CHAPTER XVI.

"It is but waste to bury them preciously."—*Chaucer.*

The manner of disposing of the bodies of the dead in this country varies greatly according to the religious customs of various creeds and castes. Christians, Jews, Mahomedans, Chinese, and some castes of the Hindus bury them in the earth; the Hindus in general burn them, or send them adrift in the sacred streams; and the Parsees or Zoroastrians expose them to the elements and to birds of prey in Towers of Silence.

The Christian, Jewish, and Chinese dead are usually buried in coffins; the Mahomedans and Hindus simply wrap in a winding sheet. Some castes of Hindus, such as the Boistums, are buried in an upright or sitting posture. The peculiarity of the Mahomedan mode of burial has been fully described in the chapter on Burial-grounds and need not be repeated.

The Hindu dead are cremated on the banks of the sacred Ganges, or where too remote to be carried thence, on the banks of some stream or tank, and except within municipal limits, where regulations are strictly enforced, the corpses of the poor are very generally sent adrift after a slight charring, or perhaps only touching the mouth with fire; and only a few years ago the number of floating corpses, on which the foul carrion crows rode merrily over the waters of the Hooghly, was one of the sights for which Calcutta was famous or infamous. An old writer says: "Either from indolence or penury, the body is generally placed on a small hurdle, and when little more than scorched, is pushed off from the shore with a bamboo, there to float until it arrives at the ocean, unless it be previously picked up by a shark or alligator, or which is frequently the case, dragged ashore by pariah dogs and jackals and devoured by them in company with a numerous train of carrion birds of various descriptions. From one hundred to one hundred and fifty of these disgusting objects may be counted passing any one point in the course of a day, and in some places, where eddies prevail, a whole vortex of putrid corpses may be seen circling about for hours together. It was very common for us to be obliged "to clear the cable" occasionally of a human body speckled over by the partial separation of the cuticle and the *rete mucosum* from putrefaction."

I can well remember this state of things, and how, before the passing of the law forbidding the practice, and which is popularly known as *Beadon's Act*, the residents in the river-side villas at Garden Reach and from Cossipore to Barrackpore, had constantly to employ *domes*, or murdafurashes, to push off stranded bodies, and even to remove putrid corpses from under the open basements of the houses, where they were dragged during the night time by jackals and dogs, to the intense discomfort of the inmates of these otherwise delightful residences.

It would serve little purpose to enter into a consideration of the relative merits of cremation and burial as a means of disposing of the dead in this country. The former is, as is well known, the common mode of disposal amongst the Hindus; but the sentimental and medical jurisprudential objections which stand in the way of the general adoption of cremation in European countries, would have equal force here as regards our Christian population, while there is a strong religious prejudice which would always prevent its adoption by our Mahomedan fellow-subjects. Cremation, as practised in this country by the Hindus, is however but little understood by Europeans, few of whom, though perhaps long residents in the country, have cared to investigate into the subject, and it is perhaps therefore not a matter of astonishment that we find even the latest and best writers on sanitation giving currency to such vague and incorrect statements as the following, which I quote from the "Treatise on Hygiene and Public Health, edited by Albert H. Buck, M.D., of New York," (1879), one of the latest, most complete and comprehensive popular works on sanitary subjects ever published.

"The list of nations in which cremation has been the customary way of disposing of the dead is a very long one, including the Greeks and Romans, many of the ancient tribes of Europe and Asia, and at the present day the East Indians and some Indian tribes in north and South America. In all these cases the body is burnt on a pyre in the open air, and the process is a very objectionable one, requiring, as it does, a long time for its accomplishment, an enormous mass of fuel, and creating an intolerable stench, which has to be smothered with the aroma of spices, where the relatives can afford it. Moreover, the burning is often imperfectly done, the heat attainable in this way being insufficient to calcine the remains." (Vol. II, page 454.) Now this statement is so widely different from fact that it is plain the writer could have had no personal knowledge of the subject, and it is apt to create an unwarranted prejudice against a practice which, religious prejudices and sentimental objections apart, has every thing to recommend it. Now what are the actual facts as regards cremation as carried out at the established cremation ghats or grounds within municipalities in Bengal. I give them from intimate personal knowledge of the subject, there being from six to eight thousand bodies annually cremated at two burning ghats within my jurisdiction, and which I constantly visit. The quantity of fuel (ordinary soondry, gran, ban or other common fuel wood) required to completely consume the corpse of an average adult is from three to five maunds, or 240 to 400 lbs. The time required is from two to four hours, and the burning is so perfectly effected that nothing remains but a small pile of grey ashes, a small ball of contracted sinew about as big as a tennis ball and occasionally a few scraps of calcined bone, such as the ball of the great trochanter, or a small portion of the base of the cranium, while as for "the intolerable stench which has to be smothered in the aroma of spices," it is only the rich who indulge in sandal wood and the like, and that not from necessity, but from ostentation; and I may aver with truth, that though I have spent hours in watching the process, and have stood within a few feet of the burning pyres, that unless directly to leeward and in the way of the smoke, no offensive odour was perceptible. In fact there is but little to offend either sight or olfactories, the bodies are so folded up and hidden by the wood that there is little to be seen; and as to the smell there is hardly any perceptible at a short distance; and when the burning ground is surrounded with a high wall, the nuisance to the neighbourhood, if any, is reduced to a minimum. Dr. Parkes admits that 'the impurities in burning can be well diffused into the atmosphere at large, and would not add to it any perceptible impurity;' but *he* also appears to consider the expense an obstacle to its general adoption. Now the entire necessary cost of burning a Hindu corpse, including fuel, extras, the fee of the officiating priest or moripora brahmun, and the domes, or undertakers, is only Rs. 3-7 annas, or say six shillings. Compare this with the very cheapest form of funeral and charges for interment in any Christian burial-ground, and there can be little doubt as to the economy of cremation, while as to its superiority over burial in a sanitary point of view, there can be hardly a difference of opinion.

CHAPTER XVII.

"I feel that the question of the fitness of unsound meat for food is in such an unsettled state, that my action in the matter is often very uncertain, and I should like to have the question experimentally determined, for as it now stands we are either condemning large quantities of meat which may be eaten with safety, and are therefore confiscating property and lessening the supply of food, or we are permitting unwholesome meat to pass almost unchallenged in the public markets."—*Dr. Letheby.*

One of the principal duties of officers of health, or where there is no special health department, of the conservancy staff of a town, is to prevent the sale or consumption of unwholesome articles of human food,—that is to say, any flesh, fish, fowl, vegetables, corn, rice, bread or other food constituent, which is diseased, unsound, unwholesome, or unfit for the food of man.

It has been said, and with justice, "that a thorough practical knowledge of the qualities and appearances presented by the various articles of diet in their wholesome or unadulterated state, is a necessary qualification for the detection of unwholesome or adulterated specimens;" and I fear that that class of knowledge is one in which most conservancy officers in this country are very deficient, especially in the matter of meat. Still most natives of this country have a sufficiently intimate knowledge of the qualities of food grains and vegetables, to discriminate between what is good or bad. With regard to fish there can hardly be a mistake made, while as regards meat, even good authorities in England, such as Dr. Letheby, confess to doubts.

The most important staple of the food of the people of Bengal is *rice*. Of this grain there are numberless varieties, and, as a rule, unsound rice is seldom exposed for sale in the open markets. The greater portion of the rice is brought to market by boat, and accidents in the rivers and canals are of frequent occurrence. It often happens, therefore, and especially in the neighbourhood of Calcutta, that boats laden with rice are sunk in the channels, and some portion of the cargo is recovered after immersion for a longer or shorter time. In these cases, more particularly if the rice has been submerged in tidal or brackish water, it becomes sodden, decomposes, and is quite unfit for human consumption.

Rice is also occasionally damaged in large quantities by accidental fires, and by being drenched by the water poured over the burning buildings to extinguish the flames, the combined action of heat, smoke, and water rendering it quite unfit for food. Smaller quantities are also damaged by leaky buildings, damp storage, bad harvesting, &c.

Natives of the poorer classes will, however, readily buy such rice at a nominal price and use it for food. It is also purchased by the makers and vendors of the coarse inferior sweetmeats or cakes called malpowas and dall-puries, which are largely consumed by the poor and labouring class, and which are well known to cause diarrhœa and colic. Such rice should at once be taken charge of by the Conservancy or Health Department, and submitted for examination to a medical officer. Where there are any large pig-feeders, like the Chinese hogslard manufacturers of the Calcutta surburbs, it may be sold to them under bond, but otherwise it should be buried in the nightsoil trenches as the only safe way of preventing its being used.

It may possibly be that, after only a short immersion in clean *fresh water*, the rice, if spread out to dry in the sun, may, though deteriorated in quality as a commercial staple, be not actually unwholesome; but this the medical officer will determine. In this view, however, every facility consistent with security against removal without permission should be given to the owners to spread it out in the sun and turn it over to dry, the object being to *prevent injury to the health of the people* and not to *confiscate property* or add to the already serious loss which has fallen upon the owner.

It is, as a rule, easy to distinguish fish which has become unfit for food. Fresh fish differ very much in appearance from those that have become stale or have begun to decompose. The gill should be bright and red, not muddy, pale or discolored; the flesh firm, stiff, and elastic. On pressing the finger into the flesh it should at once rise; if it remains dented in, or has a doughy pasty feel, the fish is stale and unwholesome.

But perhaps the sense of smell may be the most reliable guide: tainted or putrid fish cannot be mistaken.

Large quantities of chingrees in a putrid or semi-putrid condition are often exposed for sale in the markets. It is well known that the consumption of fish or shell fish in such a state not unfrequently produces serious intestinal disorders, and this is the more to be dreaded in warm climates. There is no article of food in respect to which the lower orders are more reckless: they will eat fish in almost any stage of putridity. The Burmese and Siamese habitually eat rotten fish as a condiment under the name of gnapee and ballachong.

Even fresh fish and shellfish at certain seasons and with certain individuals produce serious illness. I have myself suffered from cholera from incautiously partaking of oysters out of season in Bombay, and at the present time two or three Bombay oysters, however fresh and good, in or out of season, are sufficient to produce violent choleraic symptoms. The same effect is produced on many persons from eating crabs and other crustacians, and if the fish be at all decomposed, the effects are more marked and violent. The sanitary officer should never hesitate to seize and impound any fish which he finds in *any stage* of decomposition, always remembering that when that stage has *commenced,* every hour adds to its intensity.

There is a very considerable trade in dried fish, which is not only a source of nuisance to the neighbourhoods where they are stored, but which is a most unwholesome article of diet when partaken of, as it often happens to be, in a state of putridity. Natives, as a rule, cannot be brought to see this, and consider the seizure and destruction of such fish an arbitrary and unjustifiable proceeding. A few days before this page was written, some cart-loads of such fish were brought to me for examination, the greater portion of the mass was moist and putrid, swarming with maggots, grubs, and weevils, and the smell arising from it most offensive and sickening, still the owners would not admit that the fish was in any degree offensive or unwholesome. It consisted of numerous kinds of freshwater fish, with a small admixture of the heads and tails of larger fishes, evidently the rejections of the market, but largely of small flat round fish, about the size of a rupee, and which when tilted into the trench for burial, looked like a heap of withered and decayed leaves.

A reference to the subject of unwholesome milk will be found under the head of *Cow byres*.

Meat is a much more difficult subject to deal with, especially with untrained native overseers and inspectors.

The following simple hints may be a guide to the judging of good or bad meat:

The muscle should be firm, but elastic, neither too pale nor too dark. When the flesh is pale and moist, it is an indication that the animal was diseased. The fat should be firm, white, and with no sign of hæmorrhage.

Yellowness of fat is not always a sign of unwholesomeness, as feeding on oil-cakes has a tendency to color the fat.

Any juice which exudes from the meat should be small in quantity, reddish in color. There should be no softening mucilaginous fluid or purulent matter in the cellular tissue lying between the muscles.

This tissue also softens, and is easily torn when stretched, if decomposition has commenced.

The odour of the meat should be only slight, fresh, and pleasant. When meat is suspicious, but shows no distinct outward sign of putrefaction, it may still be detected by thrusting a long clean knife deep into the flesh and smelling the blade. When meat is commencing to putrefy, it becomes pale, moist, doughy, smells sickly and offensive, and gradually turns greenish; after this stage no mistake can be made, and no further instructions are necessary. The consequences of eating diseased and unwholesome meat are somewhat uncertain. Parkes says, "Instances are not at all uncommon where persons, after eating presumedly diseased meat, have been attacked with serious gastro-intestinal symptoms, vomiting, diarrhœa, and even cramp, followed in some cases by severe febrile symptoms. The whole complex of symptoms somewhat resemble cholera at first, and afterwards typhoid fever." On the other hand, it is well known that diseased meat has been largely eaten without producing any ill effects, and it is probable that the antiseptic power of thorough cooking may destroy the elements of parasitic disease.

The death returns of the suburbs, however, show that there is heavy mortality amongst the low classes of natives who habitually eat dead animals and diseased meat, such as the domes, mehters, chamars, and dosauds, the death-rate in 1879-80 ranging from 100 to 151 per 1,000.

Large quantities of tinned provisions are now imported into the country and sold by auction, and it often occurs that some portions of the consignments are damaged or *puffed* as it is termed in the trade. These are bought up and retailed by bazar dealers and up-country *boxwallas* or itinerant vendors. Sickness, diarrhœa, and colic are not unfrequently caused by using tinned or canned provisions, especially lobsters and other shell-fish: the only guide the inspecting officer has is the condition of the cans. If the heads or ends of the cans are concave, they are usually good and wholesome; if, on the contrary, the heads are convex, bulged out or puffed,' decomposition has commenced. If an awl or *brod* or sharp nail is driven through one end of the puffed can, the gas which is generally most offensive, will rush out with a noise like a steam escapement. Puffed cans should be confiscated and destroyed: they may do infinite mischief if sold, and their contents partaken of by the poorer classes of Europeans or Eurasians, the only people likely to purchase or consume them; *cheapness* being always a sore temptation to the poor, though, as a sequel, the cheapest bargains often prove the dearest in the end.

CHAPTER XVIII.

"By a disinfectant is meant first a substance which destroys or renders inert that which produces disease, whether of an infectious or contagious type; and secondly, a substance which arrests those putrefactive processes in decomposable material which foster or perhaps produce the germs, gases, and vapours that induce disease in the human organism."—*Waller on Disinfectants.*

One of the disinfectants in most common use in the present day, is carbolic acid (Phenylic acid or coaltar kreosote). This is an oily liquid of active caustic properties, and is antiseptic in its action. It exists in the form of needlelike crystals, which liquify at a temperature of 93 20° Fahrenheit. It is prepared in various ways, but for commercial purposes it is distilled from the oil of coaltar. Naturally it is found in the urine of cows (Tidy), and if in their urine, it possibly exists in their dung. May not this be one reason for the reputed purifying and disinfecting properties possessed by the excremental products of the sacred cow.

Carbolic acid, whether in the form of solution or powder, is a most useful disinfectant. "It is destructive of the low forms of animal and vegetable life, and arrests and prevents all kinds of putrefactive changes. (Wilson.)

Professor R. V. Tuson, Royal College of Veterinary Surgeons, London, has lately recommended an improved disinfectant consisting of carbolic acid saturated with sulphurous acid: its composition is sufficient to show that it must be a most useful disinfecting agent. A similar combination was some years ago proposed by Professor Abel.

Calvert's carbolic powder is a convenient dry form in which it is procurable at any chemist's.

The acid (Calvert's) costs in London about four shillings a gallon.

Carbolic acid is usefully employed in conjunction with the iron salts, as well as mixed with slaked lime. In the latter combination I have used it extensively for disinfecting latrine seats and drains.

For liquid matters, such as the contents of cess-pools, drains, privy-wells, and slaughter-house reservoirs, four pounds of Ferrous sulphate, or two to three pints of strong solution of perchloride of iron, with two ounces of pure carbolic acid, dissolved in a gallon of water, will be found useful; for disinfecting heaps of solid manure, or other offensive matter in bulk, five to six gallons of water may be added, and the solution distributed through the rose of an ordinary garden watering can.

Carbolic acid in its pure concentrated state is an active caustic destroying the skin. If it unfortunately comes in contact with the hand, the best remedy is olive or other sweet oil. Taken internally, it is a violent poison: olive oil is in this case also the best antidote. A very pleasant and useful deodorant is formed by the admixture of equal parts of carbolic acid and camphor. This mixture dissolved in water may be employed in cases of domestic sickness, for disinfecting utensils, bathroom drain pipes, and the air of sick-rooms.

Macdougall's powder is a carbolate of lime and magnesia. It is one of the first and best disinfectants for sewage, privies, cess-pools, and excreta pails. It is sold in casks by the cwt., and is an economical agent when a deodorant is required for use in large quantities.

Sulphurous anhydride or sulphurous acid gas is one of the simplest and most powerful agents for disinfecting the impure air of hospitals, sick-rooms, dead-houses, privy-vaults, and even the open air where foul odours arise from the decomposition of deposits of street refuse in ponds and tanks. It decomposes sulphuretted hydrogen, acts powerfully upon organic matters, and completely disinfects miasms (Parkes). It *is* produced by burning sulphur in the presence of oxygen.

Chloride of lime, the bleaching powder of commerce, prepared by impregnating lime in a dry state with chlorine is a well known and valuable disinfectant for drains and cess-pools, but for use on a large scale is too expensive.

Quick-lime is useful for public latrine-drains and for open drains into which sewage flows, but its effects are neither thorough nor lasting. It may be better described as a detergent than a deodorant.

Ferrous sulphate (copperas or green vitriol) or proto-sulphate of iron has been recommended for disinfecting heaps of dung, foul cess-pools, and the like. It is easily prepared, the crude material being obtainable in the bazar. It is prepared by spreading it out on a floor in the open air, watering it, and turning it over till completely oxidated. Its beneficial action is, however, somewhat doubtful.

Ferric chloride (Perchloride of iron) is next in usefulness to Macdougall's powder. It is prepared by mixing equivalent proportions of common salt, iron rust, sulphuric acid, and water. When used as a disinfectant, it yields chlorine to organic matter, becoming itself reduced to ferrous chloride (Tidy). It acts both on sulphuretted hydrogen and on sulphide of ammonium. It contains a small proportion of arsenic (Parkes).

The cost of manufacture is about twenty-five rupees a ton.

Nitrate of lead (Plumbic nitrate) has recently been recommended, dissolved in water with the addition of common salt, but I have not discovered that it has any effect in deodorizing either urine or fæces.

Chloralum is a much advertised and belauded preparation for disinfecting purposes. It is simply a chloride of aluminum, useful as an antiseptic, but with little disinfecting power compared to the zinc and iron salts.

Alum is useful for precipitating the impurities in stagnant pools or liquid sewage, with the after addition of milk of lime or cream of lime as it is sometimes called.

The salts of copper are powerful disinfectants, but their expense is against their general use. The usual form is the sulphate of copper or blue vitriol.

The waste solutions from telegraphic batteries may be usefully employed for disinfecting purposes, their action being aided by the copper compounds which they contain to a small extent.

Among the more simple disinfectants suited for domestic use may be mentioned roasted coffee. The way of using it is to dry the raw bean, then pound it in a mortar, and roast it on a heated iron plate or a hot fire shovel until of a dark color. The smell is pleasant and refreshing.

CHAPTER XIX.

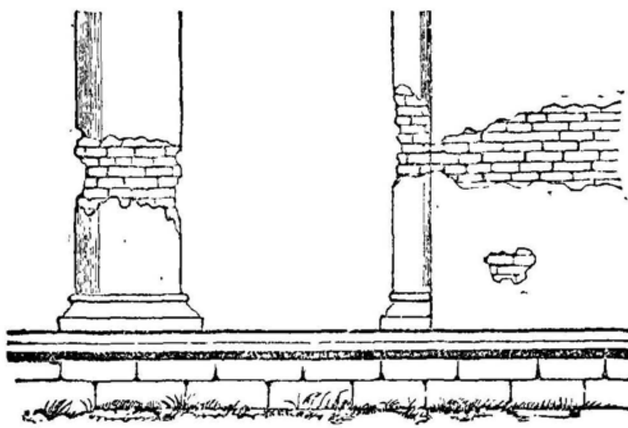
"Houses are built to live in, not to look on; therefore let use be preferred before uniformity, except where both may be had."—***Lord Bacon.***

In Lower Bengal all houses, however well raised from the ground, are more or less damp in the rains.

Even in the best built European dwellings, raised on arches, it may be five to six feet from foundation level, the unmistakable *damp line* makes its appearance both on the outer and inner walls as soon as the rains have lasted long enough to saturate the subsoil on which the foundations rest. This is owing to the clay soil which retains moisture even in well-drained localities, and to the materials of which our houses are constructed being of a spongy and absorbent nature. The hardest and best burnt brick will absorb one-sixteenth of its weight of water, and the softer and more porous the brick, the greater quantity will it drink up.

The brickwork, therefore, being in immediate contact with the wet subsoil, the damp rises in the walls by capillary attraction until it reaches the line of evaporation. As both the soil and the materials of buildings are often saturated with nitrous salts, the latter crystallise as the moisture evaporates, and their bulk being thus increased, they burst the pores in which they are contained and the disintegrated plaster and brick crumble away, causing that unsightly desquamation and dilapidation so common in the basement walls of ordinary buildings and especially in inferior native houses.

It will be observed that this crumbling away does not take place at the foot of the walls or pillars, but at some distance from the ground, and that if the lower part be protected by a coating of Portland cement, the line of evaporation and erosion only mounts higher, but this deteriorative action is not prevented from taking place. The extent to which this disfiguration, and ultimate ruin



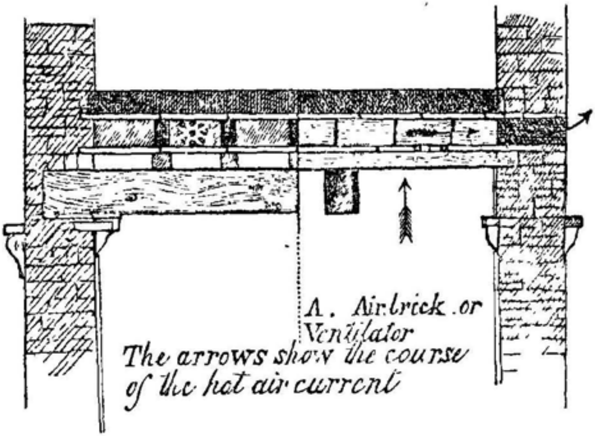
EFFECTS OF NITROUS EFFLORATION ON BUILDINGS

of buildings, goes, is shown by the above sketch, which represents the state of many buildings familiar to every resident in a Lower Bengal town. This state of things is due either to ignorance or heedlessness on the part of the builders in neglecting during the construction to insert a *damp-proof material* as the last course of the plinth. Several plans have been tried with more or less success to prevent damp from rising in the walls, and to remedy or hide it when present, and the lower stories of many otherwise comfortable houses are rendered uninhabitable or unsightly from failure to accomplish this. Portland cement plastering, high dados of dark coloured silicate paints have all been tried, but still the nitrous efflorescence appears, and the damp line mounts higher and higher till it can escape into the air by evaporation. Silicate paint, though better than the ordinary paints, is inefficacious where there is much nitre in the walls. The following, which is a Russian recipe, may be tried with advantage: Make a boiling solution of two seers of green vitriol (or copperas) to fifty seers of water, or about twelve gallons; add one seer white resin, five seers of sifted red or yellow ochre, four seers of rye meal (or coarse country flour), and three and-a-half seers of linseed oil; stir the whole together till the ingredients are thoroughly incorporated, and apply two coats while hot, allowing the first to dry before applying the second. The mixture must be applied in dry weather while the walls are free from damp: a coat of silicate paint of any desired color may be afterwards applied. Complete prevention, however, is only applicable at the time of construction, and it is effected by the insertion of a damp-proof course or a layer of some non-absorbent impervious material or composition between the foundation and superstructure. Various substances have been used or suggested for this purpose. Sheet-lead or sheet-copper would perhaps be the best materials, being indestructible, perfectly impervious to damp, and neither apt to break nor crack beneath superincumbent and unequal pressure, but their expense is quite against their general use. I once knew a case where a German engineer, in charge of buildings near Calcutta, put sheets of plate glass in the wall of a building as a damp-proof layer, I fear without much success, as the unequal settlement of the building and the weight of the superstructure must have reduced it to fragments. In those days De la Bastie's process of toughening glass was not known, and it may now be well worth ascertaining whether toughened glass tiles or slabs manufactured from blast furnace slag by De la Bastie's or Siemen's process, might not be introduced into buildings for damp-proof courses with every prospect of success; as if the glass thus produced is sufficiently tough for railway sleepers, it would surely be quite capable of bearing the inert pressure of the weight of a building. Slag bricks, enamelled bricks, and vitrified stone-ware perforated tiles, as recommended by Eassie, are also now manufactured. The material most commonly used in this country is Seyssel Asphalte, but it has several disadvantages, the principal being its aptitude to soften at a high temperature and its compressibility, the great pressure of the superstructure squeezing and forcing the yielding material from between the joints which interferes with its successful action as a damp preventer, and the superstructure of buildings has even been known to slip from the softening of the asphalte in hot weather. An useful but little known composition for the purpose is a mixture of fresh slaked lime and vegetable oil. This must be well mixed by hand the day before it is wanted for use. It is then to be spread evenly over the foundation course with a trowel in a layer about three-quarters of an inch thick, and after it has been left for a day or so to set firm, the building may proceed, care being taken in laying the first courses of brick not to break up or disturb the cement. A damp-proof course may also be laid with bricks, which, after being heated, have been plunged into a bath of boiling coaltar and then rolled in dry sand. It will add little to the first cost, but greatly to the stability and good appearance of houses generally, if the basements are plastered with Portland cement instead of the ordinary sand plaster; and the extended manufacture of cement in this country, especially by the Indian Cement Company, will tend to bring the material into more general use. Damp houses can never be healthy houses, moisture being a necessary factor in the process of decomposition of organic matters in the soil, which give rise to malaria and consequent danger to health. A house built on a damp site, without a damp-proof course, and with walls often of insufficient thickness, exposed to heavy driving rains, lasting as they sometimes do in the tropics for days together, cannot fail to be unhealthy; the damp is absorbed by the walls and given off in vapour inside the rooms. Thus during the rains in Bengal we find our boots, books, and everything made of leather covered with green mould, and falling to pieces, while clothes refuse to dry, and all our surroundings feel damp and clammy. Pictures hung against the walls become irretrievably ruined, and every piece of furniture or cabinet-work with glued joints falls asunder.

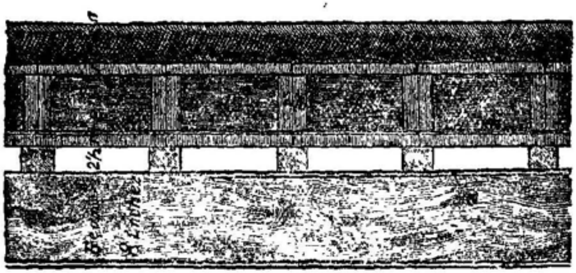
Every house should be surrounded with a well-constructed stone or brick drain, well cemented with Portland cement, to carry off the water streaming down the outer walls and which would otherwise lodge about the basement and soak into the foundations. There should always be a space of ten or twelve feet round the house either paved, tiled, or laid with a good layer of jhama or stone well consolidated and sloped from the basement and nicely gravelled. Grass should never be allowed up to the walls. A belt of sharp gravel is also a great obstacle to snakes, which are too apt to find their way into our Indian houses.

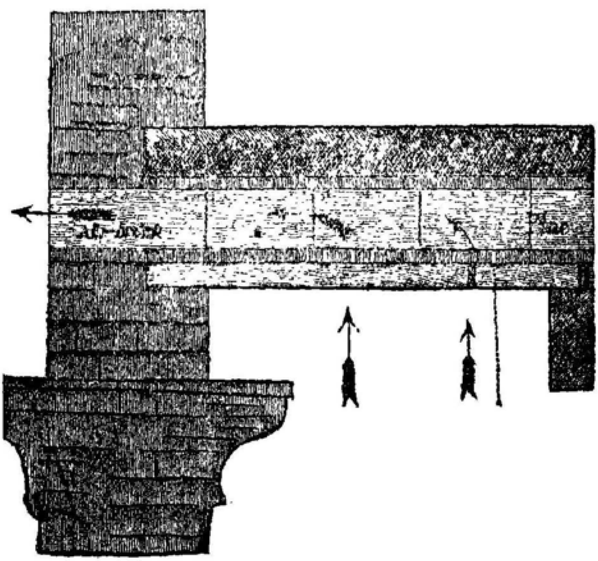
Moisture and heat being the two most essential elements in the process of organic decomposition, the next desideratum of our Indian dwellinghouses, after the prevention of damp, is to keep the temperature as low as possible. Single storied, or what are called lower-roomed houses with flat terraced roofs are often unbearably hot. Terraced roofs are usually constructed with beams, rafters, and a double layer of tiles; the upper layer imbedded in mortar and placed diagonally, so as to break joint with the lower, and from five to eight inches of concrete beaten and plastered. In some of the older houses a depth of even ten to twelve inches of material will be found, evidently put on with the intention of opposing a greater obstruction to the sun's rays. A roof of this kind is, of course, very weighty, and necessarily requires stout walls and timbers of considerable scantling for its support; and in the older houses alluded to, very considerable deflection of the beams may be observed. I have recently constructed an improved form of terraced roof or floor, which, while it has all the strength, rigidity, and stability of the ordinary form, possesses three important advantages, *viz.*, greater depth or thickness with comparative lightness, economy of material, greater resistance to the heat of the sun, and complete ventilation.

Over the ordinary beams and burgahs (rafters) the



first course of tiles is laid as usual, a row of table-moulded bricks is laid on edge in mortar over the longitudinal oin, and the second layer of tiles is then laid with mortar, thus leaving flues or spaces of nine inches by five as shown in the following sketch. Four inches of finely broken khoah is then spread as before, mixed with a sufficient quantity of good fresh lime, well turned over, incorporated, beaten, and finished off in the usual manner. We have thus nearly double the depth of the ordinary roof with less weight, and the air spaces not only interpose a stratum of air and prevent radiation of heat as in the case of the solid terrace, but by the use of air bricks or ventilators at the ends of the flues, and perforated tiles in the lower layer or ceiling, perfect ventilation and escape of hot air from the upper part of the room is secured, and the temperature correspondingly reduced. There can be no reasonable doubt as to the stability and durability of a roof so constructed, for I have had a floor constructed on this plan, over which there is constant daily passing to and fro, and over





which the whole of the heavy furniture of the upstairs rooms, including heavy almirahs, requiring ten or twelve men to lift them, has been carried without in the least affecting it.

Doubts were expressed by several practical builders and engineers at the time of construction as to whether this floor would stand, or even bear the concussion of the beaters while consolidating the concrete, but the result has proved these fears to be groundless. Where iron can be procured, a more durable form of this roof would be to substitute iron girders and inverted T iron for the timber beams and rafters, the tiles resting on the flanges of the inverted ⊥ irons. Another advantage of this form of construction is, that the ceiling between the girder beams can be plastered smooth and flush with the under-surface of the ⊥ iron, and will thus give more scope for ornamentation if desired. There is in many other directions great room for improvement both in the plan and construction of our Indian dwellings, and which, if followed, would add not only to our comfort and enjoyment, but to the preservation of health. Little attention has been paid in the first instance to the requirements of a tropical climate, and house builders have gone on from generation to generation building upon the same lines and following the same models as their predecessors. As far as appearance is concerned, there seems to have been little attempt at æsthetic treatment of private dwellings, and in short, if, as a well-known writer on architecture says, "architecture is building with something more in view than mere utility and convenience, *it is* building in such a manner as to delight the eye by beauty of form, to captivate the imagination, and to satisfy that faculty of the mind which we denominate taste;" then it is evident that architecture had nothing to do with the construction of the hideous square four-sided, equally divided buildings in which Anglo-Indians seem, as a rule, content to pass the best part of their lives.

The object of this work, however, is not to descant upon æsthetics beyond this point, that beautiful surroundings by adding to contentment and happiness, are undoubted aids in preserving that '*mens sana in corpore sano*,' which is essential to our well being. With regard to the construction of our Indian dwellings, it has often been a matter of wonder to me that English settlers in this country have not taken a lesson from the people of the sunny lands of the south of Europe, or from the Syrians, Egyptians, and other eastern nations, and built their dwellings with an open central court, thereby admitting light and air to the very heart of their habitation.

I cannot claim this idea as an original one, for I have quite recently, whilst employed on these pages, come across a similar suggestion made as far back as 1863 by that excellent authority on such subjects, Colonel J. G Medley, R. E., late Principal of the Roorkee College and Editor of the Professional Papers on Indian Engineering; but I believe I may fairly claim to be the first who has not only independently arrived at the same idea, but has, to use his words, " worked the idea into a tangible shape." The room in which I am now writing looks into just such a court as Colonel Medley has suggested in the following extract,—" In many parts of the country perhaps the old eastern style of building round an open quadrangle in the centre might be adopted with advantage. This open court paved with marble or stone, filled with fragrant shrubs, and with a fountain and tank in the centre." My court has no fountain at present, there being no regular water-supply, and all fountains which depend upon a tank filled by the bhisty, are to my mind but a delusion and a snare; but it is enlivened and made fragrant and healthful by many-hued and sweet-scented shrubs and plants, and is shaded by an ornamental verandah or sunshade on all four sides. The rooms being built around it, every room in the house opens to the open air on *both* sides, and as the sun in his diurnal passage from east to west only shines directly into the court for a short period of the day, whilst every current of air finds its way into it, the house is cool and pleasant at all times. I may remark that the house was not newly built on this plan, but the opportunity of restoring a very large and somewhat ruinous house was taken, and the centre portion entirely removed and converted into the court, and a residence in the house throughout the three seasons has proved its complete suitability to the climate.

There can be no doubt that in damp and badly drained localities the health of the people would be better if their habitations were well raised from the ground, so as to remove them from immediate contact with the subsoil, and permit the air to permeate freely underneath them. This is recognised by tea-planters and others who settle in malarious and jungly districts, and is adopted with great advantage by nearly all the agencies for deportation of emigrant coolies.

It is hopeless to expect that the people will ever be induced to depart from their old plan of hut-building, but local authorities who may have to hut coolies or nightmen or other employés might follow this plan with advantage, and there can be no doubt that the extra cost of construction will be more than repaid by the increased healthiness of their workmen, and consequent gain in the amount of work obtained from them.

When huts are so raised from the ground, however, they must be sufficiently high to admit of any dirt or rubbish that may gather under them being cleared away, and the space below the floor must neither be allowed to become a deposit for garbage or to accumulate stagnant water.

Huts so built may be floored either with split bamboos, or with *jarool* planks. The ordinary dwellings of the poorer classes of Bengal are constructed chiefly of bamboo framework with timber posts, either sâl-wood (Shorea robusta), soondri (Heritiera littoralis), or goran (Ceriops roxburghianus or Rizophora decandra) with a roof of tiles or thatch of paddy straw, ooloo-grass (Sacharum thunbergi), or goleputta (Nipa fruticans). The latter is much used in the neighbourhood of Calcutta, being brought in great quantities from the Sunderbunds, in some parts of which it grows in great profusion, and regarding which Dr. Hunter, the Statistician of Bengal, has fallen into a curious error, as he states this to be the leaf of the hental (Phœnix paludosa), known in the Sunderbunds as hurtal, hental, or bokra. The latter is a species of wild saltwater date, the fruit of which is a favorite food of the rhinosceros, and the pith of which is eaten by the wild pigs, and occasionally under pressure of hunger by boatmen, but the stiff prickly leaf of which is most unsuited for thatching purposes, as would be evident to any one who tried to force himself through a patch of hental jungle or 'bokra-bon,' as I have often had occasion to do in pursuit of game.

Grass, straw, and goleputta roofs become extremely inflammable in the hot weather, and for this reason laws and bylaws have been enacted to prohibit their erection in towns, and it is no doubt the duty of local authorities to discourage them in every way in populous localities. As a question of comfort and hygiene, however, I consider the golepùtta or any thatched roof far superior in every way to one of tiles. In the first place, it is *less costly;* secondly, it is much cooler in the summer, more watertight in the rains, and warmer in the cold weather. True, it is more inflammable, and in this respect there is an element of danger; on the other hand, an occasional fire is a great *purifier,* and as the hut-owner has seldom any heavy property to remove, and there is, as a rule, little danger to life, I am not sure that the balance is not on the whole in favor of inflammable constructions (in thinly populated neighbourhoods and situations remote from other valuable buildings or property always understood).

However unfavorable to public health such a result may prove to be, we must accept the fact that one of the inevitable consequences of the spread of civilisation and increase of prosperity in any country is the aggregation of a large portion of their inhabitants in towns. And in all the problems we have to consider for the sanitary improvement of our towns, we must constantly keep in mind the fact, that the evils attendant upon overcrowding and the aggregation of large numbers of people within an urban area, will continually increase with the growth of the population. In all our plans for improvement, therefore, we must not only bear in mind the actual wants of the present, but the probable necessities of the future. These points should be especially considered when remodelling old bustees and mohullas, as well as in laying out new quarters and extensions. It is mainly by their utter disregard to future requirements that the predecessors of the local authorities of the present day have left their successors such a fearful legacy of intricacy, disease, danger, and filth, as exists in the crowded mohullas and paras, the narrow tortuous gullies and lanes, and the reeking cess-pits and filth-sodden soil of the majority of native towns: for one of the greatest difficulties in the way of municipal improvement in this country is the irregularity with which the streets and lanes are laid out, most towns presenting a perfect labyrinth of tortuous lanes, bylanes, and gullies, clearly showing that their arrangement has been a matter of chance, following the necessities of the time being, without any respect to the public convenience or the future of the townships.

The following description by Mackintosh of the native town of Calcutta, in 1780, is very characteristic of the condition of many native towns even at the present day:—"From the western extremity of California to the eastern coast of Japan there is not a spot where judgment, taste, decency, and convenience are so grossly insulted as in that scattered and confused chaos of houses, huts, sheds, streets, lanes, alleys, windings, gutters, sinks, and tanks which jumbled into an undistinguishable mass of filth and corruption, equally offensive to human sense and health, compose the capital of the English Company's Government in India."*

Not only does such an arrangement largely contribute to the general insanitary condition of our towns from the imperfect perflation of air, and the impossibility of carrying out proper scavengering, but in cases of conflagration it adds greatly to the rapid spread of the fire and to the difficulties in the way of checking its ravages and its advance. Where the houses occupying these confused areas are constructed, as is usually the case in Bengal, of most combustible material, which, after baking in the torrid heat of the summer sun, becomes as dry and inflammable as tinder, the fire spreads with a rapidity that is most appalling, the heat from the blazing huts creating a vacuum, which on the stillest day generates an air current, which in its turn drives the flame forward with increased fierceness. Everyone who has assisted at such a conflagration will understand the powerlessness of even steam fire-engines, and that the only means of effectually checking the advance of the fire is to pull down the huts in a wide gap, and so cut off the communication with the rest of the town.

This, when the streets are straight and wide, is easily effected; but where, as is too often the case, the crowded masses of huts and houses are intersected only by narrow winding lanes and gullies, is almost an impossibility. Torrents of sparks rain on the dry leaf or grass roofs, blazing bamboos propelled by the steam generated in the hollow stems are projected like rockets into the air, and the flames leap from hut to hut with uncontrollable

* Census Report, by H. Beverley, C. S.

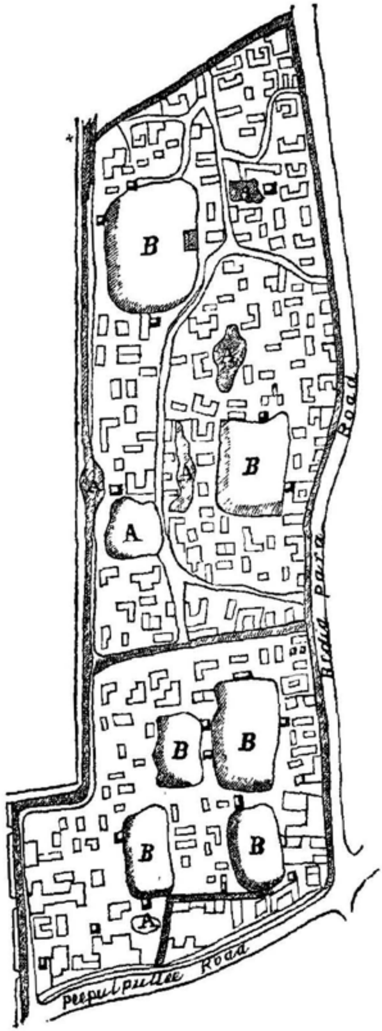
rapidity. The heat and smoke become insupportable such as not even trained firemen can face, and I have seen the men of the European fire-brigade of Calcutta fairly driven from the hose of a steam fire-engine and obliged to abandon it in the midst of the flames, it being impossible to extricate it before the fire was upon them. On this occasion the flames devoured everything before them till they reached a broad street, where they died out simply from want of further fuel.

It is a curious thing that these great fires in our native towns appear epidemically. During one hot season hardly a single large fire will occur; the next, village after village, mohulla after mohulla, will be swept away. It is difficult sometimes to account for these occurrences; they probably originate in the majority of cases from accident or carelessness, but they are not unfrequently, whether rightly or not, attributed to the ghuramee, or thatcher class, who are supposed to act the part of the incendiary to obtain work; and in cases which have come under my notice there could be little doubt on the subject, rags soaked in kerosine oil having been found in the thatch of a hut. The ghuramee is popularly believed to impress the crows into his service in carrying out his nefarious designs; a piece of smouldering tinder being attached to a bit of flesh, which is then thrown to the crows, who seize the tempting morsel, and flying off with it, drop it, the chances being ten to one that it falls on the roof of a thatched hut and sets it in a blaze.

It will thus be apparent that there can be no real security for life and property unless wide straight streets and roads are constructed, so as to intersect the bustees and mohullas at convenient intervals. These streets should, as far as possible, run in parallel lines and the cross streets should intersect the others at right angles, advantage being taken of large public tanks to construct squares. The municipal or local authority should always take advantage of the clearance effected by periodical conflagrations to control the rebuilding of the houses and huts, and to remodel the bustees, securing them by the construction of roads and cross lanes, the proper arrangement of the huts, and the prohibition of inflammable walls and roofs from future risks from fire; and providing for proper ventilation, thorough scavengering, and sanitary supervision. The plans given on the next page give a good example of the vast improvement that may be effected in this direction; they represent the past and present state of one of the *bustees* in the suburbs of Calcutta. The huts which were formerly constructed with mat walls and goleputta roofs of all shapes, sizes, and elevations are now replaced by neat compact houses with white-washed mud walls and red tiled roofs, at the same elevation throughout. The huts are six feet apart from wall to wall, and three feet from eave to eave: between each row is a footpath nine feet wide, while the main roads are sixteen feet in width and are metalled.

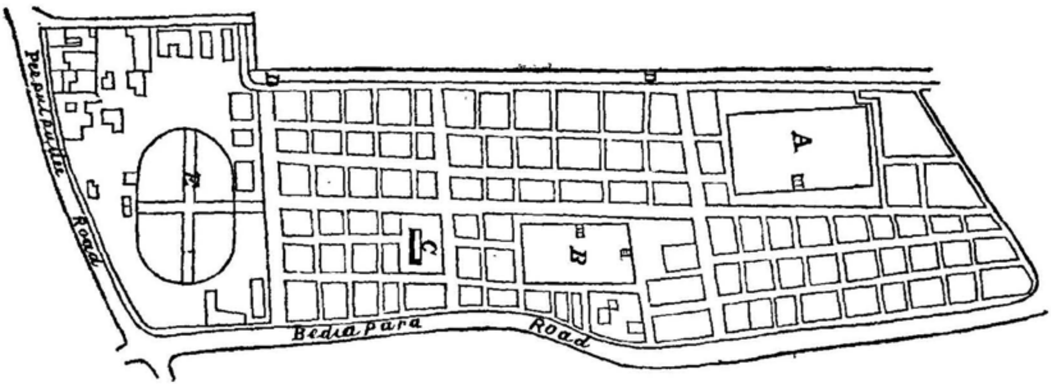
The floors of all huts are well raised, the material for floors and walls being taken from the spoil earth from the re-excavation of the tanks kept for drinking and bathing, several filthy useless tanks having been filled in with refuse, and the material obtained by levelling the whole space occupied by the old bustee before its reconstruction. A fire-engine can have access to any part of this bustee, and from the arrangement of the houses and their construction, the risk from fire has been reduced to a minimum.

 Gosain Bustee before improvement, 1877.



A Cesspools.
B Tanks containing foul water.
Filthy ditches.
Privies and latrines.

Gosain Bustee as remodelled, 1879.



A Bathing tank.
B Tank for domestic uses.
C Public latrines.
DD Road over covered sewer.
E Intended site for a garden.

In every municipality or station we may presume that there is something in the shape of a fire-brigade, or at least some appliances at the disposal of the Municipal authority, the Magistrate, or the Police authorities, for the extinction and controlling of fire, and if there is not any organised establishment, there certainly ought to be. Even in our larger towns, however, the means at the command of the local authority have seldom been in any way efficient. and what I have myself noticed as being a great want on the occurrence of serious fire, even when an European brigade has been present, has been the want of sufficient appliances for cutting down and removing inflammable roofs and walls in order to cut off and confine the fire to a certain area, *viz.*, light sharp axes, tomahawks and bills, as well as pole-hooks and drag-hooks and chains. These are of greater importance even than fire-engines and hose in the case of bustee fires. To play upon a blazing hut even with the steam-engine, is, as a rule, a waste of time, labor, and water; the thing to be done is to pull down and remove the huts in the track of the advancing flames, and to saturate the roofs of the huts in front of the fire so as to prevent them, if possible, from catching.

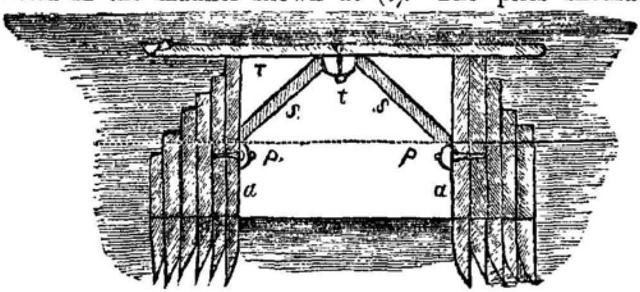
CHAPTER XX.

"A smooth, firm, dry road is one of the greatest conveniences and enjoyments, while a rough, soft, muddy road is one of the greatest drawbacks and annoyances of country life. Bad roads form the greatest obstacles to progress and permanent improvements in all the neighbourhoods that are blasted with their presence; they have a demoralising effect upon the inhabitants, and are a sure sign either of poverty or mismanagement, or both."—*American State Report.*

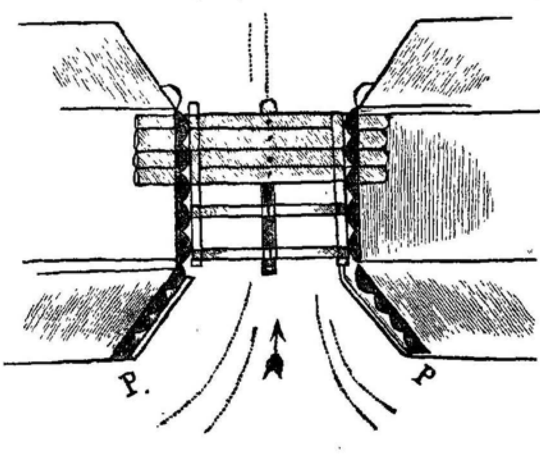
Roads in Bengal are of two kinds—cutcha, or fair weather roads, and pucka, or metalled roads. The cutcha road is simply a track more or less raised and drained, formed on the natural soil of the district, and unless in gravelly or sandy soils, is hardly passable in the rainy season.

Pucka roads in Lower Bengal are again divided into stone or Macadamised roads and jhama roads, or roads metalled with jhama khoa, or broken vitrified brick. Higher up the country, roads are made with kunker (nodular limestone) or quartz pebbles.

In making cutcha roads on alluvial soil, nothing can be done beyond raising the surface of the road sufficiently to prevent its being under water during the rains, and providing side ditches or drains with sufficient fall to carry off the water and prevent the saturation of the subsoil. Culverts or waterways must also be provided to allow the drainage of the country to follow its natural inclination, and so prevent the road embankment from being breached. Where masonry structures cannot be afforded, very efficient bridges may be constructed of tâl trees or other indigenous timber, as shown in the figure below. This is formed by a row of sheet-piles formed of tâl trunks (*a a*) split in half, pointed at the lower ends, and driven down below the bed of the watercourse. A plate (*p*) is then bolted or spiked along them, a similar piece (*t*) being bolted to the underside of the bridge timbers (*T*), and struts (*ss*) fixed in the manner shown at (*t*). The piles should



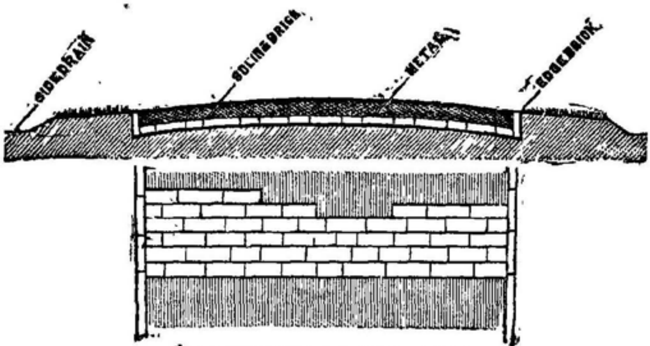
be continued in the form of a wing-wall on the upper side of the bridge to prevent the water cutting away behind it as shown at (*PP*). The banks should always be



turfed, as slopes so protected will last for years without repair or attention. Cutcha roads should not be made too wide, as the wider they are the greater will be the cost of maintenance; 20 to 25 feet will be found a sufficient width as a rule. If I were asked to define a perfect road, I should say that it is one the course of which is perfectly straight, its line perfectly level, and its surface as hard, smooth, and non-elastic as possible.

A well-constructed jhama road when kept in proper order and watered during the hot months to keep down the dust, is one of the most pleasant forms of roadway for horse and carriage traffic imaginable, but for heavy cart and waggon traffic it is hardly sufficiently durable. What is known as jhama, is hard well-burnt brick partly fused or vitrified by the action of the fire. Good well-burnt jhama breaks with a clean sharp fracture, does not pulverise to any appreciable extent, and packs close and firm on the road surface. It should be hard, heavy, of a dark red color, running into *blue* in parts, with a clear metallic ring when struck with a hammer. Overburnt jhama becomes porous, honeycombed, and mixed with scoriæ, and is sometimes so light as to float when thrown into water; this is useless for road-making. First class road metal should consist of about 75 per cent. of jhama of the kind above described, the remainder consisting of sound well-burnt brick.

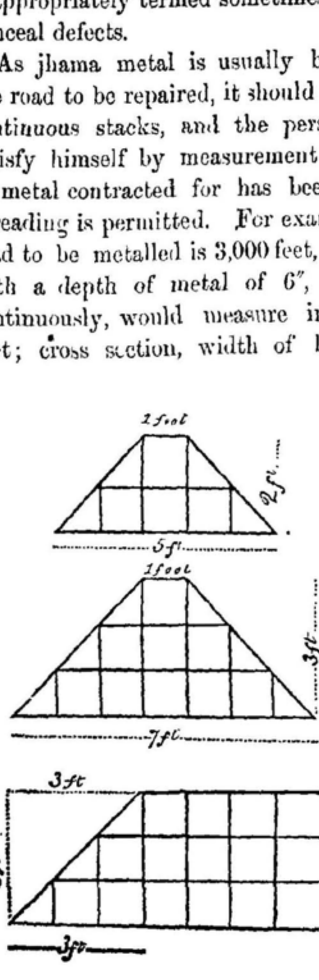
All *amuh*, or soft brick, and *peelah*, or unburnt stuff, should be rejected. In making a new road, the surface of the ground should first be cut to the proper level and section, and with a slight rise to the centre of the road. The whole surface is then laid with bricks flat, called the soling. Soling bricks should be laid by a bricklayer, or other workman accustomed to the work, and should break joint over the whole surface so as to make a firm



SOLING BRICK BREAKING JOINT.

stable foundation. Over this soling is laid the jhama broken to a size which will pass through a ring of two inches diameter. It is to be laid to a depth of five to eight inches, and to an equal depth all over, but with a slight rise to the centre of the road. The jhama after being raked over is handpacked, all large lumps being broken with the hammer; the whole surface is then rolled with a one-ton to two-ton roller, plenty of water being sprinkled over the surface throughout the rolling. When sufficiently consolidated, which can only be judged by practice, an inch of good dry kiln or building rubbish is spread over the surface, which is again watered and rolled till a thoroughly hard even surface is the result. Plentiful watering during the rolling is a *sine qua non.* The person supervising road construction should never allow rubbish as binding to be put over a road until he has satisfied himself that the metal has been properly handpacked and sufficiently consolidated. Contractors and underlings will hurry on the binding, or as it is not inappropriately termed sometimes, *blinding!* material to conceal defects.

As jhama metal is usually broken on the side of the road to be repaired, it should be stacked in uniform continuous stacks, and the person responsible should satisfy himself by measurement that the full quantity of metal contracted for has been supplied before any spreading is permitted. For example, say the length of road to be metalled is 3,000 feet, and the width 12 feet, with a depth of metal of 6″, the metal, if stacked continuously, would measure in stack, length, 3,000 feet; cross section, width of base 5 feet; width at top, 1 foot; height, 2 feet; sectional area, 6 square feet; *contents*, 18,000 cube feet; but as it is in practice usually impossible to stack metal in an unbroken line on account of cross-passages, gateways, house entrances, trees, and other obstructions, it is more convenient to put it up in stacks of, say 20 feet long. Eighty-eight stacks of the following dimensions will give 18,000 less 48 cube feet:—



Length of base, 20 feet; length of top, 14 feet; height, 3 feet: cross section, width of base, 7 feet; width of top, 1 foot; height, 3 feet; sectional area, 12 square feet; contents, 204 cube feet. The diagrams in the margin will show this clearly, the following being the mode of calculation:—

$$20 + 14 = \frac{34}{2} = 17. \quad 7 + 1 = \frac{8}{2} = 4.$$

$$17 \times 4 = 68 \times \cdot 3 = 204.$$

The same principles apply to stacks of any dimensions, but it will be found convenient to have a standard measurement and supply the contractor with a wooden gauge.

In repairing or remetalling old roads, the surface of the road is to be well picked up and levelled, so that the new and old metal may bind properly: no part of the old-metal should be removed and used as binding for the new layers.

A well made jhama road, laid with good picked material, should last without repairs, subject to ordinary town traffic, for three seasons: this, however, depends on the quantity and class of traffic.

Stone roads, or what are often called Macadamised roads (after Macadam, one of the first constructors of modern roads with broken stone), are laid with indigenous stone or ship's ballast broken into irregular cubes so as to pass through a ring of two inches in diameter. In Calcutta and its neighbourhood the stone used is either brought from Oodooa nullah in the vicinity of Rajmahal, and excavated from the low spurs of the Rajmahal Hills, or is ballast from Bombay, Melbourne or

Mauritius. Laterite is much used in Madras, but is too soft to stand much traffic. Granite, trap, and hard limestones are the best kind. All stone roads should be laid upon a foundation of stone boulders, or, where they are not procurable, on a well-laid soling of sound hard bricks. A stone road made without soling, though it may be; to all appearance, a hard sound road, will never bear heavy traffic, the subsoil will yield more or less under the superincumbent weight, and in long continued wet weather, especially with the tremendous tropical downpour of these latitudes, the mud will work up to the surface and the road will speedily become impassable. I do not overlook the fact that Macadam maintained that no foundation of large stones or other material was necessary even in the softest soil, but recommended that the foundation be made of broken stone the same as the surface.

Where a good foundation of boulders has been first laid, a six-inch layer of broken stone will form a good lasting road; but where bricks are used over a soft subsoil, at least eight to nine inches of metal will be necessary at first construction to ensure a good trafficable road. The amount of traction power required varies very considerably on roads of different construction, and is much less in proportion to the strength and hardness of the surface.

It has been proved by experiment that, "on a well made pavement, the power required to draw a wagon was 33 ℔s.: on a road made with six inches of stone of great hardness laid on a foundation of large stones, the power required was 46 ℔s.: on a road made with a thick coating of broken stone laid on earth, 65 ℔s., and on a gravel road laid on earth, 147 ℔s."

Stone for road-making must be broken into sharp angular forms. They then wedge together into a hard compact mass. According to Macadam no binding material should be used, but in this country the use of binding is universal, and care must be taken that the binding used is good dry brick and lime rubbish without any admixture of earth or clay, which would make the road muddy during rainy weather, or where streets are copiously watered. The transverse section of the road should be gently convex. As footpaths are seldom used in this country, pipe drainage is not required; but there must be provision for letting the surface water pass freely into the side drains, which should be of sufficient depth to drain not only the surface but the whole formation. It should always be borne in mind that the best stone,—that is to say, the hardest and toughest,—though perhaps more costly at the outset, is the least so in the end. The best material for stone roads, as before noticed, is tough granite. Water is the worst enemy to good roads; it is therefore one of the first principles of road-construction that they should be kept dry; no water being allowed to lodge on the road surface.

A useful material for raising and metalling lanes and byroads, where there is little traffic, is often available in towns where any large manufactories, mills or foundries exist, in the slag, cinders, ashes, and scoriæ from the furnaces.

In some parts of England, and on the Continent of Europe, as in Silesia, slag is largely used in road-making. It is not available, however, in sufficiently large quantities here to make it of value for that purpose, but occasionally sufficient quantities of it, mixed with ashes and cinders, are procurable in suburban districts, to form a dry substantial surface to small lanes and footpaths. It merely requires to be laid on the road surface, levelled and rolled with a light roller. Where there is little or no wheel traffic, it will last with a little attention for a long time, and add greatly to the comfort of the residents at a very small cost.

During the hot weather the stone composing road surfaces is very apt to work loose: all loose stones should be gathered up and removed, as they are not only likely to throw horses down or lame them, but each stone, as a heavy wheel passes over it, acts as a pick to loosen others, the mischief thus repeats itself, and the road, if neglected, soon becomes almost impassable. Great economy will result from a regular attention to, and immediate repair of any small portion of road surface which has worn out.

There is some difference of opinion as to whether trees are beneficial or hurtful to road surfaces. Some authorities consider that where trees are planted close to and overhanging a road, the droppings from the leaves injure the surface, and their shade keeps it from drying properly.

Others consider that they do more good than harm, by protecting the surface from extreme heat. I think that if the undoubted comfort to the wayfarer be added to the probable benefit, the balance is in favor of planting trees, so as to give the greatest amount of shade with the minimum of obstruction to traffic. American engineers hold, that shade is objectionable on earth roads though admissible on stone roads, and their objections, so far as they go, have reference more to the exclusion of the sun from the road surfaces in winter, when the roads are dangerous and slippery from frost, than to any other question.

The metalled portion of a road should not be less than sixteen feet, to allow vehicles to pass each other with ease.

Although probably few Municipalities have to undertake extensive works of this class, it may happen that those situated near the sea-board, or contiguous to the large tidal rivers, may require protective works of the kind, and a few words on the subject of constructing, protecting, and maintaining embankments may therefore not be out of place.

Whilst engaged in the construction and maintenance of such works, and the reclamation of tidal lands at Port Canning and in the 24-Pergunnahs, Sunderbunds, I had exceptional opportunities of studying the system of embanking them in vogue and in detecting its faults and weaknesses, and an improved system was introduced by me in the works under my charge, with great advantage.

The common faults were: the construction of embankments with insufficient slopes, especially on the river face; the digging of the earth required for the construction from irregular holes or pits (locally termed chokats) from both sides of the embankment indiscriminately; and the throwing up of long lengths of rough embankment without beating, ramming, and consolidating the material whilst moist and plastic. The evils resulting from these errors were: first, the erosion and instability of the embankment from insufficient slopes; secondly, the holes from whence the earth had been dug being below high water level, the earth was kept constantly moist and soft, mud crabs burrowed freely through the softened base of the embankment, there was continuous percolation backwards and forwards as the tides rose and fell, and the embankment being thus rendered unstable, settled, and cracked, leaked, and finally gave way, or was breached by the spring tides; thirdly, the stiff alluvial earth being cut in plastic lumps was thrown together to form the bank, and when these lumps were exposed to the sun and air, they quickly dried and hardened, forming hard clods, which could not be afterwards made to pack or lie close, the embankment was thus full of hollows, and these admitting the water, formed leaks and fissures, which soon caused its destruction. We will now consider how an embankment ought to be made. No particular form or dimension can be insisted upon for general adoption, as the necessities of each case, and the forces which the embankment will be required to withstand, must determine these points; but it may be accepted as a first principle, that where the bank is formed of sand, as light sandy soil, the sea or river face must have a sufficiently long slope to receive and deaden the force of the waves as they traverse its surface, and that to oppose, an abrupt slope to receive the shock of the waves or the constantly eroding action of a strong tide or current, would be to court the destruction of the embankment. The height of an embankment must entirely depend on the maximum height of the tides calculated at the highest springs, and no rule as to height can therefore be given; the top of the bank, however, should never be less than two feet higher than the highest known rise. A good form of embankment for a four-feet high bank is a base of twenty-four feet, top four feet, external slopes three to one, and internal slopes two to one; where the material is sandy, the outer slope may, with advantage, be increased to three and-a-half to one, and the inner slope reduced to one and-a-half to one.

Where, on the other hand, the material is sound and durable, as it usually is in the case of salt marshes, the outer slope may, with safety, be reduced to two to one, the base of the embankment being thus reduced to eighteen feet.

The material for the construction of the embankment should never be taken from holes or chokats on both sides of the bund; it may be taken from the main ditch or drain within the embankment, or be taken from cuttings along the foreshore. In the latter case the high tides which flood all the land outside the embankment would deposit so much silt, that these holes or cuttings would soon be entirely filled up, this silting up being greatly facilitated by planting brushwood spurs diagonally across the foreshore. In this manner the whole of the land outside the bank would be gradually raised, thus adding greatly to the stability of the work. The great benefit to be effected by the use of simple means, like the planting of brushwood spurs, is not sufficiently appreciated or understood, but I have seen large gaps in river banks, and the mouths of very large reclaimed creeks, made up by this very easy and inexpensive expedient. It is well known that large rivers like the Ganges and its affluents running their course through alluvial soils, bring down in suspension vast quantities of mud and silt, especially during the rains. This is carried out to sea, and aids in the formation of those dangerous bars and shoals at the entrance of the deltaic rivers called the Sandheads; but it is not, I believe, so generally recognized, that the floodtides bring back a very large quantity of this silt. This, so long as the tide is running, remains and is carried along in suspension; but when the force of the tide is spent, and what is termed the period of slack water occurs, the mud and silt rapidly subside, and if not exposed to the scouring action of the ebb, gradually raise the ground where they are deposited. The unvarying law of the currents aids this process, for the floodtide rushes over the shallows, but the ebb water subsides gently off the higher ground and seeks the deep channel, where its scouring action is, therefore, greatest. The spurs act by intercepting the silt, breaking the force of the current, thus causing more rapid subsidence and lessening the scour. The third point referred to is faulty construction; this can only be avoided by constant and intelligent supervision, by insisting on every length of the embankment being well packed, rammed, and beaten into a solid homogenous mass before the clay has lost its plasticity by drying and hardening, and all fissures caused by the sun-drying and cracking the bank, being carefully filled and rammed, water being added, if necessary, to moisten the earth. All embankments should, when completed, be well grassed or turfed to preserve them from the effects of the weather and the erosive action of water; the best grass for the purpose is the common *dhoob* or *doorva* (panicum or cynodon dactylon), which, when once fairly established, is almost irradicable, and forms a fine close-matted covering to the bank and yields an excellent fodder. It is easily planted either by dibbling in small rooted tufts three inches or so apart, or by chopping up a large quantity of the roots and jointed stems, mixing them with a puddle of clay and cowdung, and plastering the mixture all over the bank. A few coolies, or even old women and children, can thus cover a very large surface at small cost, and if done in the rains, three weeks or a month will suffice to cover the whole surface with a fine growth. Of course turfing or sodding makes a closer, stronger turf in less time, but it is much more expensive, and sufficient turf is not always procurable. Stone or shale will seldom be available; but where it is, it may be used for facing the bank to great advantage. All sea and river embankments require constant watching to prevent and remedy the perforation of the banks by rats, crabs, and other burrowing vermin. Crabs do an immensity of mischief to the cultivators' bunds, and the Government embankments in the Sunderbunds and the 24-Pergunnahs. An embankment must be kept perfectly impermeable to water, a rat-hole or crab burrow (or ghogue, as it is locally termed), though apparently of little consequence at first, if unattended to, will be the sure precursor of a breach.

This danger can only be guarded against by constant inspection and by keeping (bildars) or working patrols constantly traversing the embankments and stopping the holes and repairing weak places.

In America, in the reclamation of marsh lands, great difficulties have been experienced from the destructive ravages of muskrats, and in many cases attempts at reclamation were entirely defeated by these persevering and destructive rodents, who bored through the embankments between high and low water mark. In the reclamation works at Newark Meadows, New Jersey, this difficulty was at last overcome by the insertion in the heart of the embankment of iron dike-plates or cores, covering the space between high or low water mark. Such a material would probably be found too expensive for ordinary use, but where common timber is plentiful, a dike core of wooden slabs might be used with advantage.