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Public works DEPARTMENT.

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No. 408. Read the following Proceedings of the Government of India in the Public Works Department, (Buildings and Roads—Miscellaneous,) dated Simla, 6th July 1871, No. 223—235 B—C:—

Read the following:—

From the Secretary of State for India, to the Government of India, dated 18th May 1871, No. 32.

YOUR Excellency's despatch, No. 149, of 27th September last, with the enclosed copies of proceedings, in regard to a scheme for the drainage of Cawnpore, duly reached me several months ago, but have not hitherto been answered, because I was desirous that certain investigations which the subject seemed to call for should first be made.

2. I am quite of your Excellency's opinion that Indian municipalities should receive all reasonable encouragement to undertake well-devised schemes of the kind in question, and I learn with satisfaction that your Government have under consideration a legislative enactment for the regulation of loans to municipalities for drainage and other sanitary purposes.

3. It is, however, of no ordinary importance that the schemes undertaken by Indian municipalities should be framed with the strictest attention to sound principles, and with all the light which the latest European experience has thrown upon the theory of sanitation; and with the view of being assisted in judging how far this has been done in the case of the Cawnpore project, I permitted the papers describing it to be placed before Mr. Edwin Chadwick, C.B., who, both while a leading member of the Government Board of Health, and unofficially since, is understood to have made sanitary questions a special study.

4. Mr. Chadwick has, in consequence, favoured me with a very interesting report, 25 printed copies of which are forwarded herewith, and which appears to me well to deserve the attentive consideration of your Excellency's Government. The mode proposed to be adopted at Cawnpore is therein represented to be one which has for some time back been abandoned in England, where it is now said to be considered a mistake to attempt to provide for the discharge of extraordinary rainfalls through sewers, and where glazed pipes of a few inches' diameter are generally admitted to be as superior in efficiency as they are inferior in cost to the old fashioned man-sized brick drains.

5. It is certainly very important to ascertain how far the conclusions suggested by these representations are applicable to India, before any further action is taken in regard to the proposed loan of nearly 27,000*l.* to the municipality of Cawnpore. According to the results which Mr. Chadwick speaks of as having been obtained at Carlisle, it seems not unlikely that, by adoption of the arrangements which he recommends, the drainage of Cawnpore might be effected in the completest manner for less than a third of the sum just named.

Memoranda on the plan and estimate for the drainage of Cawnpore, by Mr. EDWIN CHADWICK, C.B., *late Metropolitan Sanitary Commissioner, and Chief Executive Officer of the first General Board of Health.*

THE plan of the main drainage works of Cawnpore, as it involves a principle of sewerage which may affect all town drainage works, their efficiency, and the means of paying for them, is of very great importance for the whole of India, perhaps as well as for that important city.

For the consideration of this plan of Cawnpore, it is requisite to revert to first general principles of town drainage works, involving two distinct systems. For those who have paid little attention to the subject, an endeavour is made to give concisely results spread over several volumes of sanitary reports.

The general plan is for main sewers, calculated for the removal not alone of ordinary rainfalls, but of extraordinary storm waters, from the whole surface, covered and uncovered, urban and suburban, of the civic area.

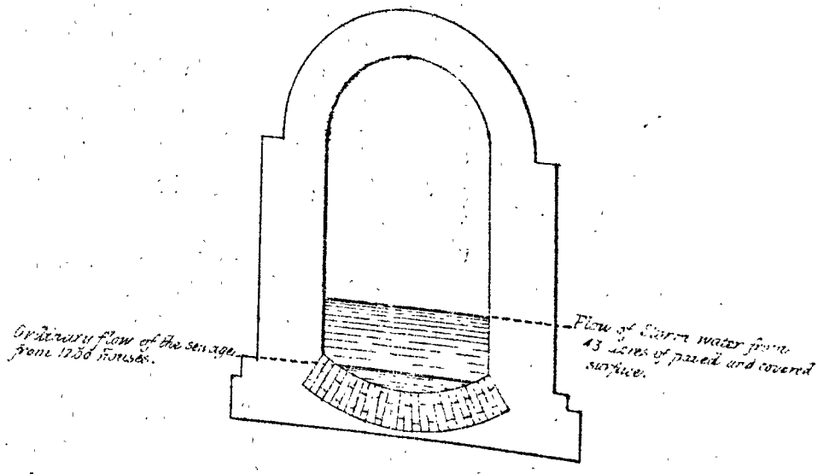
The scheme has probably been laid out from old text books on plans of old town drainage works, or of those of the forms and sizes mostly adopted in London about half a century ago.

The results of the works on this principle were examined by our Metropolitan Sanitary Commission in 1848, when it was found that, at enormous cost, they extensively detained deposit, and engendered noxious decomposition from the excreta intended to be removed.

Being constructed to receive all storm waters, even of such extraordinary storms as occur only once in some twenty years, and having only flat bottoms or very flat segments, the effect was that the ordinary sewerage from the houses, and often even the ordinary rainfall on the street surfaces, formed during the greater part of the year a very small stream, which often did not cover the whole of the surface of the large sewer bottom. The flow of the thin stream spread over the wide surface, was retarded by increased friction, deposit was occasioned, and it went on increasing, until sewers of the largest size were choked up with deposit.

Hence it became necessary for men to enter them periodically, and remove the deposit by hand labour and cartage. The branch as well as the main sewers were also constructed on the scale for the removal of storm waters, and deposit being occasioned in them, they were generally made "man-sized," that men might enter and cleanse them. The products of decomposition of the deposit occasioned in them give off noxious vapours, which enter the houses through the house drains and the streets through the gulley shoots, pollute the air breathed by the population and lower the general health, and aggravate all other causes of excessive mortality.

The following cross section shows the general scheme of these sewers, and what we found to be the ordinary rate of flow of the house sewage proper, and what was the greatest height of storm water, and their consequent excess of construction and cost.

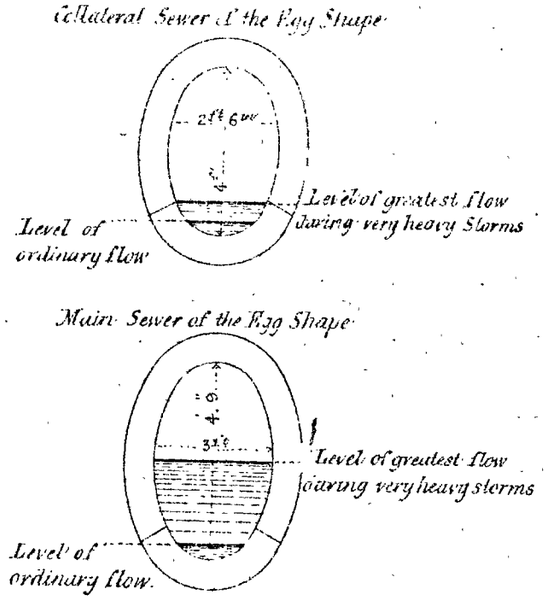


One improvement was made in the egg-shaped form, chiefly to enable the deposit to be removed by flushing with pent up water more easily and less expensively than by the hand labour and cartage required for the cleansing of the flat bottomed sewers of deposit.

This egg-shaped form, as it concentrates small and intermittent flows of water, accumulates less of deposit, than the flat segmented sewers, and is less expensive in material and construction.

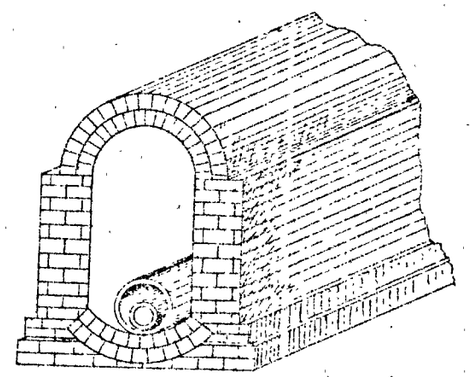
But still they were constructed of excessive sizes, and did regularly accumulate deposit, which is a fundamental default, inasmuch as provision for flushing is, under a good system provided, not for regular cleansing, but only for use to ward off the consequences of accidental stoppages, which will be rare in good constructions.

The following cross sections display the common conditions even of these improved sewers and what, *mutatis mutandis*, may be expected to be the common conditions of the large egg-shaped sewers designed for Cawnpore.



The like errors of form and size attached to the common house drains, made usually of brick, with wide flat bottoms, which occasioned deposit.

Mere reasoning upon the conditions of town sewers as above visibly displayed, did not suffice, and I consequently got trials made of the flow of sewer water in different sized channels, to determine what sizes with what flow of water, would be self-cleansing. The annexed cross section is presented as an example of these trials.



In this sewer, which had a flat segmental bottom three feet wide, and a sectional area of fifteen feet to receive the storm water, and the drainage from one thousand two hundred of the average sized houses in the metropolis, the deposit accumulated at the rate of six thousand cubic feet per

month. But a pipe of fifteen inches in diameter, placed along the bottom of this sewer with a somewhat less inclination (one in one hundred and fifty-three instead of one in one hundred and eighteen) was kept by the accelerated flow perfectly clear of deposit.

The average flow of the sewerage (without rainfall) was about fifty-one gallons per house per diem, and the absolute drainage, apart from the rain water from all the one thousand two hundred houses, would have passed through a five-inch tube of not one-third the relative size of the minimum sized single house drain which had, up to the time of the investigation, and upon advice of professors of architecture, been declared and enacted in the Metropolitan Building Act to be necessary for a single house, namely, one of not less than nine inches in diameter.

The instructions set forth,—

"In all cases of drainage by natural streams, important opportunities will occur to a competent local surveyor for diminishing the friction, and accelerating the discharge of surface water, by straightening and thereby shortening the water courses, as well as by concentrating the flow by the construction of properly formed channels."

I apprehend that the sanitary disaster, as it appears to me to be, from the construction of a large man-sized main sewer at Calcutta will have to be remedied by the application of the principle above described which I beg to illustrate further.

It had been accepted as a rule that no sewer would work with a fall of less than one in three or four hunded, as might well be the case where the sewers were made, as they mostly were, large and wide. But with improved adaptations of sizes to the concentration of the ordinary flow, outfall sewers have been made self-cleansing, with a fall of little more than one in a thousand. Accepting the old practice of Civil Engineers, Captain Denison, of the Royal Engineers, (afterwards Sir William Denison, the Governor of Madras), examined and reported upon the city of Salisbury for the Health of Towns Commission, and gave it up almost in despair on account of the assumed insufficiency of the only fall apparently attainable. But by a better adaptation of the sizes that city has subsequently been drained effectually with self-cleansing house drains as well as main sewers, and the death rates there have been reduced by more than a third.

At a late visit to the camp at Aldershot to see the sewerage farm there, I was enabled at once to pronounce the drainage of the camp to be false in theory and pernicious in result. On being asked why, I ventured to say so without having seen the plan of the works. I stated that I was enabled to say so decidedly by the smell; the smell from the sewerage at the outfall was the smell from decomposition, and decomposition denoted stagnant deposit, and stagnant deposit denoted bad engineering. You may at once and decidedly test all town engineering works by the smell. In the instance of that camp, the mistake had been made of making large sized 18-inch sewers with the view of taking in extraordinary storm water, when 6-inch pipes would have been self-cleansing for all ordinary occasions.

* * * * * * * *

It has been the practice of Civil Engineers and Architects to enlarge the area of any main pipe in proportion to the sectional area of each junction into it, whereas it was found by trial works we got made that the addition of eight junctions, each of three inches in diameter, into a main line of only four inches in diameter, so increased the velocity of the stream that the 4-inch pipe carried it away.

This principle of accelerated velocities with small additional heads of water is of great practical importance, as enabling much ordinary rainfall to be admitted from covered surfaces, the roofs of houses, and paved streets into the sewers primarily adapted to remove the sewerage and waste water from houses, with which alone in dry weather they should be kept sufficiently full to be self-cleansing.

By careful adaptations of sizes, and, in house drainage works, getting improved falls by draining at the back instead of through the houses to the front streets, on a system of combined back drainage works (which would appear to present peculiar advantage for Indian cities) it has been found that three houses might be drained well at an expense heretofore incurred for one.

The difference of system is displayed in the annexed plans.

The late Mr. George Stephenson, the celebrated Railway Engineer, made an estimate for sewers works for the city of Carlisle, on much the same principle as that proposed for Cawnpore,

Proceedings of the Madras Government, Public Works Department, 30th August 1871.

and apparently as those described as adopted for Calcutta. They were all to be large "man-sized" sewers, to be entered and cleansed by hand labour. The estimated expense was 70,000*l.* The city has since been sewered by Mr. Robert Rawlinson, C. B., one of our Inspectors, on correct principles, as laid down by the Metropolitan Sanitary Commission and the General Board of Health, with self-cleansing sewers, at an expense of about 20,000*l.*

It must be observed that there are gross interests on the part of contractors as well as of Civil Engineers in the profits of works on the larger scales, which were cut down by the General Board of Health, which thereby subjected itself to violate organized hostility, and from these interests, which are hardly yet appeased or reconciled to the large economies of the new system or by the new work created by it, requiring a change of practice

In illustration of the principle of concentration, or of the close adaptation of channels for drainage to the ordinary dry weather flows of sewerage, I quote the following passage from an expository paper of mine on land drainage :—

"Near the metropolis there are, besides the common ditches, large open water-courses, which serve to carry away flood waters. When there are no floods, the water in the shallow streams or in threads of water moves sluggishly over the uneven bottoms, or it lodges in stagnant pools in these ditches, giving off offensive and insalubrious effluvia, for many of these ditches are used as outfalls for the drainage of suburban houses, and, with the addition of such house drainage, the effluvia becomes at times highly noxious, and even fatal. The courses of these open water-courses were marked by excessive ravages of the cholera amongst the population living near them."

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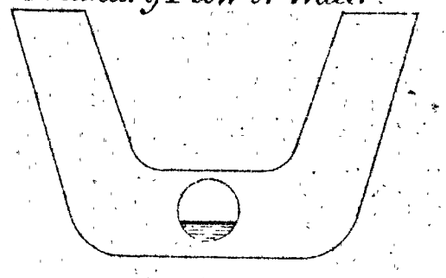
I do not see the exact method recommended for the treatment of the Cawnpore nullah, but it is stated that "its cost alone is estimated at Rupees 45,000, and it is therefore not likely to be made for some time to come." "The Lieutenant Governor does not feel justified in authorizing the expenditure of large sums of money upon what, after all, might fail of success."

Just so! With such works and such expense, that has been precisely the state of things in England, where, however, it has been thus obviated.

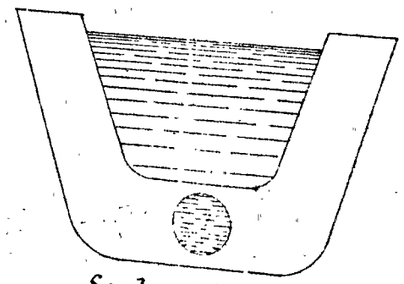
"In some cases the course was taken of laying down tubular drains of about 18 inches in diameter, below the bed of the natural water-course and (leaving openings at intervals for junctions of side drains) covering over the tubular drain. The bed of the stream being re-formed with clay and gravel, so as to form a better channel, such extraordinary flood water as will not pass through the pipe beneath is taken on that bed. In this mode a better fall is got, the flow and the sweep of the water is accelerated, and comparative cleanliness and salubrity is obtained at from one-fourth to one-eighth the expense which would have been required to have covered the culverts of a sufficient capacity for extreme floods. So great is the acceleration of the flow through the pipe in the water courses, that it is only on comparatively rare occasions, perhaps two or three times a year, that there is any overflow above them, and the surfaces usually present the appearance of a dry and narrow road. The cost of the work was from 2*s.* 6*d.* to 4*s.* 6*d.* per foot of run; to have arched over such a stream would have cost vastly more. In some cases the foul water of open streams may be diverted into neighbouring streams, when no further expense need be incurred, except for re-forming the bed of the brook for the conveyance of flood water."

The following transverse sections will illustrate the treatment, the principle of which, it is submitted, might well be made known in India, where it would be extensively applicable.

Ordinary Flow of Water.



Flood



Scale 5 Ft to 1 Inch.

It appears that the area of Cawnpore is about 320 statute acres, and that it is proposed to construct sewers to remove half an inch per hour of rain when the sewers are half full. Now it is confidently averred that any calculations of dimensions and costs of sewers made from such data ought not to be adopted. This would be a preparation for 12 inches of rain in 24 hours; or, if the sewers were to run full, not less than 36 inches of rain in the area drained. It is stated that, at Calcutta, the rainfall is at times a quarter-inch per hour, or six inches per diem. This would be 600 tons on each acre. The Engineer there says that six inches of rain from the surface of Calcutta will be equivalent to a stream of 40 feet wide, eight feet deep, and flowing with a velocity of four feet per second. This is equal to 427,516,000 gallons per day, or nearly double the dry-weather flow of our River Thames at Teddington Lock.* In the way of illustrative contrast with what is chiefly to be dealt with in town sewerage, the waste water, and the matters which it may convey from *within* habitations, it may be mentioned that, when we examined the water supply of London, the quantity pumped in was about forty-four millions of gallons daily. This, if it had been equally distributed, would have given about 13 cwt., or 60 pailsfull to each house, more than half of which we found was wasted. The total supply would have been delivered in a brook nine feet wide and three feet deep, running at the rate of three feet per second, or a little more than two miles per hour during the 24 hours; and for the removal of the same volume of refuse or soil water three sewers of three feet diameter and with the proper fall would suffice. I have not the present population of Calcutta, but I conceive that less than one such sewer would suffice for the similar removal of the house drainage proper there, and so in the proportion of the population and the water supply at Cawnpore.

It follows from the established principles of town drainage in England, that sewers of such capacity as are proposed for India are not required, even taking in roof water, and, if they were required, it is apprehended that very few could be constructed because of the cost.

* To display the reflex opinions of professional men in London to those of the Engineers of Cawnpore and of Calcutta, I would beg to present a portion of my examination of the late Mr. Joseph Gwilt, the author of the Dictionary of Architecture, and at that time the Officer of one of the Metropolitan District Sewers Commissions :—

"*Question.* It appears that there were, in the whole of the metropolis, 270,000 houses. Now, if each house were to have, at the least, a 9-inch drain, as you, and architects in general, recommend, it appears that the area of the stream to keep them full and flowing would be 1,132 feet in width by 105 feet in depth ?—*Answer.* Yes.

"*Q.* It is estimated that a supply of water for the metropolis, supposing each house to have a supply of 125 gallons per diem, or 25 gallons per head, would be given by a circular tunnel or aqueduct 12½ feet in diameter. Can you prove any addition of rain water, or even of extraordinary storm water, requiring a system of drainage of a sectional area more than five times that of the Thames at Waterloo Bridge at high water, or nearly a thousand times the area of the aqueduct that would furnish the whole supply of water to the metropolis ?—*A.* I apprehend that in providing drains for a house, you are to provide against accidents, therefore I should say it would be prudent always to have drains larger than necessary, to guard against stoppages. A stoppage in a small drain stops up the whole orifice. A stoppage in a large one is partial. There may be, most likely, a means of running off in some way or other.

"*Q.* Do you dispute the fact that a 4-inch drain to a house keeps clearer than a 9-inch, and clearer still than a 12-inch ?—*A.* I certainly do dispute it."

The fact, however, was established indisputably, by trial works and by subsequent extensions, very soon, in hundreds of thousands of instances under our regulations.

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In England, rain falls in thunder showers at a rate of one inch in 15 minutes, or four inches have fallen in one hour. Sewers cannot—properly—be constructed in England or in any country to contain heavy falls of rain. Surface water must pass away at and over the surface. This is the first fact any Engineer must now master before he designs main sewers for towns.

In London, rain falls at a rate of about two and three inches per hour in thunder-storms—at times steadily two inches in 24 hours. The new intercepting sewers for the metropolis provide only for quarter inch in 24 hours.

At Alnwick, in Northumberland, the area sewered is upwards of 2,000 acres. The main outlet sewer is 18 inches diameter, with a fall of one in 400. There have been falls of rain in Alnwick since the town was sewered which would have filled a tunnel sewer 20 feet diameter.

This water went as it ever passed over the surface.

It may be confidently averred from the premises that the arrangement proposed for the Cawnpore main sewers ought not to be adopted, and that covered sewers in India should not provide for monsoon floods nor for flood waters caused by rain at any time.

One point of experience in England, in driving large and deep tunnel sewers, devised on the plan in question, through old urban districts, is, I conceive, important to note for India, and that is, that you can hardly ever anticipate what sort of old and tall superstructures you may endanger, or what sort of loose and difficult strata, heretofore disturbed, you may have to encounter, and, consequently, that with such work you can never rely on your estimates. Of this an instance was presented at Westminster, not far from the India Office. When I was at the Metropolitan Commission of Sewers, I got a plan made for the new sewerage of the whole of Westminster proper, with self-cleansing tubular sewers 16 miles in length, which was to cost about a thousand pounds per mile. For the sewerage of the new wide street, Victoria Street, and Parliament Street, to beyond Whitehall, two—nine inch if I remember rightly—tubular pipes were provided to be laid down one under each foot pavement, to save the expense of carrying all the drains to one sewer under the distant centre of the streets. And these two pipe sewers would have accomplished everything wanted, and endangered nothing. We were compelled, by the pressure of an epidemic visitation, to leave that commission, and to confine our work to the severe duties of the General Board of Health. The work of the Metropolitan Sewers Commission was charged upon some eminent Civil Engineers, in the reliance that they would follow out the new system. But they reverted to the old one, and directed a large man-sized tunnel sewer to be constructed for Victoria Street down to Whitehall Yard, about a mile, at an estimated expense of 14,000*l.* When this sewer arrived amidst the old buildings at Whitehall, my friend, the Comptroller of the Exchequer, came to me in great alarm at finding the walls of his office beginning to crack, and the doors not to shut, from an increasing settlement. There was nothing for it but to prop up that and other old buildings which suffered serious damage. Midway of the deep cutting, however, a very loose slippery sand was encountered, on which it was extremely difficult to get a foundation. The total cost of this work has been little under 150,000*l.*, with the result of a large noxious sewer of deposit, which is little else than an extended cesspool. To avoid the danger of deep cuttings in old districts, if one pipe sewer near the surface does not suffice, it will frequently be safer to have two, even in narrow streets.

On the more general question, the Engineers should be required to consider that the purpose is not mere discharge of the surface rainfall in an acre of land, the greater part of it uncovered by houses or paved surface. If the object were the drainage of uncovered lands, it would then, under proper treatment, be by drainage *through* the lands by subsoil drains, instead of *over* the lands or by surface by channels merely to convey the surface washings by rains, which carry away with them manure as well as the finer portions of the soil. By the removal of the rainfall from uncovered garden or agricultural land through subsoil drains the discharge is largely modified, requiring corresponding modifications in the way of reduction of the sizes of the trunk and tributary channels. The later established doctrine of town drainage has been formularized, as "the rainfall to the river, the sewerage to the land," including, however, in the sewerage, some of the ordinary rainfall on streets and roofs, in which special rainfall imbibes—in the soot and dung on roofs and on the

streets—often as much good manurial matter as is obtained in the waste water discharged from within the houses. The treatment in respect to these covered spaces is, not to provide for the overflow of the tails of storms, when the surface washing has been pretty complete and the discharge is chiefly of very clear rainfall.

In other respects, the Engineer should be instructed that the *objective* point in town drainage is the discharge of the waste and foul water from *within* the houses during dry weather, with the addition of any ordinary surface washing of the roofs and streets by ordinary, and not extraordinary rainfall; and that he should carefully observe what that actually is, in fair specimen districts, or in any model district, and adapt his channels to that, holding him responsible for the result that every channel shall be self-cleansing; and that all stagnancy and all smell from decomposition means default on his part. His duty is to ensure that all foul or waste water, all excretory matter thereon that can be removed on suspension in water,—and no modes of removal are so cheap or so good,—shall be removed from within houses or the sites of towns before it can enter into advanced or noxious stages of decomposition. In this respect, the merits of his plan, as before instanced, may really be tested by the smell, which any civil superior may do. One mode of testing the complete drainage work of a town is this. Some substance, which can be distinguished, of the specific gravity of water,—in England a split turnip serves,—is taken and pieces are put into one or two of the water-closets at the head of the district drained (when all the house drains and service are on), and timed when let go, and watched for at the outfall, and the time of their arrival noted, and the plan judged of accordingly. If the pieces do not arrive, there is stoppage and defect somewhere, which has to be removed at the cost of the contractor.

To illustrate the difference of systems, I may mention that I have inspected the outfalls of the old sewers of the metropolis and of several cities in England, and I never saw fæces in form or any paper discharged from them. What you saw discharged was a chocolate-coloured stream. This was overflow matter disintegrated by decomposition whilst detained in cesspools, or in drains of deposits, or in sewers of deposit, putrid sewage, in fact, which kills fish. On the change of system in towns newly sewered with self-cleansing sewers, the people were surprised and disgusted at seeing the abundant continuous discharge of fæces in form and paper. The *fresh* sewerage feeds fish, and anglers get their best sport at the sewer mouths of the newly drained towns. It is now, however, being found that a better use may be made of this fresh sewerage than feeding fish with it. Its manurial powers are, of course, greater than putrid sewerage, and in its fresh application, properly and immediately, before advanced stages of decomposition can set in, it is free from noxious emanation and danger. The vegetation produced by it is of extraordinary superior quality, some farmers, regarding the profit of the produce, have called the paper *bank notes*. When successfully applied it will certainly surprise the Natives.

In the towns where the drainage work is according to principle and complete, at Bedford, for example, the excretory matter will be on the land in less than an hour or two. At Cawnpore, all the manurial matter of the morning ought to be on the land, not in mechanical suspension, but in chemical combination, before the afternoon; and if actual working examples in England be duly examined, it may be seen how this may be done.

But the most full reports with varied illustrations make but little way in England without the sight of actual works. On the Metropolitan Commission of Sewers we could only make way with the improved new system of combined back self-cleaning house drainage and self-cleaning sewers when we had got some blocks of buildings drained upon the system as trial works. We allowed several officers to try and show what they could do with different blocks.

We first got well drained the block of buildings comprising the Cloister at Westminster where there had been a severe epidemic, then some blocks of buildings in the worst conditioned neighbourhoods, which served to instruct workmen as well as others with the new system. This course is suggested as a future expedient for Indian cities. It would be to take some available street or a Government block of buildings for the purpose, to carry a constant supply of water into them to put in soil-pans, perhaps on the Turkish principle, and lay down drains to be made self-cleansing. This would serve to familiarise the Natives with the work, and enable the Engineer to see the better

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what was to be done for the general extension of the system, and enable contracts to be made when well observed results have been obtained.

It is to be repeated that the *house*, which is commonly the last thing that has hitherto been regarded, ought to be the first to be studied for efficient sanitation. In England vast expense has been incurred by driving even well formed sewers through streets without regard to house junctions or providing for them; excellent tubular pipe sewers have failed and have accumulated deposit like the large old brick sewers from only a small part of the houses for which they were intended being joined on to them, giving scarcely more of sewerage than sufficed to wet a long line and occasion deposit in consequence of the disproportionate amount of friction. This default of house junctions arose from an administrative default of which it is important to be aware,—of requiring poor owners, or poor occupiers of poor tenements, to undertake, or to pay the whole amount for the entire house drainage works at once,—an immediate outlay of four or five pounds at least, instead of doing the work for him at the lowest contract prices, and requiring repayment only by equal annual instalments of principal and interest, say of four shillings a year, payable quarterly, for the fresh water supply constantly carried into his house, and for the waste water and everything being constantly carried away from it. The Engineer, if he does his duty to the Administration, will give a greater water service for the house at a lower price than that of the cheapest water carrier.

When the Officiating Chief Engineer of the North-Western Provinces states, in his notes on the drainage of Cawnpore, that "this question of the drainage and sewerage of towns is confessedly very difficult; indeed, it is not yet satisfactorily solved anywhere;* he must be understood to mean that it is very difficult in the present state of knowledge in India; that he has seen no reports or instructions there sufficiently elucidating it, and that it is not yet solved anywhere in India. That such a statement should be made, and the conflicts of opinion occur as displayed in the papers on the drainage of Cawnpore, shows that the instructions of the Sanitary Commissioners on this subject are insufficient, and that more precise and full information, with varied detailed illustrations, are now required, as indeed will be evident from other papers from India.

I would submit, in this very example of Cawnpore, that it would save vast waste in useless outlays in India if the latest examples of the solution of the difficulty in England were carefully examined and put in form for the instruction of officers charged with the planning and execution of sanitary works in India.

The instructional papers which I prepared with the aid of the Special Engineering Staff of the General Board of Health for the information of local authorities in England, on the drainage of lands and of houses and towns and on the application to agricultural produce of sewerage, and which have been accepted as text books,—are now out of print, and copies fetch high prices. I have visited several places where new works, on the principles set forth, have been got in complete action to show them to officers in the Indian service. On such occasions I have put to Engineers,

* I observe that the dry earth closet system, that is to say, the system of preparing the soil and taking it to the houses to receive the smaller part of house sewerage, etc., the fæces and the urine, in place of taking all the sewerage, soap suds, slops, etc., at once to the land, is favourably regarded by some people in India, not only for detached houses, but for contiguous houses and whole districts. Independent testimony displays the errors committed in respect to that contrivance. The reports I have seen are unfavourable. Unless great care be taken, which it never is, it becomes a nuisance. The manurial assimilation with the soil is imperfect. As much water is often wanted to cleanse the places properly as would serve to work a watercloset, and the whole process is dearer than a proper soil pan or watercloset apparatus. I was recently asked by an officer from the Colonial Department, whether I could suggest any remedy for a difficulty that had arisen from the use of the dry earth closets in the West Indies where it had been introduced in some places. The dry earth was found to be a convenient nest or feeding place for some flying insects which bit ferociously and painfully, and which could not be safely approached uncovered. Could not the earth be prepared in some way? I was asked to make it repulsive to the unpleasant and dangerous intruders. I had no other suggestion to give than that of drowning them and the nest too, by the application of water, *i. e.*, by a recourse to the watercloset principles. In fact, for detached cottages out of the way of any town water supply, or any proper system of house drainage, and where the Levitical provision is expedient, the best and cheapest method is the use of a pail containing the waste water and slops of the cottage, which the cottager should be instructed to remove *daily*, and empty into a trench in the garden prepared for its reception as manure, to be immediately covered over by soil, is the most advantageous manurial and sanitary process. You get a larger quantity of manure more readily and completely assimilated.

or to intelligent officers in charge of the works, questions to this effect: "Suppose these works were to be done over again, on your experience of their working, what alterations would you make in any, and what part of them?"

Different local Engineers have applied the same principles, with deviations of their own which I must say have, as respects the scales generally, proved to be in error, but such questions do frequently elicit suggestions of modifications in details which the practical Engineer would appreciate as of great importance.

I should be most happy to aid any Indian officers in such a work. Indian Sanitary Officers have of themselves visited some of the towns where new works have been got into action, but their reports, it may be shown, are of little or of inferior practical value, from their not having distinct perceptions of principle, or the chief objective points of attention.

Economy for sanitary works in India is, I apprehend, of greater importance for their adoption and extension there, even than the poorer urban districts of England. It has proved here very up-hill work to press economy for this purpose against "brick and mortar interests" and professional inertia, and convenience in current practice with common ascertained materials and prices in settled price books.

The Romans distributed, as Columella states, water into towns and houses with earthen pipes under a 100 feet of pressure.

For the sake of economy, I got some trials made of the strongest earthenware pipes that could be obtained, but it was reported that they did not succeed. However, I have learned that in thirty towns in France water is distributed in earthern pipes, in instances where it is required at 160 feet of pressure, at one-half the price there of iron pipes. I submit that, for the sake of economy in India, it would be of importance to have those examples carefully examined.

As one means of economy, I also got trials made of concrete for sewers and drains, but it was reported that concrete would not answer. I was not then sufficiently acquainted with concretes to enable me to judge of the sufficiency of the trials, but now it appears that concretes made with Portland cement do answer well for sewers in France, Holland, and Germany, where there use is extending. A trial has indeed been made, under the Metropolitan Board of Works, of concrete for some sewers; and the Engineer informs me that he makes superior work with it at one-third less expense than brick-work; and that it might, indeed, be further cheapened. But in the north of France and some parts of Germany, I learn that concrete with Portland cement in large proportions of one in three, and even of one in two of cement, has been used successfully for the conveyance of water into towns and houses, in one instance, it is stated, under a pressure of 200 feet, and with great economy, and with some special advantages over other materials.

How far these means may be made available for India, with economy—whether Portland cement, which is now being sent there in increasing proportions, may be made there with advantage,—are, I submit, important topics for inquiry. I cannot but believe that the materials, chalk or lime, of the right quality, and clay, with fuel, may be found, if sought for, in India, and the excessive cost of transport from England avoided.

It may be confidently anticipated that, by one means or other, the expense of sanitary works for the Indian cities may be greatly reduced.

With a view of giving some proximate notion, though a wide one, of the expense of complete sanitary works executed in England on the new system, it may be stated that a constant supply of water, of 100 gallons per diem, is carried to the door of every house for about 1½*d* per week, and that the waste water is carried away for about another 1½*d* per week, whilst the internal works, to be paid for by private improvement rates, including the supply water pipe to the sink, to the soil pan, and the seat, and the drains for the discharge of all waste water and the excretory matter from the closet, are defrayed by another penny per week, or a total expense of threepence halfpenny per week, or a halfpenny per day to all houses.

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The houses of the middle classes or the higher classes, which have several closets, will pay in proportion.

What difference might be made by the different prices of labour and materials in India I have no means of judging.

I beg to be allowed the opportunity of stating that the general result of these rudimentary sanitary works, when got into complete action, is a reduction of the common death-rates by about one-third,—leaving much still to do. In that old city of Salisbury which I have mentioned, as having been at first thought a case beyond sanitary cure, the old death-rate had been about 40 in 1,000. By better water supply and other works, it was reduced to a fluctuating rate of from 26 to 28 in 1,000. But by the complete self-cleansing house drains and sewers, the fluctuation is brought down to from 15 to 17 per 1,000. The general sanitary data are now so far established that a great contractor or a contracting company would be warranted, and would profit in contracting for results upon payment of the existing private and public expenses of insanitary conditions. The data are most clearly distinguishable in public institutions. Thus, in an orphan asylum for boys where the death-rate had been 12 in 1,000, water-closets and self-cleansing drainage was introduced, and it was reduced to 8 in 1,000; then, by further improved ventilation and by regular application of the water supply to complete personal ablution, it was reduced to about three in a thousand, the death-rate amongst the children of the same ages outside remaining at 10 and 11 per 1,000. Indeed, in one district half-time schools, orphan schools, the "children's diseases," of spontaneous origin may be said to be positively banished, and the sickness and death-rates are reduced to one-third of those regularly prevalent amongst the children of the outside population. Good returns of sickness now denote defaults with certainty to those who understand them. There is a sudden outbreak of dysentery in a prison. But dysentry is regularly and severely prevalent amongst the outside population, it is first observed in excuse? That may be, but it ought not to be in the prison! On sending to enquire, it is found out that by reason of some clumsy work, the prison drain had leaked into the well which supplied the prisoners. A severe outbreak of fever takes place in a a women's lying-in ward; there must be some default with some one? On investigation, it appears that an old stagnant ditch a short distance from the ward has been emptied, and that the stuped men have spread the putrid contents over the ground on either side, so that the noxious evaporation has reached the inmates. We get no such protection for private houses, except common lodging houses. The papers in relation to Cawnpore do not enable me to judge in respect to it, but I conceive that, as a rule, complete sanitary works for Indian cities will need more than in England a wide basis of subsoil drainage and culture of suburban and adjacent land. It appears to me that two-storied barracks have been somewhat indiscriminately constructed to lift the sleepers in them above ground miasma at an expense, which good subsoil drainage (costing in England 5*l* per acre) would remove. Of sanitary work applicable to India, I got Lord de Grey, when he was at the War Office, to direct the examination of one example presented in Algeria, of which I had been informed by French sanitary authorities. It was visited and examined by one of our former inspectors, Dr. Sutherland, now of the Army Sanitary Commission; by Mr. Robert Ellis, C. B., late President of the Sanitary Commission of Madras (he who set Masulipatam to rights after it had been overwhelmed by the cyclone,) and by Colonel Ewart, R. E. On a tract of somewhat wet land, which it had been deemed necessary to occupy for strategical purposes, the old Indian Army death-rates of 80 in 1,000, and more, had prevailed amongst the troops, and the loss was most severe. Colonization and culture was attempted, but three sets of colonists were cleared away; the death-rates amongst the children greatly exceeded the birth-rates, and succession from the colonists was impossible. But by getting a good water supply and good drainage works, and putting the habitations in a good sanitary condition, and by the drainage and cultivation of the surrounding land, taking sanitary precautions which protected the labourers, on opening up the land, and other sanitary attentions the death-rate amongst the soldiers was reduced from the old Indian death-rate to below the most recent one (20 in a 1,000) to 12 in 1,000. Amongst the civil population the death-rates have been equally reduced; but above all, for settlement, the death-

rates amongst the children have been greatly reduced below the birth-rates, and the examiners found on the site a crop of ruddy children, as healthy as the average of children in France. Mr. Ellis, to whose special Indian sanitary experience and success much weight is to be attached, declared that the principles of the Algerian sanitary works were practically applicable to Indian.

EAST SHEEN, SURREY,
April 4th, 1871.

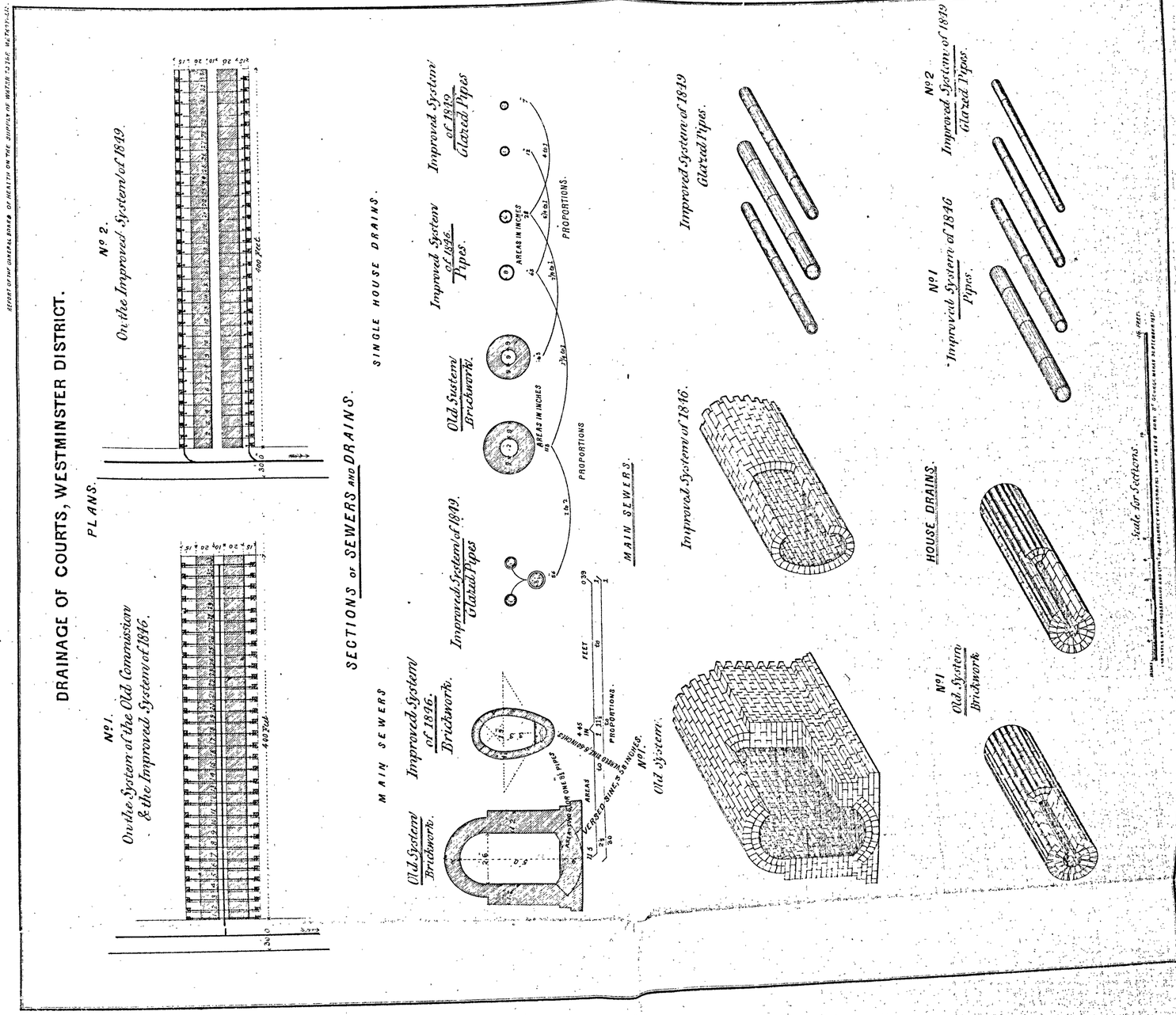
(Signed) EDWIN CHADWICK.

OBSERVATIONS.—The remarks of Mr. Chadwick, so far as they criticise the scheme for the drainage of Cawnpore, appear to be based on a misconception of facts, as the project which is in hand makes, it is believed, no provision whatever for house sewage, but the paper enunciates general principles, and gives various information, which may be of much practical utility.

ORDER.—Ordered, therefore, that a copy of the despatch with its enclosures be forwarded to the Government of the North-Western Provinces in the Public Works Department for special report, and to the Local Governments and Administrations in the Public Works Department noted on the margin, for information.

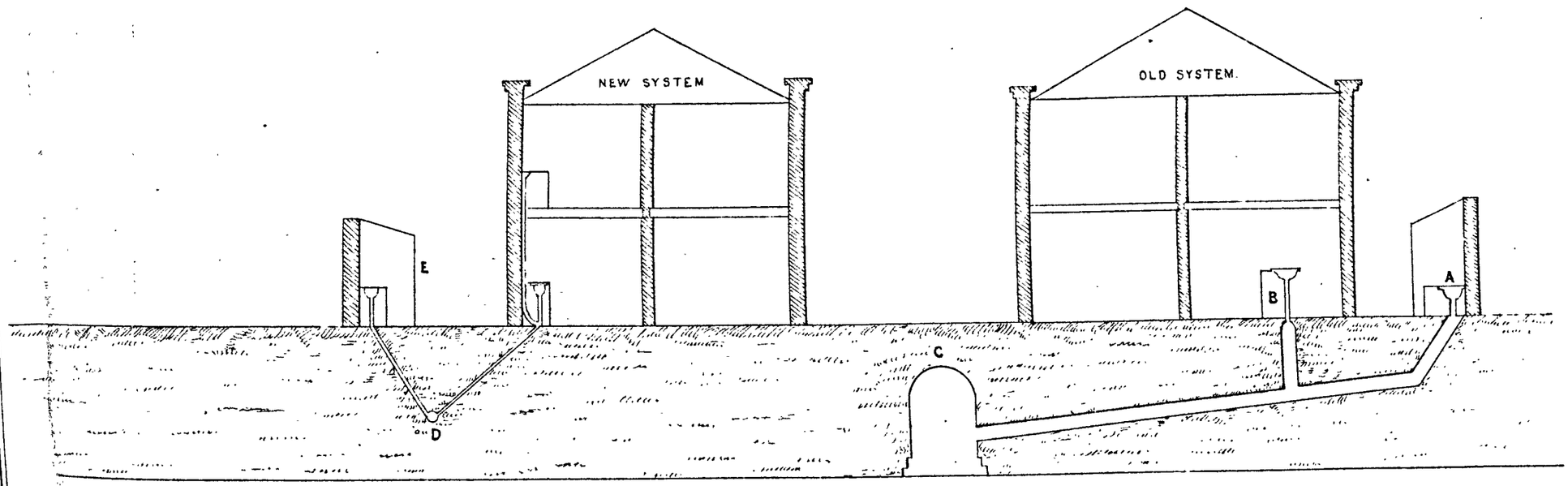
Madras, Bombay, Bengal, Punjab, Oudh, Central Provinces, British Burmah, Mysore, Central India, Rajpootana, Hyderabad, Port Blair.

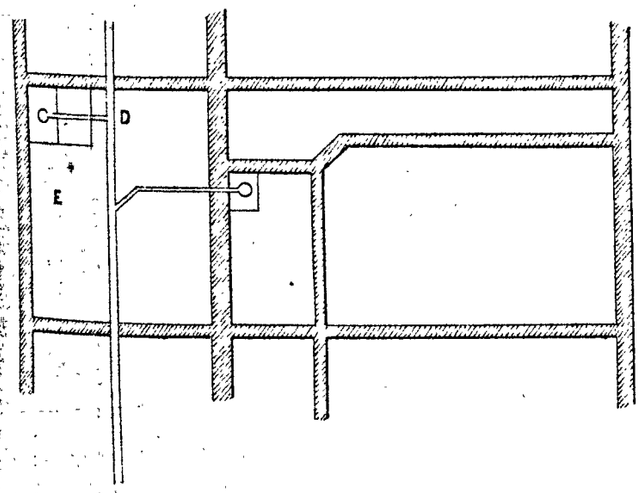
(Signed) R. B. PEMBERTON, Captain, R.E.,
Asstt. Secretary to the Govt. of India.

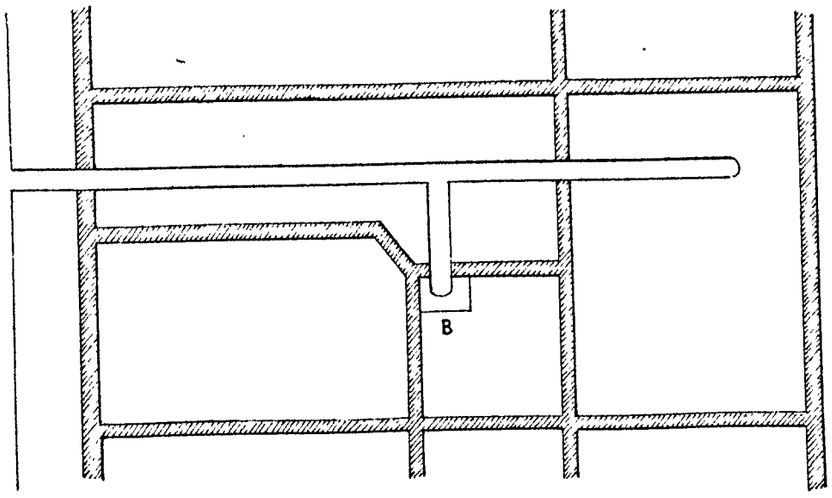


PLANS AND TRANSVERSE SECTIONS SHEWING THE RELATIVE FRICTIONAL AREAS OF THE SELF CLEANSING NEW SYSTEM

AS COMPARED WITH THE OLD SYSTEM OF HOUSE DRAINS IN LONDON.







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Proceedings of the Madras Government, Public Works Department,
30th August 1871.

No. 409. ORDER THEREON, 30th August 1871, No. 2,217.

CIVIL WORKS, No. 15.

COMMUNICATED to the Superintending Engineers.

(True Extract.)

Captain, R.E.,
Under Secretary to Government.

To Superintending Engineers.
,, Major R. B. Kennedy.
To the Public Department.

Exd. S. T. Augustin.

Public Works 1871 Department

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

BUILDINGS & ROADS.

Miscellaneous.

No. 3620

To

Nos. 223—35 B—C.

Dated Simla, 6th July 1871.

Received 28th July

Enclosures Two, viz

Drainage of the city of Cawnpoor.

No 2217. 30th August 71

In the order

No 3620

Govt of 1871 Madras.

PUBLIC WORKS.

To The Superintending Engineer

Dated

Recd. 2

G. O 30 Aug 71, No 2217.

A

Nos. 408 & 409

Drainage of the city of Cawnpore.

Ref. the papers herewith forwarded for information
papers relating to a scheme
for the drainage of the
city of Cawnpore, Com.
& the Inspg. Engr.