taining their remarks on this subject. Captain Cook says,—"A song, not altogether unlike their war-song, they sometimes sing without the dance, and as a peaceable amusement. They have also other songs which are sung by the women, whose voices are remarkably mellow and soft, and have a pleasing and tender effect; the time is slow, and the cadence mournful, but it is conducted with more taste than could be expected among the poor ignorant savages of this half-desolate country; especially as it appeared to us, who were none of us much acquainted with music as a science, to be sung in parts; it was at least sung by many voices at the same time." (*First Voyage*, Vol. III., p. 468). And Mr. Anderson, who was the surgeon in Cook's ship on his third voyage to New Zealand, thus writes:—"The children are initiated at a very early age into the keeping the strictest time in their song. They likewise sing, with some degree of melody, the traditions of their forefathers, their actions in war, and other indifferent subjects, of all which they are immoderately fond, and spend much of their time in these amusements, and in playing on a sort of flute. Their language is far from being harsh or disagreeable, though the pronunciation is frequently guttural; and whatever qualities are requisite in any other language to make it musical, certainly obtain to a considerable degree here, if we may judge from the melody of some sorts of their songs." (*Anderson, in Cook's Third Voyage*, Vol. I., p. 163.) But far beyond all, as I take it, is the scientific testimony of Dr. Forster, who was with Cook in his second voyage to New Zealand,—already, however, given by me in a former paper, with some interesting additions from Sir G. Grey's work.*

ART. IV.—*Notes on the best Method of meeting the Sanitary Requirements of Colonial Towns.* By EDWARD DOBSON, C.E., President of the Philosophical Institute of Canterbury.

[*Read before the Philosophical Institute of Canterbury, 5th August*, 1880.]

IN the following notes I propose to lay down certain propositions, which may be termed sanitary axioms, applicable alike to all towns, whether built on hill-sides, on table-lands, or on low-lying plains; and which may serve as standards, by which to test how far the sanitary arrangements, which are being carried out in our Colonial towns, fulfil, or fall short of, the conditions necessary for the due maintenance of the public health.

I refer especially to *Colonial* towns, because the conditions of sanitary work are very different in the irregularly laid out and closely built cities of

* See "Trans. N.Z. Inst.," Vol. XI., pp. 103–106.

the Old World, and the regularly planned and sparsely built towns of a new country. Not only does the fact of the denser population, on a given area, bring within the means of the inhabitants, works, the cost of which would be prohibitive in thinly peopled districts; but, in planning new towns, favourable conditions may be secured by legislative enactment, which are unattainable where the ground has been closely built over with an utter disregard of sanitary requirements.

And first, as to the Requirements of a Town House.

Access.—Every house should have access to a public thoroughfare, both from the front and rear; so that no rubbish, nor offensive matter, need be carried through the dwelling.

This is also an important point in case of fire; both as regards the escape of the inmates, and the facilities thus offered for checking the progress of the flames.

Surface drainage.—Every town property should be formed to such levels that the surface-water will drain, by gravitation, into the street channels; unless there is a fall to a natural water-course along which a right of drainage has been reserved.

This involves a careful consideration of the levels in the first laying out of the streets, so that the desired end may be attained without having either unnecessarily to raise the level of the sections, or to cut down the gutters to an inconvenient depth. As a general rule, the original levels of the streets of a town should be *lowered* by cutting down the lumps and ridges, rather than *raised* by filling in the hollows; the principle being the opposite of that to be followed in laying out a road through rural lands.

House Drainage.—Every house should have a paved channel, either open or covered, for the removal of the house-slops; communicating with either the street channels or underground drains, and provided with a sufficient supply of water to keep it constantly flushed.

No drain should be allowed to pass under or through any dwelling; but, should there be cases in which this is unavoidable, the drains should be perfectly isolated by being laid in concrete, and no communications should be made inside the dwelling with sinks or cisterns, the overflow from which should pass into the open air before being led into the house-drains.

Water Supply.—Each dwelling should have a supply of water for domestic use at a daily rate of not less than twenty gallons per inmate, exclusive of what is required for flushing the closets.

If rainwater has to be stored, the tanks should be protected against filtration from sources of impurity, and should be covered over to exclude the sun's rays, the light and heat from which have a powerful effect in promoting vegetable growth.

If the system is one of intermittent supply and cisterns are used, there should be separate cisterns for domestic use and for flushing the closets, and there should be no communication between them.

If there is a constant supply delivered at stand-pipes, there should be paved channels to take the overflow to the house-drains, and care should be taken to prevent the saturation of the ground by the waste water.

Dust-bins.—Every dwelling should have a properly constructed receptacle for ashes and kitchen refuse, the periodical removal of which at short intervals should be compulsory under municipal regulations.

The gratings to the house-drains should be provided with moveable strainers to collect the solid refuse, for which the dust-bin is the proper receptacle, and which would otherwise be carried into the house-drains.

Closets.—The closets should if possible be isolated from the dwellings, but, where they are unavoidably connected with them, the communication should be through a lobby freely open to the external air.

The introduction of sunk cesspools for the storage of excreta should be strictly prohibited within the boundaries of every township, no matter what the nature of their construction.

Closets may be of three kinds, namely :—

1st. The ash-midden, in common use throughout the Midland Counties of England.

2nd. The pan-closet, which, in many English towns, is superseding both the cesspool and the ash-midden.

3rd. The water-closet.

The ash-midden is a combination of the dust-bin and privy, and may be considered as a form of earth-closet. When this form of closet is adopted, the floor should be paved and slightly raised above the general surface of the ground, and provided with a drain to carry off any liquid not absorbed by the ashes.

If the pan-closet is used, the floor should be paved so that any droppings can be readily removed, and there should be a free circulation of air under the seat, and a ventilating shaft carried up into the open air.

The pans should be of ample size, and should be fitted with stout handles and with air-tight lids for use during removal, and they should be thoroughly cleansed and disinfected after emptying, before they are replaced.

Both ash-middens and closet-pans should be compulsorily emptied at short intervals, under municipal regulations.

The introduction of water-closets involves a considerable amount of municipal organization for the double purpose of providing a water-supply for flushing them, and a system of underground drains for the removal of the excreta.

The geological conditions existing in Christchurch, under which every householder can, at small expense, obtain a stream of artesian water rising to the height of several feet above the ground, are very rarely to be met with, and, as a general rule, water-closets cannot be introduced into towns unless in connection with public waterworks, by which the water can be supplied to the houses under sufficient pressure to rise into the cisterns supplying the closets.

In the construction of the closets themselves, the two principal points to be attended to are:—simplicity in the mechanism employed, and such cistern arrangements as will, on the one hand, ensure the complete flushing of the pan after use, and, on the other, prevent needless waste, as it must be borne in mind that every additional gallon used diminishes the economic value of the excreta, and adds to the cost of pumping at the outfall.

In the second place, passing from the individual to the community, or from the house to the town, What are the Requirements of Town Drainage?

The requirements under this head may be thus summed up :—

1. Surface and subsoil drainage.
2. Discharge of storm-water.
3. Discharge of local rainfall.
4. House-drainage; and, lastly—
5. Removal of excreta.

The main point of our enquiry is—to what extent can the same channels be used for the several purposes?

Surface and subsoil drainage are two distinct things. The first is the removal of water which comes from a higher level, and lies on the ground simply because there is no outlet for its discharge. The second implies the lowering of the water-level below the surface of ground which is either water-logged by filtration from above or by springs rising from below. Christchurch, thirty years back, afforded ample illustration of my meaning. The south-east portion of the town, between Jackson's Creek and what is now the Caversham Hotel, was a pond covered with *raupo* growing in water about a foot deep, on a tolerably firm bottom; whilst at the south-west corner of the town, near the South Belt, and along what is now the Windmill Road, was a district of treacherous peat swamp, tolerably free from surface-water, but full of springs, and so soft that cattle could not cross it. You will now look in vain for any trace of this early state of things: the Ferry Road ditch, the Windmill Road drain, and the south drain, having effectually done their work of reclamation, and having, in their turn, disappeared, to be superseded by brick sewers; but if you will only call to mind the hundreds of pounds which have been paid as compensation for the right of cutting these necessary outfalls, the thousands of pounds which have been spent in abortive

attempts to supersede them by the construction of drains on even less suitable lines, the litigation and heart-burning which have been always connected with them, and the danger to the public and the injury to the adjacent properties, arising from the construction of deep open drains alongside the public roads—I think it will be unnecessary for me to bring any further argument in favour of my next proposition, which is—that before laying out the streets of a new town the lines of surface and subsoil drainage should be decided on, and reserved for drainage purposes.

Next in order comes the question of the storm-water outfalls.

In almost every district, however level the ground, there will be found depressions, which, although not fed by springs, and therefore not coming under the designation of water-courses, are the channels by which, in heavy rainfalls, the storm-water passes from the upper to the lower levels. Instead of blocking up these natural channels, as is too often done in the formation of streets, they should be utilized, straightened, deepened, and connected with suitable outfalls to the rivers, so that the storm-water shall not unnecessarily be thrown on the street gutters; but that, on the contrary, the latter shall have such freedom of escape into the storm-water channels as to avoid all chance of the streets themselves being flooded.

And when the lines of surface and subsoil-drainage have been marked out, the storm-water channels reserved, and the position and levels of the outfalls defined, *and not before*, we may proceed to lay out the streets of our town; taking care, in doing so, to grade the streets in such a manner that, with a minimum of earthwork, the surface-water on every property may drain, by gravitation, into the street gutters, and the latter into the outfalls.

There is nothing quixotic, or unreasonable, in these propositions, which simply aim at defining the sequence of steps to be taken in laying out a new township; but they involve a great principle, which underlies the whole question of sanitary reform, viz.,—that, in a new country, the work of the engineer should precede, and not follow, that of the settlement surveyor;—and until this principle is recognized and acted upon by Colonial Governments, not only in the planning of townships, but in many other matters connected with the preparation of a new country for successful settlement, the history of colonial progress will always be a record of costly struggles to regain facilities of communication, drainage, and water-supply, which have been heedlessly sacrificed by handing over the Crown lands to private ownership, without the one reservation of conditions essential to the general welfare of the community.

Now, let us suppose our town to have been judiciously laid out as above described, and provided, in every part, with an efficient surface, subsoil, and storm-water drainage.

What are we going to do with our house-slops? Bearing in mind that the surface-drainage of the streets themselves unavoidably communicates a considerable amount of impurity to the rivers, into which it ultimately flows, even with the most efficient system of street cleansing—it appears, to me, idle to object to passing the house-drainage to the outfalls through the street gutters, provided that the excreta and all solid refuse are kept out of the house-drains, as previously suggested; and that they are kept constantly flushed by an efficient water-supply.

If, however, the closets discharge into the house-drains, a distinct system of sewers must be provided, leading to a pumping-station, at which the sewage is lifted for disposal upon the land, as the cases in which this can be effected by simple gravitation are quite exceptional. And this involves,—1st, that the rainfall must be kept out of the house-drains, to avoid the risk of the pumps being overpowered, and the sewage thrown back upon the houses in heavy storms; and, 2nd, that there must be special means provided for flushing the street gutters, as the domestic water-supply is no longer available for this purpose.

Lastly, let us take into consideration the different methods of disposing of the excreta, to which I have previously briefly referred.

The ash-closet is a great advance upon the cesspool system. There is no risk from sewer-gas, and no pollution of the soil from leaking or overflowing cesspools. The ashes act as absorbents and deodorizers, and there is but little smell or inconvenience experienced at the emptying of the closets; and as their contents are ready to be placed on the land without undergoing any intermediate process, the sale of the manure goes a long way to recoup the cost of collection.

The system is, however, less adapted for use in closely-built cities than in villages and small country towns, where there is ample garden-space round the houses, combined with an absence of municipal machinery for the periodical cleansing of the closets.

The system of closet-pans has the great advantage of giving facilities for disinfecting the excreta of persons suffering from infectious disease, an advantage which cannot be too highly estimated. With properly constructed pans, their removal may be effected in the day-time with no more annoyance to sight and smell than is occasioned by the visit of the brewer's dray, whilst the freedom from sewer-gas and the absence of complicated and expensive machinery, which is constantly liable to become deranged in unskilful hands, are great inducements for the adoption of this style of closet.

The water-closet is, probably, of all three systems the most luxurious, and, in theory, the most perfect method of disposing of the excreta. Its successful introduction demands three conditions—

1st. An ample water supply, with sufficient head for flushing the closets.

2nd. The cutting-off the sewer gas from entering into the closets from the sewers.

3rd. The satisfactory disposal of the sewage without the pollution of the water-courses.

The first condition is readily fulfilled wherever public waterworks have been established and the streets reticulated.

The second condition does not involve serious engineering difficulties, but the habits of plumbers and sanitary experts are so fixed, that it would be idle to expect its fulfilment except under compulsory legislation.

The third condition is one which is full of difficulty, as it involves the construction of a distinct system of sewers, separate from those required for storm-water outfalls, and the maintenance, in perpetuity, of a pumping station to lift the sewage to the surface at the outfall, whatever may be the means adopted for its ultimate disposal.

For the cost of these works there is no financial return.

The liquid sewage pumped up at the outfall has no commercial value, and the cost of the processes required to bring it into a saleable form are too costly to be undertaken with profit.

If on the other hand the sewage is used for irrigating the land adjoining the outfall, the results may be considered very satisfactory if the increased productiveness of the land so irrigated recoups the cost of the maintenance of the pumping station, leaving the interest of the constructive cost of the sewage works as a permanent charge on the municipality by which they have been undertaken.

The cost of sewage works must not, however, be adduced as an argument against the principle of water-carriage for excreta, although it may be a good reason for not introducing the system where the population is so small that its cost would become a burden upon the ratepayers.

It is easy to conceive that, in the crowded cities of the Old World, it may be the most economical that could be devised.

The real, and (as I consider) the fatal, objection to the water-closet system, consists in the danger arising from the gas generated in the sewers, which, if impregnated by the emanations from the excreta of diseased persons, becomes a fertile and wide-spreading source of disease.

It is true that with proper precautions we may cut off the direct entrance of sewer-gas into our dwellings from the house-drains, but we cannot prevent it from polluting the air of the streets, nor is it possible to say to what extent the germs of disease may not be carried in this manner.

I need scarcely remind you that typhoid fever is pertinently called "the water-closet disease;" and, if you will take even a cursory glance at the

sanitary literature of the day, you will see that it is chiefly devoted to the discussion of this special subject.

Sewer-gas is the modern Frankenstein monster, which has been created and turned loose upon the world by sanitary experts, who are now vainly struggling to control and repair its ravages.

And I would ask, Whether it is not our solemn duty to ourselves, to our children, and to the rising generation, steadfastly to resist the introduction into our midst of this most insidious evil; and to stamp out, as we would the plague, any system which is likely to conduce to the spreading of infectious disease, and the consequent lowering of the physical standard of the future population of New Zealand.

In conclusion, I would submit for your consideration three propositions, which embrace the practical deductions to be drawn from my previous remarks:—

1st. That under a proper system of surface, subsoil, and storm-water drainage, it will be found advantageous to discharge the house-drains into the storm-water channels through the street gutters.

2nd. That of the systems of closet at present in general use, that with moveable pans is the one best adapted for colonial towns, on the grounds of safety to public health, simplicity, and efficiency, and economy in cost both of construction and maintenance.

3rd. That it is desirable to prohibit, by legislation, the storage of excreta in sunk cesspools, and the placing of night-soil in any drain, public or private, in any township in New Zealand.

Art. V.—*On periodic vertical Oscillations in the Sun's Atmosphere, and their Connection with the Appearance and Disappearance of the Solar Spots.*

By H. Skey.

[*Read before the Otago Institute, 24th August,* 1880.]

In a former paper* I endeavoured to show a tendency to periodicity in the vertical oscillations of the earth's atmosphere, and to connect the pressure of the barometer and the state of the weather therewith. And, in opposition to the generally received opinion, the downward oscillation of the barometer was shown to correspond to the greatest elevation or crest of the atmosphere, while the upward and greatest reading of the barometer would correspond to the lowest elevation or trough of an aerial wave; the vibration

* See "Trans. N.Z. Inst.," Vol. III., p. 306.