of 9 inches diameter.

24 The four chief things that struck me in this system were: (a) the

almost entire absence of manholes; (b) the general inaccessibility of the drains, some being at a great depth, and a part of the main drain (where are the important junctions of branches 6 and 7) being under a ramp of earth, making inspection practically impossible; (c) the absence of ventilating shafts or manholes; and (d) the mixing up of surface and foul drainage without disconnecting chambers. Other points might be mentioned, but there is no need to go into further detail, as sanction has been given for a general process of reconstruction according to modern experience. Two points, however, should be alluded to, on account of their importance, though they did not come under my own personal observation; (1) I was informed that the overflow pipe of one of the underground rain-water tanks below the south-east casemates, leading into the main drain, had been laid in such a way that it allowed back flow of sewage into this water tank; and that on account of partial choking, or deposit, in the main drain, some actual back flow had taken place; there was no disconnexion between drain and overflow pipe; this pipe had been entirely stopped up before my visit to Portland. (2) The main drain being a brick culvert, as large as 2 feet 6 inches in diameter, and constructed many years ago, it had been thought that its condition would almost certainly be unsatisfactory, owing to erosion of joints and roughening of surface, leading to deposit of sewage; it had therefore been recommended that the brick culvert should be replaced by a 15-inch pipe. I was not able to examine its interior, as it lies at a depth of 35 feet below the surface. Mr. W. C. Tyndale, Sanitary Engineer to the War Office, has made his way along the interior of this sewer for a considerable distance, and has found that it is extremely well laid, is cemented, and is in good condition; that it is sweet and clean, the fall being rapid towards the sea, and the volume of contained air large. He considers that there is no need to replace it by a pipe-drain. He recommends the construction of a ventilating shaft at the point where the *sudden* fall to the sea commences; also a hinged flap in the drain, on the upper side of the shaft. The personal inspection by Mr. Tyndale settles the question; there can be no need to replace such a good drain by a smaller pipe (as was previously and very naturally thought to be necessary); it is true that bad smells have been complained of, when the wind blows up the drain from the east; but with the provision of a large ventilating shaft, and flap, at the point named, together with other ventilators inside the Citadel, as now proposed, and with more frequent and systematic flushing, I feel sure that this brick culvert will cease to be a source of danger or inconvenience.

25. Some few disconnecting manholes have been constructed within the last few years, with siphon traps; some are open to the air at ground level, as those outside A and B blocks, Officers' quarters; although facilitating inspection, there is risk of gravel and silt getting in through the grid and blocking the drain; they are also (I think) too much in the way of traffic for an open drain disconnexion. The manhole outside B block, containing a junction, is badly constructed; the benching opposite the incoming branch drain is not "extra steep and high to meet discharge of branch drain" (see *Drainage Manual*, para. 188, and Plate V, Fig. 28), but is very low and gradually shelving; moreover, the branch drain does not enter at a higher level than the main channel, and has therefore no "cascade action"; the result is that the discharge from the branch gets thrown up on to the benching opposite, where I found a considerable and offensive deposit. This can be easily remedied, according to the instructions in the *Drainage Manual*.

26. The size of the main drain (2 feet 6 inches) and of some of the collecting drains (9 inches) is larger than is necessary or desirable, if some modifications were made in the arrangement of surface and foul drainage systems. The fall is generally sufficient to cause a good flow, but with the somewhat limited supply of water (as will be always more or less the case at the top of this hill), it is for consideration whether smaller collecting drains would not be preferable. For the main drain a special flushing tank should be provided. In two places (in front of the south-east casemates, and near the hospital) the fall has been found to be insufficient, and some deposit of sewage occurred. Special precautions will be required to obviate this in

future; and with a flushing tank and inspection chambers, such as are proposed to be constructed, there should be no danger of this occurrence.

27. The *latrines* are Jennings' old-pattern pan latrines; they are flushed once, or perhaps twice a day. My opinion is that a very much larger quantity of water is required to keep latrines of this (or any other) pattern in a decent state. The instructions on page 21 of the manual of *Instructions in the Care of Barracks* are excellent, but I do not know that they are ever carried out; they would require very much more than the regulation allowance of water. I consider that an automatic discharge, or flush, operating at frequent intervals during such times of the day as the latrines are especially in use, is the only satisfactory plan.

The south-east block of latrines is closed, that range of casemates being at present unoccupied.

28. The *urinals* are coated with a thick deposit, showing that flushing is insufficient; as they are only flushed once, or perhaps twice a day, this is bound to be the case. This has already been referred to in para. 19. I recommend that the existing regulation (A.S.C. Regulations, Appendix 22, para. II, *f.*) be modified, and that an automatic flush at short intervals be provided.

29. From the above short description it is evident that the drainage arrangements have been, and are, very far from satisfactory; and that there has been opportunity for pollution of air, and possibly water, by access of faecal and urinary matters. A comprehensive scheme for setting the whole system in order has been prepared by the Commanding Royal Engineer, the estimated cost being about £1,800; the only additions that I would recommend are those just noted, viz.: (1) provision of automatic flushing for latrines and urinals; and (2) improvement of existing (new) manholes outside Officers' quarters.

Section 3.—*General Sanitary Condition of Barracks.*

30. The *situation* of the barracks is entirely satisfactory from a sanitary standpoint, being at the top of the Verne Hill, 487 feet above sea level, freely open to the breezes on all sides, and not exposed to any unhealthy influences. The hill is composed of Portland oolite, but a portion of the area of the Citadel consists (I was informed) of made ground, there having been considerable excavations and levellings. There is accommodation for 786 rank and file (250 in south-east casemates, 480 in south-west casemates, and 56 in lower flank), and for 944 of all ranks; the usual garrison consisting of a battalion of infantry and a small detachment of Royal Artillery. Since the middle of July, 1901, when the Manchester Regiment left, there have been about 300 details of the Northamptonshire Regiment in place of a full battalion. The strength on 31st January, 1902, was—Infantry, 233; Royal Artillery, 40; Staff, &c., 13. Total, 286.

31. The *barracks* are all casemates, and are therefore unavoidably difficult to maintain in a satisfactory sanitary condition. There is an additional difficulty also from the fact that their aspect is either directly north (as in the south-west range), north-west (south-east range), or north-east (hospital), consequently they never get any appreciable benefit from the direct rays of the sun; this cannot be helped, as, presumably, it was a military necessity to construct the barracks on the southern side of the Citadel (*i.e.*, facing more or less north). The rooms are lofty and not overcrowded; but the ventilation is not as satisfactory as might be possible under the circumstances. Each room has two Galton grates, and four outlet ventilators leading up to the open air above the ramp. Along the whole length of each range, at the back, runs a corridor, ventilated by shafts leading straight up to fresh air above, which are intended to act as outlets; as in each case a flat stone is accurately adjusted to close the top of the shaft (leaving only a *lateral* aperture of about an inch all round) the extractive power of these shafts must be very small. On the recommendation of Dr. H. R. Henley, Civil

Medical Officer in charge, three extra ventilating shafts, with upcast revolving fans, have been fixed in the south-east corridor; these are a great improvement, and I recommend that similar ones be provided for the south-west corridor. Gas jets, kept alight at the bottom of some of the old-pattern ventilators, also help to extract the foul air. It is necessary to keep out rain, but this might be done without stopping up the whole area of the shaft, as is the case at present with the old ventilators. The rooms communicate with the back corridor by doors and windows, the corridor being intended to draw out foul air from the rooms.

32. The barrack rooms are clean, and were limewashed about 9 months ago; the corridors, however, are dirty. I could not find out when they were last limewashed, but they need it now; the wall surface in the corridors being rough, catches the dirt very much. This point requires careful attention, as, on account of the construction, ventilation must always be a difficult matter, and it is most important that the interior surfaces of the rooms and corridors should be kept as clean as is humanly possible, so that the air the men breathe be not fouled more than can be helped. The rooms ventilate into the back corridors, therefore these should be kept clean; frequent limewashing is perhaps the best way to bring this about. I think that this is a case in which an extra allowance of materials, and extra money to pay for the necessary labour (by the troops), should be sanctioned, the conditions being exceptional. (Carnelley, Haldane, and Anderson have shown that the micro-organisms present in the air of inhabited spaces mostly come from the walls; the cleaner these are kept, the purer is the air breathed.)

The flooring of the south-east range has been renewed within the last few months. I was informed that the ground underneath had been found in nearly every case to be quite clean and dry. The flooring of the south-west range and hospital, though not new, is in good order.

35. The *cookhouses* and *ablution rooms* are satisfactory, except that No. 1 ablution room (south-west range) still has some of the old-pattern *fixed* iron basins. Excellent hot-water apparatus are provided for baths in both ranges of barracks; there are three bath rooms and six baths; but at present only two baths are in use, owing to want of water.

The coffee bar has a small cistern, properly covered in; this is the only cistern in the men's quarters throughout barracks. The serjeants' mess and canteen are satisfactory, except that the kitchen for the former is in the basement below the ground level; two men sleep in this room.

34. A range of casemates called the *Lower Flank*, lying at a lower level than the rest, are used as stores, shoemaker's shop, &c.; except two rooms, one for single serjeants, the other for men of the Royal Army Medical Corps. These rooms have all the disadvantages of the other casemates, and, in addition, are quite deprived of sun and fresh air, as they look on to a blank wall some 8 or 10 yards in front (the substructure of the Hospital). They should not be inhabited if it can be helped.

II.—Summary of the Results of Bacteriological Examinations.

35. The only bacteriological examination made was that of a sample of water taken in the Citadel barracks. The details are given in Appendix I.

Two litres and a half were submitted to examination by filtration through a Pasteur-Mallie filter, and collection of the deposit on its surface; no indication was found of the presence of *Bacillus typhi abdominalis*, nor of any coliform bacteria, nor of *B. enteritidis sporogenes*, therefore excremental pollution may be considered to be absent. Secondly, neither *Streptococci* nor spores were found to be present; nor were there any colonies of *B. mycoides* or *Cladothrix*, therefore no indications of surface washings. The number of germs was 14 per c.c. in agar at blood heat, and 85 per c.c. in gelatine at 20° C.; the comparative smallness of these numbers is probably due chiefly to the cold weather, but indicates that the water is bacteriologically fairly pure. It is good for drinking.

III.—Enteric Fever at Portland.

36. The accompanying table shows the number of cases that have occurred during the last 6 years. There were none in 1896–1899, nor in 1900 until December 20th, and there have been no admissions since September 17th, 1901.

37. It will be seen that the total number of cases fall into two groups—cases 1 to 10 were admitted at short intervals between 20th December and 10th March; cases 11 to 18 were admitted at short intervals between 20th July and 17th September. Between 10th March and 20th July there were no admissions.

38. Secondly, it is to be noted that all of the first group of cases except one were admitted from the south-east range of casemates, although the whole of the barracks were at that time occupied, and the occupants of the south-east range numbered only about half those of the south-west range (about 250, as compared with 480). The exceptional case, No. 9, was a hospital orderly who had been in attendance on enteric-fever patients, and, doubtless, contracted the disease in that way.

Admissions for Enteric Fever at Portland. 1896—1901.

		Name.	Barrack room.	Date.	Remarks.
1	2/Northants	Pte. Paryer ..	13 S.E.	20.12.00	Returned from furlough at Newport Pagnell, 23.11.00, and has felt unwell ever since. Has not been out of the Citadel. No insanitary conditions of barracks or water supply. Milk from Fortune's Well, where enteric fever is endemic, thought to be due to contaminated surface wells.
2	„	„ Anderson	12 S.E.	1.1.01	Milk as in No. 1. Six enteric convalescents from South Africa in same room.
3	„	„ Horwood	„	29.0.01	Same remarks as No. 2.
4	„	„ Price ..	„	7.2.01	Same remarks as No. 2.
5	„	„ Coates ..	„	11.2.01	Same remarks as No. 2. This patient had enteric fever in South Africa.
6	„	„ Minney ..	5 S.E.	13.2.01	Same remarks as No. 2.
7	„	„ Burnham	6 S.E.	2.3.01	Sanitary condition of S.E. casemates not entirely satisfactory. Milk as in No. 1. Disease probably due to contagion from South African convalescents, but medium of transference unknown.
8	„	„ Earle ..	5 S.E.	2.3.01	Same remarks as last case.
9	R.A.M.C. ..	„ Aldred ..	7 Lower Flank	4.3.01	Disease due to contagion whilst nursing enteric cases. Sanitary condition of barracks and milk, as last case.
10	2/Northants	„ Rose ..	S.E. ..	10.3.01	Probably due to contagion as No. 7. Sanitary condition of barracks and milk as No. 7.
11	„	„ Robinson	11 S.E.	20.7.01	Was at Wool Camp from June 1st to July 17th, where infection was apparently contracted.
12	„	„ Knight ..	14 S.E.	4.8.01	Same remarks as No. 11. Had felt ill three or four days before admission.

After the occurrence of the last two cases, the south-east casemates were evacuated.

		Name.	Barrack room.	Date.	Remarks.
13	2/Northants	Pte. Gould ..	25 S.W.	18.8.01	Cause possibly defects in drainage. Milk same as No. 1; it has been complained of by the troops, and is now discontinued.
14	„	„ Richards	21 S.W.	28.8.01	Had previously been in No. 2 S.E. casemate. Had returned from Wool Camp 17.7.01. Had felt ill for five or six days before admission. Drainage not satisfactory.
15	„	„ Morgan..	„	30.8.01	A comrade of last named, shared same rooms. Had returned from Wool, 17.7.01. Had felt ill ten days or a fortnight before admission. Drainage not satisfactory.
16	„	„ Fincham	25 S.W.	5.9.01	Left Portland for Wool on 2nd, and reported sick on 5th, having had diarrhœa for two days. Had occupied next bed (in No. 25 room) to Pte. Gould (Case 13). Milk from Norman's dairy. Drainage not satisfactory.
17	„	„ Bailey ..	22 S.W.	6.9.01	Sanitary conditions and drainage and milk supply as last.
18	„	„ Dickens	27 S.W.	17.9.01	Cause probably defects in drainage, or infection from previous case.

39. Thirdly, the first case of the second series (No. 11) had only returned 3 days from the camp at Wool, where he had been for the preceding 6 weeks; there can be no doubt that the infection was not contracted in the Verne Citadel. The second case (No. 12) had been back from Wool Camp 18 days before he was admitted to hospital; he had felt ill 3 or 4 days before reporting sick; it is quite possible that he also brought the infection with him.

40. Fourthly, the remaining cases (13 to 18), though admitted from the south-west range, had previously all been located in the south-east range.

41. The foregoing facts appear to show that, whether the infection was introduced or contracted in the station, the first series of cases was entirely connected with the south-east range of casemates; when these were evacuated, admissions for enteric fever ceased; the commencement of the second series was undoubtedly due to importation of infection, and though most of the cases were actually admitted from the south-west range, in many of them a connexion had existed with the south-east casemates.

42. The first group of cases (December to March) may now be examined more closely. Portland had been free from enteric fever for some years; the infection is introduced somehow or other in December, 1900; a succession of cases quickly occur, limited (practically) to one range of barrack rooms; these are evacuated, and the cases come to an end in March, 1901.

Of the 10 cases between December and March, the first came from No. 13 room, 4 were admitted from No. 12 room (adjoining No. 13), 2 came from No. 5, and one from No. 6 (adjoining No. 5); in one case the number of the room is not known; and one case was that of a hospital orderly. I could find nothing peculiar to the situation or condition of these rooms; but they had been re-floored, and had been empty for some months before my visit. The water tanks previously referred to (para. 20) do not lie under these rooms; and I was informed that when the floors were taken up the ground beneath was found to be clean and dry. Nevertheless, everything points to the existence of some strictly local condition affecting this range o

casemates, or these four rooms, that must have been instrumental in spreading the infection.

It is my belief that under certain conditions it is possible for the specific poison of enteric fever to develop in a barrack or camp, without the introduction of *Bacillus typhi abdominalis* from without. But there is no justification for assuming this to be the case, unless all possible modes of its introduction have been excluded. In the present outbreak we must try to ascertain the causation of the first case, and afterwards, the reason for the succession of cases, which may or may not have been derived from this first case. There are at least three possible explanations or modes of introduction of the infection, which require examination. (1) Private Puryer may have contracted the disease whilst he was on furlough; (2) he may have become infected in the village of Fortune's Well, or by drinking milk that had there become infected; or (3) the infection may have been introduced by convalescents from enteric fever returned from South Africa.

43.—(1) In his report on the case, Captain E. W. Slayter, R.A.M.C., states (28th December, 1900) that Private Puryer "returned from furlough 23rd November, 1900. He has attended hospital for treatment for anæmia since that date, and has not left the Verne Citadel during that time. He is very steady; he has been feeling unwell ever since his return, and probably contracted the disease in his village, Newport Pagnell, Bucks." He was admitted to hospital on 20th December, that is 27 days after his arrival at Portland, and at least 27 days after departure from Newport Pagnell. The incubation period of the disease is very uncertain, but the longest period that has been assigned (as far as I know) is 23 days (Report of Committee of Clinical Society); this is certainly extremely unusual. As the patient was attending hospital for "anæmia," and therefore under medical observation, it is not at all likely that he had been suffering from fever for more than a day or two before his admission. Without denying the *possibility* of importation from Newport Pagnell, there can be little difference of opinion as to its extreme improbability. I have no information as to whether the disease was or was not prevalent at that place.

44.—(2) *Importation from Fortune's Well.*—As it is stated that Private Puryer had not been outside the Citadel since his arrival, the possibility of direct infection in the village is about as remote as that of importation from Newport Pagnell. But as the sanitary condition of Fortune's Well has to be considered in its connexion with the milk supply, as well as on its own account, it may be as conveniently dealt with here as later on.

Portland constitutes an urban district, consisting of several villages, the principal one being Fortune's Well and Chiswell (which are practically united), lying at the foot of the hill on which stands the Citadel, and on the main road to Weymouth, through which every one passes in going to and from the barracks. These villages are much frequented by the military, and though some distance from the barracks, their sanitary state is likely to affect that of the garrison on this account. Without entering into detail it is sufficient to state that, in 1900, enteric fever was endemic in Fortune's Well and Chiswell: there were 20 cases in the whole island, 19 of which occurred in these villages: in 1901 there were only two cases in these villages, and none at all in the rest of the island; the last case was notified on 13th November, 1901. Dr. D. J. Lawson, the Medical Officer of Health, has kindly given me these figures, and informs me that in his opinion the cause of the prevalence was the drinking of contaminated surface well water. In this opinion Dr. H. R. Henley concurs.

Portland is supplied with water from the Downs beyond Weymouth, possessing its own waterworks at Upwey; but for some reason, during 1900, the supply was very defective, being cut off for many hours in the day; the inhabitants were consequently compelled to use the surface-well water,* which in many cases is almost certainly contaminated with sewage matter, there

* From one of these very old surface wells the place derives its name, Fortune's Well. "Chiswell" is only another way of spelling "Chesil," and does not refer to any well.

being at present no sewerage system in these villages. During 1901 the supply of pipe-water from Upwey has been fairly constant, and the use of well water has almost ceased; during this year, also, enteric fever has been almost absent from the island.

The pipe water is of excellent quality, and is practically of the same composition as that of the Weymouth Company, supplied to the troops. For the following analyses I am indebted to Dr. Lawson: No. I is water taken from the shaft at Upwey; No. II is from a house in Chesil, near the Portland Railway Station. The results are stated in parts per 100,000:—

	I.	II.
Total dissolved solids	58·3	65·7
Total hardness	20	20
Chlorine	2·86	2·86
Saline ammonia	0	0
Albuminoid ammonia	0	0
Nitrogen as NO_3 and NO_2	0·0006	0

These are good samples of drinking water, although rather hard.

I was not able to obtain any analyses of any of the surface wells; but there is no reason to doubt the general opinion that they are extremely liable to sewage contamination. It would therefore be possible that the troops might contract enteric fever in public houses or eating houses in Fortune's Well, or by drinking milk contaminated, either by adulteration or by washing the milk cans, with this dangerous water.

The milk supply is stated to have been quite satisfactory during the first outbreak. It was obtained from Brain's Dairy in Fortune's Well, the milk being brought from Sparkford, in Somerset; the dairy was in good order, the milk of apparently good quality, and no adulteration was suspected. As no case of enteric fever occurred among the women and children, there is really no reason for suspecting the milk supply, either in connexion with the first case or those occurring subsequently.

45.—(3) *Importation by Convalescents returned from South Africa.*—From a report by Captain Slayter, R.A.M.C., dated 19th April, 1901, it appears that the barracks were first occupied by invalids returned from South Africa on 4th December, 1900, when the Details, 2nd Northampton Regiment, took over the south-east casemates from the 3rd Northampton (Militia).* In No. 13 room (where Private Puryer stayed) there was Corporal Goss, an enteric convalescent, who arrived from South Africa in s.s. *Dilwara*, and is said to have joined at Portland on 10th October, 1900 (but it is not stated what barrack he then occupied, or whether he went on furlough, as was probably the case). In the adjoining room, No. 12, there were 9 returned enteric convalescents, previous to the occurrence of the 4 cases that were admitted from this room—these 9 men were Corporals Stickland, Asplin, and Reynolds; and Privates King, Sydie, Coates, Stanley, Agates, and Knott. The men of Nos. 12 and 13 rooms messed together in No. 12 room.

It appears therefore that in these two barrack rooms, accommodating 20 men in each, there were 10 enteric convalescents, brought into the most intimate association with the remaining 30 inhabitants as regards their living, sleeping, and eating, and as regards using the same latrines and urinals. Five cases of enteric fever occurred amongst these men (one of them in the person of a returned convalescent). As to the first case (Private Puryer), it has already been stated that neither infection at Newport Pagnell, nor in Fortune's Well, nor by milk, was a likely explanation for the occurrence of the illness. The only remaining source of infection, viz., from

* From another return, furnished by the late Major Coombs, commanding Details (17th April, 1901), it would appear that some convalescents had arrived here before this date; besides Corporal Goss, two men (Knott and Shore) are said to have joined in August, two men (Simpson and Sydie) in October, and one man (King) in November. It has been impossible, after several months, to trace these movements.

association with enteric convalescents, must, in my opinion, be considered a highly probable explanation. As to the exact mode of conveyance of the poison, it is impossible to prove anything; but there were certain conditions which would aid in the propagation of the poison, supposing it were present in the person of any of these convalescents.

I do not think there would be much danger in messing in the same room, that is, in the actual eating at the same table, supposing the men were ordinarily clean in their habits, and the whole 40 men could hardly have had their dinners all together. But as regards sleeping in the same room, and habitually breathing the same air, the risk of infection (supposing the convalescents to have been infective) would be considerable. All the rooms are casemates, and consequently very badly ventilated at the best. They were not, according to regulation, overcrowded, and the air space and floor space were up to the allowance; but the space between beds is little more (sometimes less) than two feet, and in the absence of any means for rapidly changing the air, there is no doubt that any infective exhalations or emanations from one occupant might be easily breathed or swallowed by another on either side. Moreover, I was informed by Dr. Henley that it was the fact that occasionally men would commit a nuisance in the back corridor into which the barrack rooms open, either from inability, or more likely from not taking the trouble, to get as far as the latrine and urinal outside. Urine tubs are provided, placed in the front porches, but I was informed that the men would occasionally urinate in the back corridor (perhaps being more accessible and less cold). Therefore, if any of these returned convalescents had any infective property in their bodies or excretions, it is not at all unlikely that the infection might have been spread, on account of the air of the rooms, or of the corridor, becoming charged with the infective matter, which might then be breathed or swallowed by the occupant of a neighbouring bed.

As to propagation through using the same latrines, this is not impossible, though I think less likely. These latrines are certainly not of a pattern to rapidly and completely carry away the excreta, which, on the contrary, might remain in a latrine for half a day or more, and get splashed about, dried, and turned into dust. As to urinals, on account of the very defective flushing, these were very often dry; therefore urine, or urinary dust, might be easily disseminated through the air. But it is the intimate association in an ill-ventilated space that I consider to have been, on the whole, the most likely condition in spreading infection.

46. Of course, if these returned convalescents were quite free from any infective properties on their arrival at Portland, the defective hygienic conditions just mentioned would not matter. Neither their freedom from, nor their possession of, infectivity can now be proved; but that this infectivity is sometimes capable of lasting a long time after the commencement of convalescence, is now becoming generally recognised. The Clinical Society's Committee considered that infectiveness lasts "until convalescence has been established for at least a fortnight"; but Dr. Clifford Allbutt has related two instances (*British Medical Journal*, 13th July, 1901), in which the disease was apparently communicated by persons who had been convalescent, or in good health, for several weeks. Horton Smith has shown (Goulstonian Lectures, 1900) that typhoid bacilli can survive in urine for many weeks. Petruschky has found them two months after the temperature has become normal, and at the Johns Hopkins Hospital, Baltimore, *five years* after an attack of typhoid, the bacillus is said to have been obtained in pure culture in the urine. It may well be doubted if in such a case as this the bacillus retained its specific pathogenic properties, but at any rate the possibility of a long-continued infectiveness must be borne in mind.

47. The direct contagiousness or communicability (not necessarily from the urine) has also recently been considered to be more frequent than was formerly held to be the case by most authorities. In a discussion at the Epidemiological Society (April, 1900) Dr. E. W. Goodall brought forward instances recorded by Dr. J. Priestley, of Lambeth, Dr. F. Bryett, of Shoreditch, Dr. Boobbyer, of Nottingham, Dr. A. Hill, of Birmingham, and Dr. J. Robertson, of Sheffield, as well as his own experience at the Homerton Fever

Hospital, to show that direct infection may not infrequently occur: many other observers agreed. Dr. Caiger, of the South Western Fever Hospital, thought there was not "sufficient appreciation of the fact that infection may be derived from a patient by means of some dry discharge which, owing to the movement or the manipulation of the patient or the bed-clothes, gets into the air in the form of dust, and so is inspired by the attendant." If it be true that infectiousness may sometimes remain far into convalescence, the peculiar conditions of the barrack rooms at the Verne Citadel (in which the air can have been changed but very imperfectly) would have undoubtedly favoured any such mode of propagation; and if Dr. Caiger's view be correct in regard to bed-clothes, *a fortiori*, the unwashed and unwashable barrack blankets of a soldier would be a likely means of spreading infection.

48. On the whole, I consider that it is more probable that the first case that occurred was due to infection from enteric convalescents, than that it was imported from Newport Pagnell, or contracted in Fortune's Well, or due to drinking milk contaminated with impure water at the Fortune's Well dairy. As to whether this infection from convalescents was transmitted through close personal association, or through the medium of still infective urine, I am unable to form a positive opinion: owing to the conditions of the latrines and urinals, and of the barrack rooms, either would be possible; but I think that the close personal association in ill-ventilated rooms is most likely to have been the mode of propagation.

49. As to the mode of infection of the subsequent cases, little more need be said: whether infected from Private Puryer or from South African convalescents, cannot be positively stated. The conditions for favouring spread of the disease were present in the south-east casemates and their attached latrines, as already pointed out. In No. 5 barrack room there were seven returned convalescents, viz., Privates Byrne, Smith, Brockhurst, Hcok, Box, Sawyer, and Edwards. It is said that the men were frequently changing about from No. 5 to No. 6, and *vice versa*, being in the same company: three fresh cases were admitted from No. 5 and two from No. 6. What has been said in regard to Nos. 12 and 13 rooms, applies equally to these cases. Possible infection in Fortune's Well, either at public houses or at eating houses, cannot be excluded; but at this time (1901) the outbreak in the village had practically come to an end. Milk is not a likely vehicle, for the reasons before stated. The poison having once been introduced into the drains, owing to some faults in their construction, there might be a possibility of its spread through their means: thus, owing to insufficient fall in the main drain, there was a partial block, and some sewage worked back into one of the tanks under the south-east range. There is no reason to suppose that this water was drunk by any one, but it may have fouled the soil in some way round the barrack rooms, or infected sewer air may have escaped through some imperfect traps, or through the surface drains which led direct into the foul drains without any disconnexion at all. With a drainage system faulty in many details, and admitting of soil-pollution and air-pollution from the drains that at this time undoubtedly contained typhoid excreta, there need be little wonder at the occurrence of several cases of the disease, though it may be impossible to put one's finger on any one particular condition, as the undoubted cause or mode of transmission. The insanitary air conditions of the barrack rooms, and the defective latrine and urinal flushing, already alluded to in connection with the *first* case, were of course still present, and might account for the later cases.

50. The case of Private Aldred, R.A.M.C., engaged in nursing enteric patients, requires no explanation; intimate personal contact, and probably want of care in handling excreta, clothing, or food, account for the infection.

51. On the occurrence of the 10th case (Private Rose) all barrack rooms from which fever cases had been admitted were evacuated, and treated recording to the Army Medical Regulations. No cases occurred subsequently until July (4 months later) when the infection was imported from (apparently) Wool Camp. I have little doubt that it was the evacuation of the quarters that caused the cessation of the outbreak.

52. The second group of cases numbered 8, and were admitted between the 20th July and 17th September. Fourteen days elapsed between the admission of the 1st and of the 2nd case, and again 14 days between the 2nd and 3rd cases; the rest came in at short intervals.

53. As to the first case: Private Robinson was stationed at Wool (or Bovington) Camp, from June 1st to July 17th, on which latter date he returned to Portland; he was admitted to hospital on the 20th. He had occupied No. 11 room in south-east casemates; but it is extremely unlikely that the infection should have been contracted within 3 days before admission to hospital. The probabilities are that the disease originated at Wool Camp; there was no enteric fever in that neighbourhood, but as the camp is situated far away from any town, and the men have neither opportunity nor inclination for visiting any centre of population, it is, I consider, most likely that the camp itself in some way originated or developed the enteric poison.

54. Wool (or Bovington) Camp is placed rather more than a mile to the north of the Wool Railway Station, between Dorchester and Wareham. The water supply was derived from a specially constructed well, over 70 feet deep (the upper 20 feet of which are cemented), and laid on to pipes in the camp. Analysis of the water at Netley indicated it to be a pure supply, the total solids being only 10 parts per 100,000; the chlorine, 1·7; oxygen for oxidisable matter, 0·0222; free ammonia absent; and albuminoid ammonia, 0·0012; on bacteriological examination, no signs of specific or sewage contamination were detected. With regard to the sanitary condition of the camp, it is stated by Civil Surgeon Banham that there were "no latrines, but trenches 5 feet deep, open 5 days, chloride of lime used daily; complaints of excreta removed in old and leaky carts." Dr. Banham afterwards qualified this by saying that there was "a proper system of latrines in the camp field to the east of the road; but no latrines erected to west of the road, where the detachment, Northamptonshire Regiment, were recently encamped." It is particularly unfortunate that the authorities responsible for the sanitation of the camp should have omitted to provide for the Northampton Regiment as satisfactory latrine accommodation as for the rest of the camp (even though the Encampment Regulations may have been complied with): one would have thought that after the occurrence of so much enteric fever in this regiment a few months before, some special care would have been taken by some one to see that *everything* that could be done *was* done to ensure perfect sanitation. I cannot ascertain whether any enteric fever convalescents returned from South Africa were out in camp at Wool. I was informed, casually, that there were bad smells in the Northants Camp at Wool. It may also be noted that the River Frome, which receives a good deal of sewage at Dorchester, flows near the camp; its water may possibly have been drunk on some hot day by some of the men. There is, however, no evidence as to how enteric fever originated in the camp, although it is in every way most likely that it did originate, or develop here.

55. Once re-introduced into the south-east casemates at the Verne, its subsequent dissemination would not be difficult to explain. The second case, Private Knight, stated to me that he had felt ill for 3 or 4 days before his admission on 4th August; he may, therefore, possibly have brought the infection with him from Wool, or may have caught it in the Citadel.

56. After the occurrence of these 2 cases the south-east casemates were evacuated, but 6 other cases were admitted: the third case, Private Gould, admitted on 18th August, probably had contracted the infection in the south-east range before they were evacuated; the same may be said in regard to the 4th and 5th cases (Privates Richards and Morgan) who were admitted on 28th and 30th August respectively; they were chums, slept next to each other, before moving into south-west casemates had both lived in No. 2 room, south-east range, and had been ill several days before admission. Private Morgan stated that he had felt bad more than 10 days before he was admitted.

Private Fincham, the next case, was admitted on 5th September; he had gone to Wool Camp on 2nd September, and on 5th he reported sick, having then had diarrhœa 2 days; evidently he contracted the infection at the

Citadel, not at the camp ; I was informed that he occupied the same room as, and slept in the bed next to, Private Gould (3rd case).

57. Although it was no doubt correctly stated (6th September) that "everything that can be done by way of improving the sanitation, without remodelling the whole system of drainage, has been carried out," still many insanitary conditions remained as before. I refer particularly to the conditions inseparable from casemates, and to the insufficient flushing of urinals and latrines. No other sources of infection were suggested, nor do any others appear to me to have been likely. The milk supply was found to be unsatisfactory in the middle of August, and subsequently was obtained from Norman's dairy, also in Fortune's Well ; but no suspicion can reasonably be thrown on the milk in regard to these cases.

58. With regard therefore to the second series of cases I consider that the infection was introduced, and in all probability from Wool Camp ; and having been introduced, that it spread owing to the existence of the same insanitary conditions as before. It is not likely that it was contracted in Fortune's Well ; there were only two cases of enteric fever in the village throughout the year, and one of these occurred in November, subsequent to all the military cases ; the disease was not endemic, as it had been in 1900. As to the reason for its origin in Wool Camp, I am unable to give any satisfactory explanation.

IV.—*Conclusion and Recommendations.*

59. A. From a survey of the present sanitary condition of the Verne Citadel, it appears that the *water supply* is of good quality ; but that recently it has been deficient in quantity, and that considerable inconvenience and even some hardship has resulted on this account : there has not been enough water to allow the men proper means of ablution, or facilities for drinking, and the laundry arrangements have only been carried on with difficulty : from a sanitary point of view, also, flushing of latrines and urinals has been most imperfect, and danger to health has resulted. The arrangements have been modified, and are now, I understand, satisfactory.

60. The *drainage system* is very unsatisfactory, the chief imperfections being almost entire absence of manholes, general inaccessibility of the drains, absence of means of ventilation, and the mixing up surface and foul drainage without disconnexions. A comprehensive scheme for remodelling the whole arrangements has been sanctioned, and the work will be commenced very shortly. The latrines are of old pattern, and both these and the urinals are in need of a better system of flushing. All the parts of the drainage system have suffered from the insufficient supply of water already alluded to.

61. The situation of the *barracks* is quite satisfactory ; but their construction, from the nature of the case, leads to great difficulties in the way of maintaining a proper sanitary condition ; being casemates, adequate ventilation is almost impossible, and although they have not been overcrowded, the means of ventilation have not been sufficient to maintain them in a fit state for healthy occupation.

62. B. The *bacteriological examination* of the drinking water corroborates the opinions based on previous analyses that it is a good and pure supply.

63. C. The outbreak of enteric fever consisted of eighteen cases divided into two groups. Between 20th December, 1900 and 10th March, 1901, ten cases were admitted at short intervals ; and between 20th July and 17th September, 1901, eight cases were admitted, also in quick succession.

As to the first group, the infection in the first case might possibly have been introduced from Newport Pagnell (where the man had been on furlough), or from the neighbouring village of Fortune's Well (where enteric fever had been endemic), or by means of enteric fever convalescents returned from South Africa. On a review of all the circumstances I consider that the probabilities are strongly in favour of the last mentioned : there were ten of

these returned convalescents in the two barrack rooms from which the first five cases were admitted; and although it is not at all certain that they were infective, it is not impossible; and the intimate personal association that existed in these ill-ventilated rooms renders this origin of the outbreak more likely, in my opinion, than any other. It is possible that infection may have been spread through the urinals or latrines, or by fouling of soil or air from defective drains; but the close personal association appears to have been the more *likely* mode of spread, both as regards the first case and those occurring afterwards. All the admissions (except one, a hospital orderly who had nursed enteric patients) were from the same range of casemates. These were evacuated in March and no further cases occurred.

The second group commenced by an admission on 20th July, the infection having undoubtedly been introduced into the Citadel, and in all probability from Wool Camp. The sanitary state of this camp seems to have been faulty, but I am unable to explain how the enteric infection originated, or developed there. Having been again introduced into the Citadel, its spread was probably due to the same, or similar, defective sanitary conditions as in the earlier part of the year, close personal association in ill-ventilated rooms being the chief factor.

In the neighbouring village of Fortune's Well, enteric fever had been endemic (nineteen cases) in 1900, but there were only two cases in 1901, and there is nothing to connect these with the cases in the Citadel. Neither is there any reason to suspect the milk supply.

I consider that the outbreak was due to association with enteric fever convalescents from South Africa, some of whom may have been still infective, and that the peculiar construction of the barrack-rooms (casemates) aggravated this association, proper ventilation being almost impracticable. Imperfections in the water supply and drainage systems (which undoubtedly existed) may have contributed to the dissemination of the infection.

64. *Recommendations.*—The chief recommendations that I beg to submit are:—

Water Supply.—1. That, as, on account of the large size of the drains, and for other reasons, the amount of water allowed by regulation (20 gallons per head) is insufficient when the garrison at the Verne is considerably below strength, an extra quantity be sanctioned (*a*) for sanitary purposes, (*b*) to allow of the use of the hot baths that have been provided, and (*c*) for laundry purposes. I have suggested 20,000 gallons weekly for (*a*) and (*b*), and 1,000 gallons weekly for (*c*), but the actual quantities required must be determined locally.

2. That the rain-water tanks be cleared out and kept clean, and that the water be used for periodical systematic flushing of the drains.

Drainage.—3. In addition to the scheme prepared by the Commanding Royal Engineer, that automatic flushing cisterns should be provided for latrines and for urinals.

4. Consequent on this, that *Army Service Corps Regulations*, Appendix 22, para. 11, *f*, be modified; the limitation of flushing of urinals to 20 minutes once a day is, in my opinion, quite contrary to the principles of sanitation according to our present knowledge; the recommendation in *Drainage Manual*, para. 277, might be substituted.

5. That the recently constructed manholes outside Officers' quarters be improved in accordance with *Drainage Manual*, para. 188, and Plate V, Fig. 28.

Barracks.—6. That new ventilating shafts be provided for the south-west range, similar to those recently fixed in south-east range, and that the existing old ventilators be better utilised than at present.

7. That on account of the exceptional conditions of these barracks (casemates), a special allowance be made for more frequent limewashing, both of rooms and of corridors.

8. That the lower flank rooms be not used as barrack rooms if it can be avoided.

9. That if Wool Camp is to be occupied this coming summer, special care be taken as to the sanitary arrangements.

General.—10. That special care be taken when convalescents from enteric fever leave hospital, or return to this country from abroad and join their corps, that the sanitary condition of their barracks (especially ventilation and removal of excreta) be as perfect as possible; the aggregation of several such cases in one room with others is certainly undesirable, and casemates are unsuitable for their accommodation.

11. It is for consideration whether periodic examination of the urine for *Bacillus typhi abdominalis* should be undertaken, to determine its possible infectivity.

I beg to mention that I have received very great assistance in making this inquiry from Dr. H. R. Henley, Civil Medical Officer, who is in sole medical and sanitary charge of station hospital, barracks, troops, &c., and has an intimate acquaintance with all the sanitary circumstances of this station.

APPENDIX.

Detail of the Bacteriological Examination.

Sample of Water taken 27th January, 1902, from Tap in Hospital Dispensary, Verne Citadel.

I. *Numeration.*

(*a.*) In agar at 37°·5 C., 14 per c.c.
(*b.*) In gelatine at 20° C., 85 per c.c.; no *Cladothrix*, no *B. mycoides.*

II. *Examination for* B. typhi abdominalis *and Coliform bacteria.*

B. *Klein-Parietti Test.*—2,500 c.c. water passed through a Pasteur-Mallie filter, the deposit on filter removed and worked up in 10 c.c. of the same water; of this mixture, 0·5 c.c. sown into each of two broth tubes containing respectively 0·1 and 0·2 c.c. Parietti solution, and incubated at 37°·5 C.

0·1 tube. After 24 hours, slight turbidity; this increased, but no pellicle formed; after 48 hours, inoculated a broth tube containing 0·2 c.c. Parietti solution with this culture; after 20 hours, a slight growth; subsequently there was slight deposit, but no pellicle.

0·2 tube. No growth.

Ba. Agar stroke culture from Parietti tube (second inoculation) after 20 hours.

After 48 hours, a thin spreading growth; after 4 days this was thick, white, and spreading, not at all coliform.

C. *Pakes' Test.*—Into two tubes of glucose-formate broth were sown respectively 1 c.c. and 4 c.c. of the unconcentrated water; the tubes were cultivated anaerobically (pyrogallic acid and caustic soda) at 37°·5 C. No growth resulted in either tube.

D. *Klein-Pakes' Test.*—Of the mixed deposit and water obtained by passing 2,500 c.c. through a Mallie filter, one-tenth (= 1 c.c.) was sown into glucose-formate broth and incubated anaerobically at 37°·5 C.

After 24 hours, no growth; after 42 hours, slight turbidity, no gas formation.

Da. Agar stroke culture from D after 42 hours.

After 21 hours, thin spreading dotted growth; this spread all over the surface, but remained thin.

Dc Potato culture from D. after 42 hours.

After 21 hours, thin yellowish growth; after 3 days the yellow colour was distinct, and the growth dotted, becoming subsequently thick and raised.

Dd. Litmus milk inoculated from D. after 42 hours.

After 21 hours, the milk was decolorised and slightly reddish at surface, no clotting; after 3 days the milk was firmly clotted and colourless.

De. Broth inoculated from D after 42 hours.

After 21 hours, marked turbidity; after 3 days this did not increase, there was slight deposit; after 5 days, a slight pellicle.

Indol reaction, after 5 days, absent.

Dx. Gelatine culture from D after 42 hours.

A small growth resulted in stab culture; and in gelatine plate a linear, somewhat raised, colourless, not liquefying, growth, not at all coliform.

III.—*Examination for* B. enteritidis sporogenes.—Of the mixed deposit and water (B) one-tenth (= 1 c.c.) was sown into litmus milk heated to 80° C. for 10 minutes, and incubated anaerobically in a Buchner's tube; no clotting and no acidification occurred, therefore no indication of *B. enteritidis sporogenes.*

IV. *Examination for Spores.*—Of the mixed deposit and water (B), 1 c.c. was sown into gelatine, heated to 80° C. for 10 minutes to destroy all non-sporing organisms, and then plated out in a Petri dish. This was kept at 20° C. for 8 days. No colonies developed, showing absence, or almost complete absence, of spores.

V. *Examination for* Streptococci.—A tube of agar having been melted, poured on to a Petri dish, and allowed to set, 1/6 c.c. of the mixed deposit and water (B) was spread over the surface of the agar, then incubated at 37°·5 C. Of the colonies that developed, none were composed of *Streptococci.*

VI. *Microscopic Examination of the Water Sediment.*—This was very small in amount, and consisted only of a little vegetable *débris.*

Remarks.—As regards number of germs present, this water appears to be fairly pure; no doubt the comparatively small number was largely due to the cold weather at the time. No indication was found of the presence of *B. typhi abdominalis,* or any of the coliform group, either by the phenol broth test, or by the anaerobic glucose-formate broth test. Some growth did appear in each test, but in neither case was it at all coliform. There was no indication of *B. enteritidis sporogenes.* No *Streptococci* were found, and no spores; no *Cladothrix* or *B. Mycoides;* there was therefore no indication of contamination by surface washings. There was hardly any sediment.

The result of the examination is to show that this water is bacteriologically pure, and good for drinking.

(Signed) A. M. DAVIES,
Lieut.-Col.,
R.A.M.C.

London, 25th February, 1902.

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272

Report on the Ventilation of Ships Conveying Troops.

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1. The chief objects of this inquiry have been (1) to ascertain what means have actually been provided in recent years for procuring adequate ventilation on board Transports and Hospital Ships; (2) to form an opinion as to whether these arrangements have been satisfactory; and (3) to consider and report if any improvements are necessary or advisable.

2. We have either separately, or together, inspected the following vessels:—

"Assaye,"	"Plassey,"
"Tagus,"	"Colombian,"
"Simla,"	"Antillian,"
"Custodian,"	"Ranee,"
"Avoca,"	"St. Andrew,"
"Orient,"	"Englishman."

3.—I. The existing means of ventilation fall under the two main heads of Natural and Artificial.

In all cases *Natural Ventilation* is made use of to the fullest practicable extent, the entrance and exit openings being scuttles (portholes) with air-scoops, hatchways with or without windsails, skylights, and air-trunks fitted with cowls; these are either fixed (upcast or downcast) or movable (acting either as upcast or downcast, according as the cowl is turned towards, or away from, the wind). We are of opinion that in fair weather, and provided that all these means are made the best use of (*i.e.*, scuttles opened, air-scoops fixed, windsails hoisted, cowls trimmed), the ventilation arrangements are satisfactory and sufficient for troop spaces and hospitals on the upper and main decks, under ordinary conditions. As, however, provision has to be made for bad weather; for the aggregation of a large number of serious cases, or cases of wounds; and for men berthed on the lower deck, whether in hospital or not, some means of artificial ventilation is always a necessity.

4. The *artificial* means of ventilation are mainly two: (1.) the Edmonds system; (2.) McWhirter's Electric Fans.

(1.) Edmonds's system of extraction by steam jets is in use in all the larger transports. It undoubtedly does extract the foul air to some considerable extent, but we do not consider it a sufficient or satisfactory plan, for these reasons:

(i.) In practice there are always several changes of direction in the air-trunks, each of which changes increases the friction, and diminishes the velocity of the current of air; it is often the case that these trunks are bent at right angles, sometimes even three right angles occurring in one shaft; as every right angle doubles the friction, or halves the velocity, it is evident that in such an air-trunk the theoretical extraction would be reduced to one-eighth, merely from this excessive friction alone; besides this, the friction arising from length of tubes and from deposition of dirt on inner walls of tubes is so great that the actual discharge is much less than might be expected.

(ii.) As at present arranged, the Edmonds system is always a method of ventilation by extraction. The question of extraction *versus* propulsion has long been a matter of discussion, both in regard to schemes of ventilation for buildings and for ships. The method by propulsion has been adopted in the Royal Navy, and we are decidedly of opinion that, for the general ventilation

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562

of ships, it is to be preferred, for reasons to be stated immediately. There are, however, special places where hot or foul air is generated, in which exhaust ventilation is of greater advantage, in place of, or in addition to, the former.

(iii.) Moreover, we have found that the practice has been to utilise these ventilators only four times a-day, and for half an hour at a time. Used in this way they are almost valueless.

(2.) McWhirter's Electric Fans are in use in many of the more recently-fitted vessels; they have usually been placed so as to cause circulation or agitation of the air; when thus fitted they are of great use for cooling the air, and are most agreeable and beneficial when the vessel is lying at anchor in hot latitudes; but they are not, properly speaking, means of ventilation, as neither is the impure air got rid of, nor is fresh air brought in to supply its place. In a few cases we have found fans connected with air-trunks, and acting as true ventilating appliances, the supply plan being generally adopted.

6.—II. As to the *sufficiency of the means at present adopted*, we have only found a few instances of actual insufficient ventilation of any troop deck or hospital, viz., in those cases where the accommodation was on the lower deck. We are therefore of opinion that, supposing fair weather conditions to prevail, and the existing means for promoting natural ventilation to be fully utilised, the structural arrangements on board transports are (in regard to ventilation, and with this exception) satisfactory.

7. We consider that the principle of exhaustion, or extraction, is not to be recommended; except in special cases, as for water closets, and places where foul or hot air is generated. Although the plan offers facilities in practical working, on account of the presence on board ship of a central heating apparatus, there is this main objection, that even if the foul air between decks is effectively removed, there is no control whatever over the source of the air coming in to supply its place, and this may be derived from other parts of the same deck, or from a deck below, or even from the hold; whereas, if fresh air is supplied by propulsion, in sufficient volume, there can be no doubt that the foul air will be driven out.

8. The existing arrangements are also unsatisfactory in several matters of detail; especially (1) in the large amount of friction opposed to the flow of air in the complicated systems of air-trunks; and (2) in their defective arrangement when combined with electric fan fittings; as, for instance, where an aperture intended for an *inlet* (and connected with a downcast cowl for this purpose) was found to act as an outlet, when a neighbouring McWhirter's fan was set in motion.

9. In Appendix XXIV of the Transport Regulations, instructions are given for occasionally using the Edmonds system of air trunks as a *supply* system, by omitting the steam jets, and turning the cowl towards the wind. We do not consider it at all desirable to *supply* air occasionally through shafts, whose inner walls are covered with dirt, derived from the foul air that is ordinarily *extracted* through them; such incoming air would certainly be fouled in its passage through these air trunks.

10.—III. We are of opinion that the simplest, the most effective, and in every way the best method of ship ventilation is that of *propulsion*, or *supply*, by means of electric fans; for the following reasons:—(1) There can be no difficulty about obtaining *absolutely pure air*, which may be introduced into the spaces used by troops through air trunks opening on the highest deck, these wherever possible, being carried down in a straight line vertically to the fan. (2) *Any quantity* that may be required can be introduced by means of an electric fan, attached to the lower opening of the air trunk. (3) The *motive power* is nowadays *always available* in sufficient amount, and at an economical rate, on board ships taken up as transports.

11. The following points are also to be considered:—(1) It is important

that there should be no more friction than can be avoided, so that no more demand should be made on the electric machinery than is necessary. In some vessels there may be such a large amount of electric power always available that economy may be of little consequence; but in other cases the demands of lighting, &c., &c., may be so great that if much energy is required for ventilation the lighting may suffer: therefore all unnecessary right angles in shafts, or other causes of friction, should be avoided. (2) The fresh air should be introduced into the place ventilated horizontally, and so as not to impinge directly on any cot or hammock. Each fan should, if possible, be placed at the end of the compartment most remote from the hatchway; and we think on the whole that it should deliver the air against the bulkhead beside it, and not towards the hatchway. This arrangement will give a better distribution, and will prevent draughts. (3) Outlet shafts should be provided as at present, with fixed upcast cowls. It may be regarded as certain that, even if all scuttles, hatchways and companions have to be closed on account of weather, the impure air will be effectually got rid of, provided an adequate supply of fresh air is introduced. (4) Portable electric fans, not connected with any air trunk, are useful and agreeable: they may be brought near to any case of illness that requires particular attention; they have a cooling and freshening effect, and help to circulate the air in the ward, but they do not at all do away with the necessity for the introduction of fresh air.

12. As a general outline, we submit the following recommendations:—

Upper Deck.—Natural ventilation arrangements alone are sufficient.

Main Deck.—Natural ventilation supplemented by electric fans, placed in the dead ends of compartments, and delivering the air against the bulkhead, so as to prevent draught and facilitate distribution.

Lower Deck.—Electric fans to be fitted; Edmonds's exhaust system, when fitted on this deck, to be utilised more than at present; it should be worked continuously.

Water Closets.—When situated on the main deck they should be shut off from communication with any space on the same deck, and should not open into any space on the deck above. They should be provided with exhaust air trunks fitted with fixed upcast cowls; and it would be desirable that a mechanical exhaust arrangement should be provided in addition.

(Signed) GILBERT KIRKER,
Fleet Surgeon,
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Haslar.

(Signed) A. M. DAVIES,
Lieut.-Colonel,
Royal Army Medical Corps.

London, 4th December, 1901.