

I have the honor to be

P.W.C. 127/14

18TH MARCH 1882, No. 303, FINANCIAL.

GOVERNMENT OF MADRAS.
FINANCIAL DEPARTMENT.

READ—again the following G.O., dated 13th October 1881, No. 1392, Public:—

ABSTRACT.—Letter from the Sanitary Commissioner forwarding abstract return of births and deaths in the districts and Municipalities of this Presidency for the month of June 1881 communicated, and an extract therefrom, together with the returns, ordered to be published in the *Fort St. George Gazette*.

READ—again the following G.O., dated 18th November 1881, No. 2262, Financial:—

ABSTRACT.—Forwarding for consideration copy of Despatch from Secretary of State and Memorandum by the Army Sanitary Commission on the Report of the Madras Municipality for 1879.

ENCLOSURE.

Extract from Memorandum of the Army Sanitary Commission on the Report of the Madras Municipality for 1879.

7. The Vice-President, Mr. Jones, proposes as an alternative to carry out the drainage of Madras on the following principles:—

“To provide open sewers along the streets for surface water, house drainage, &c.

“To provide sewers in valleys and other necessary places to carry off the sewage alone, any storm-waters being divided from it and carried to other outlets.

“To improve the present sewers, to make them more efficient for the carrying off the storm and subsoil waters.

“To pump the sewage collected and place it on land at some distance to the north of the town.

“In addition to this, the house-to-house collection of night-soil and other conservancy arrangements hereafter detailed should make a marked improvement in the health of the town.”

It will be seen that there is nothing effectual proposed to be done for the foul subsoil and its results, as described by the late Mr. Gover in his report for 1871-72, which may be described as by far the best sanitary report ever drawn up for Madras town. Mr. Gover's statement, if correct, would show that the proposed surface drainage scheme would not remove the evil, and we have frequently insisted on this. Mr. Jones quotes our last statement of the case and meets it by the following reply: “The subsoil of the city is not in the state described by the late Mr. Gover; no doubt Mr. Gover believed that he had reasons for making the remarks he did, but these were really without any foundation whatever, and what he took for ‘subsoil,’ saturated with sewage, is, what can be found all over Madras, nothing less than black sand mixed with a little clay, the sand being so fine as to have the character of tin sand. The subsoil is remarkably little polluted.”

8. It may be conceded that in a city spread over so large an area as Madras the subsoil condition may vary, and Mr. Jones admits some degree of pollution as general, although it would have been better to have met Mr. Gover's statement by a set of soil analyses at different points. The questions at issue all relate to *unhealthy districts* of Madras, and, after having stated what Mr. Jones says, we may be permitted to quote the following passage from Mr. Gover's report: “Exhalations from sewage poison the air, downward percolation of sewage poisons the water. It will be almost incredible to those at a distance, yet the fact remains that large and populous portions of Madras have absolutely no drainage at all. There are nearly 70,000 persons dwelling

in the parcheries of Madras, and I believe I am correct in saying that there was not a drain in any one of them. The excavations for the waterworks reveal very strikingly the evils of downward percolation of the sewage both where there are no drains and where there are. Mr. Woolley, the contractor for the works, has drawn my special attention to the fact that, in the more densely-peopled and old localities, he frequently suffers great inconvenience through the soil being saturated with filth; that the workmen exhibit great disinclination to continue their labor: in some places the soil has been found as black as ink to a depth of eight or ten feet—as black, to use Mr. Woolley's expression, as tin sand. I have seen excavations made for other purposes in Chintadrepetta, where the same blackness was observed for several feet down. Now, it is very evident that the earth does not retain this sewage as a well-corked bottle might retain wine. The sewage with which the ground is thus saturated is constantly undergoing physical changes. Poisonous gases from it perpetually rise through the upper stratum of earth; poisonous washings continually descend into the lower stratum of water, defiling every well. Discoloration of the soil in this way is palpable evidence that there is real danger to those who live above the polluted ground—a danger which shows itself in perennial fevers, frequent epidemic outbreaks, and a general debility of intellect and physique among the people. It seems absurd to say more on a subject that so publicly and loudly calls for attention."

9. Where there is such diversity of view and of sanitary estimate between two officers of the same Municipality, it is not for us to decide who is right or who is wrong. What we have to do is with the facts. If the subsoil of Madras is not polluted by filth, it must be a very happy exception to the general experience of mankind, and all outlay for drainage of any kind must be waste so far as health is concerned. Unless it is shown that the blackness, as of "tin sand," is not due to sewage but to the nature of the sand, the fact, as stated both by the late Mr. Gover and by Mr. Jones, must be accepted as proof of a dangerous condition of the subsoil. That there are odours from it, no one can deny. That there are violent epidemics among the poor people living over it is shown year by year in the death returns, and last year's Madras Report (1878) shows, by the infallible well-water test, that Mr. Gover's statements were correct. The analysis is here reproduced—one out of several. It is in Old Jail Street at the barracks—

	Grains per Gallon.
Total solids	14.70
Volatile	7.00
Chloride of sodium	4.69
Free ammonia	.01120
Albumenoid ammonia	.03360
Nitric acid	.06300

It is simply sand water highly charged with sewage. We must here leave the case with one remark, that, useful as a good system of impervious surface drainage may be, Mr. Jones has by no means shown that it is the only kind of drainage required for improving the health of Madras, and, to aid in the further discussion and understanding of the questions at issue, we would beg to refer to Captain Galton's report on the drainage of Memphis, United States, sent to the India Office for information in India, as indicating the methods considered to be necessary for improving a city subject, in time past, to great epidemics by authorities on the spot amply able to deal with the question.

10. It is satisfactory to be informed that the Municipal authorities of Madras still hope to drain the city, and we have said sufficient to show that the surface drainage scheme need not stand in the way of proceeding with the complete drainage of every house. An obvious requirement of both schemes is more water. Without it underground drains would not work and surface sewage drains would become offensive. But, whenever water is laid on, it must be kept out of the subsoil, and, if the surface drains are not kept sound and in good working condition, the last end may be worse than the beginning.

11. In the present state of the drainage question it is unnecessary to discuss the remaining principles, but it may be suggested that whatever outlay may be incurred in giving effect to them should be so applied that when Madras is effectually drained it may be found that the works can all be included in the completed scheme.

We may, however, call attention to the general principles of Indian drainage long ago laid down by us, and which we are glad to see have been practically carried out at Memphis, viz., that all the rainfall should be led to outlets by well-formed impervious surface drains and not by underground sewers; that underground sewers and drains should be perfectly tight and restricted solely to the conveyance of house sewage; and that drainage of the subsoil should be separately provided for.

The proposed plan for Madras would provide for the first requirement, but not for the others; and it is intended apparently to leave the subsoil as it is, and to remove the solid house sewage by hand labor, and to provide for this work by a more effective organization than at present exists.

READ—also the following Despatch from the Most Honorable the MARQUIS OF HARTINGTON, Secretary of State for India, to His Excellency the Honorable the Governor in Council, Fort St. George, dated India Office, London, 27th October 1881, No. 25 (Statistics and Commerce):—

I have given instructions for the transmission, through the Stores Department, of seventy copies of the accompanying report, by Captain Galton, on the drainage of Memphis, in the United States of America.

2. I request that your Excellency will cause the necessary measures to be taken for the circulation of the copies of this report to the best advantage.

ENCLOSURE.

Drainage of Memphis (Tennessee), in the United States of America, by Captain Douglas Galton, dated April 1881.

In consequence of the numerous cases mentioned in the Sanitary Reports for India in which it appeared that economical systems for drainage are urgently required in that country, I was led, whilst in the United States last autumn, to investigate the arrangements which have been adopted at Memphis (Tennessee), where the conditions of the town appeared to present some similarity to those of many Indian towns, viz., the absence of sanitary precautions in the face of a high temperature, and a long period of dry weather, during the summer months; combined with a low financial condition of the Municipality.

This latter consideration rendered it imperative that the arrangements which were adopted at Memphis should be largely controlled by considerations of economy. So far as the present limited experience goes, the economical methods adopted have proved efficient.

The main object of furnishing an account of these works is to afford useful matter for the consideration of Engineers engaged in Indian sewerage works, and not with any view of suggesting that the system adopted in Memphis should be blindly followed.

The city of Memphis is situated in latitude 35° 9' N., longitude 90° W.

It stands on the eastern side of the Mississippi river, to the south of its junction with Wolf river. The older part of the town stands next the river, upon a bluff or ridge bounded by a stream called Bayou Gayoso, tributary to Wolf river. The remainder of the town, behind this bluff, is on lower ground, intersected by several streams, which have their origin in springs of pure good water in the country, and which flow into the main bayou above mentioned; and thus the ground on which the town stands is favorably situated as regards surface drainage.

During the short period (little over half a century) of her existence, the city of Memphis has been the theatre of no less than twenty-two epidemic visitations of disease—small-pox, cholera, yellow fever, dengue, erysipelas, puerperal fever. Her annual death-rate, even during non-epidemic years, has rarely fallen below 3.5 per cent., 35 in the 1,000—something more than double the attainable standard of modern cities.

The town had been subjected to visitations of yellow fever in 1867 and 1873. At the beginning of 1878 the city was bankrupt. Its taxable wealth available for the support of the State, county, and city government, which before the Civil War was estimated at \$28,000,000, had been reduced to about \$12,000,000. The population had meanwhile doubled.

Negroes, who, under the system of slavery which prevailed up to the breaking out of the Civil War, had been productive laborers in the cotton fields of the adjoining States, attracted by the excitement it affords, flocked to the city, where at least one-third of them were added to the ranks of the very poor, and either as petty thieves or worthless paupers depredated partly upon the industrious few of their own color, but for the most part upon the thrifty whites. Thus the non-producers, those who consume without laboring, and live without the least regard for the obligations of good citizenship, were increased to the proportions of a small army. The debt amounted to \$5,500,000. The summer of 1878 was intensely hot.

A case of yellow fever was reported to have occurred at New Orleans on the 13th of July 1878. At the beginning of August there were indications, in New Orleans, that the epidemic was likely to be of a very aggravated form. The population of Memphis became seriously alarmed, and quarantine was established round Memphis in the beginning of August.

On the 9th August yellow fever was reported to have broken out at Grenada (Miss.). The first case of yellow fever occurred at Memphis on the 14th August. There were twenty-two cases on the 15th and thirty-three on the 16th. The population of Memphis at that time was between 40,000 and 50,000 inhabitants. More than one-half of this population then took alarm and left the town.

The medical estimate puts the total population which remained during the epidemic at 19,600 and the total sick at 17,600. The deaths were 5,150, a little less than one-third of the whole population. Members of the "Howard Visiting Corps," who have resided in the city

many years and know it well, and whose business during the epidemic it was to visit every ward every day, say that at no time were there more than 20,000 persons in the city, if so many; and that, of these, fully 14,000 were Negroes, leaving only 6,000 white people. Of the 14,000 Negroes, 946 died of the fever, and of the 6,000 whites 4,204 died, being 70 per cent. of the whole number of the whites. Not more than 200 white people escaped the fever, and most of these had suffered from yellow fever in previous epidemics.

The sanitary condition of the city was disgraceful in the extreme. There were no public sewers, and the refuse and filth were delivered into cesspools and private vaults, while not a small portion found its way into the gutters of the public streets, and these during a prolonged dry season became reeking and putrescent, and emitted the foulest odours.

Some years ago many of the streets were paved with wood pavement; this had very much decayed, and readily absorbed some of the liquid filth that flowed over the rotten wooden gutters, and in course of time the streets became so permeated with it that the periodical flushings of rain storms utterly failed to cleanse them. The street surfaces were then the constant source of poisonous exhalations, which none of the inhabitants in the city limits could avoid, as the subsoil was reeking with the offal and excreta of the community.

There was no organized scavenger system, nor any means by which the ashes and garbage could be daily carted away. The foul accumulations of forty years were decaying upon the surface. The Bayou Gayoso, dividing the city, and which was the receptacle of the contents of privies and water-closets, was sluggish and without sufficient current, owing to a want of water and to the fact that there had been scarcely any rain for several weeks. The carcasses of dead animals were decaying in many parts of the city, and pools which had formed at the abutments of the several bridges were stagnant and covered with a scum of putridity, emitting a deadly effluvia. The cellars of the houses in the leading thoroughfares were also alembics, in which were manufactured noxious gases which stole out and made the night air an almost killing poison.

The privy pits in Memphis are so deep as to reach the sand substratum on which rests the great clay bank known as the Chickasaw Bluffs.

Through this sand the water of the river finds its way at every great rise, so that in many places the gradual advance of the Mississippi may be actually gauged by the rise of the excreta, which, when the river falls, are drawn after the water through the soil.

In the early days of Memphis, privy vaults or pits were purposely, and are yet, made deep enough to reach this sand, as a sure means of dispensing with the labor of the night-soiler.

There is an old city ordinance still in operation which was very defective. For instance, it says, whenever a privy vault is filled within three feet of the surface it must be emptied. The result in many instances is, that only enough was taken out to evade the law, although many of the vaults are from fifty to sixty feet deep.

Another plan has been resorted to called "*honey-combing*;" that is, a new pit is dug by the old one, so close that they merge into one. Owing to such a disregard of cleanliness there were privy pits and vaults in Memphis, in which had accumulated excreta, and even kitchen offal, for from ten to forty years.

A general idea of the condition of the houses may be gathered from the description of a detailed examination of one of the blocks of buildings made by the National Board of Health.

"This block contains 202 houses, the average age of which was about 20 years. There were 65 cellars. In 37 of these there was little or no provision for ventilation. Fifty-four of the cellars were damp or wet; the walls in some cases soaked with leakage from privy vaults; in other cases stagnant water, 5 or 6 inches deep, was standing on the floors; in some cases disused cisterns contained foul water. There were 184 privies, of which 32 are in cellars, 48 in the other parts of the houses with vaults beneath; 48 adjoin houses, and the remainder are in the yards, at distances of from 3 to 40 feet from living rooms; 23 houses are without privies, the occupants using a neighbouring one. Of the total number less than 40 are in good sanitary condition. The prevailing evils were deep vaults, full or nearly so; leaky and broken vaults, allowing the contents to soak into the ground; dilapidated sheds, rotten floors and seats, old hogsheads sunk into the ground for vaults, &c.

"Of the yards, 80 were filthy and undrained, containing more or less decomposing organic matter, soaked with stable and cow-shed ooze and faecal matter. Forty-eight of the yards were fairly good, being brick, paved and drained with brick gutters. The drainage was entirely surface. Sixty-four houses had brick drains, of which 24 were in good condition, and 40 foul, broken, and choked up where they run under the houses from the rear to the street gutters in front. The drainage of the remaining 138 lots was either by dirt gullies or left to the natural slope of the ground."

The water-supply of the town was not satisfactory. It was partly derived from cisterns in the houses, partly from a large rain-water reservoir, and partly pumped from Wolf river, and delivered by pipes through hydrants. The cisterns were for the most part built in cellars, and, as a rule, within from eight to twenty feet of the privy vaults. It was estimated that eight out of ten were pervious to water. The soil is of a porous character and seepage is constantly going on, especially in wet weather. Owing to this seepage the vaults and cisterns are brought in communication. So unmistakably is this the case in many cisterns, that the rise or fall in the cistern from seepage equals that in the privy vault.

Owing to the great depth of these privy vaults and the mild winters, the temperature never falls low enough to destroy animal life (*animalculæ*). In summer the temperature cannot be high enough in these vaults to create very rapid changes.

An examination of the water-supply was made in 1879 by the National Board of Health. There were fifty waters examined, of which thirty-six were from sunk cisterns, one from the round tank or reservoir, five from wells, one from Elmwood Creek, six from Wolf river, and one from Mississippi river.

Of the thirty-six cisterns, ten were in sound condition and twenty-six leaked. The waters they contained may be classified as follows:—

—	Good.	Fair.	Bad from foulness of Cistern.	Bad from infiltration of Sewage.
Ten sound cisterns ..	7	3	..	..
Twenty-six leaky cisterns ..	11	3	2	10
	18	6	2	10

These thirty-six were believed to be above the average of Memphis cisterns, as nine of them belonged to the public schools, while not more than a dozen of the samples were sent in by Inspectors, the others having been furnished from the residences of gentlemen who attach importance to the water-supply of their households, and endeavor to keep their cisterns in good condition.

The sample from the tank or rain-water reservoir was good.

Of the wells four were organically pure, and one exceedingly impure, the last showing that a leak in the brick lining of the well may admit of sewage infiltration as readily as one in the brick wall of a cistern. In some of the pure wells the amount of earthy and saline matters was such as to cause a doubt as to their wholesomeness. Of the running waters, that from the creek at Elmwood Cemetery was very impure. A sample from the mouth of Wolf river, taken after recent rains, was exceedingly impure. A sample from the same river furnished by the city supply before rain was also exceedingly impure. Three samples from Wolf river, as stored in cisterns when the river was low and free from turbidity, were of good quality. One sample from Wolf river, at a period of normal flow, when passed through a charcoal filter proved exceedingly pure. One sample of Mississippi river-water, taken after the rains from a point half a mile above the mouth of Wolf river, proved a fair water, being but slightly inferior to that delivered in Washington as the city supply.

After the cessation of the fever in 1878 the city underwent considerable purification. The streets were cleansed, the houses ventilated and exposed to the cold of the winter, and artificial means of disinfection were also applied.

To outside appearance the city thus cleansed would have compared favorably with other cities north and south of it which were free from fever; but the privy pits and vaults, the impure sewers and polluted subsoil and water-supply remained.

In the summer of 1879 there was a fresh outbreak of yellow fever. The first case was reported on the 9th of July. The disease did not become epidemic till about the 10th August.

The estimated population of Memphis at the commencement of this epidemic of 1879, according to the reports of Colonel Cameron, Superintendent of Camps, was 38,400. The greater part of this population, viz., 24,800 persons, were then moved out into camps, situated within five to ten miles of the city, and the population of the city itself was thus reduced to 13,600, of which about two-thirds were blacks. Prompt and active depopulation appears to have prevented a repetition of an epidemic like that of 1878.

The following are the cases reported and the deaths:—

	White.	Colored.	Total.
Cases	853	679	1,532
Deaths	379	106	485

During this epidemic the "National Board of Health" made a survey and report upon Memphis.

The following are the chief recommendations they made:—

1. The systematic opening up and chilling throughout the winter of every house within the city limits, the thorough exposure to sun and air of all textile fabrics, bedding, clothing, carpets, upholstered furniture, &c., the destruction by fire of every article suspected of being infected by exposure to yellow fever during either 1878 or 1879, and of all accumulations of rags, paper stock, and second-hand clothing, the usual contents of junk shops and second-hand stores.

2. The absolute destruction of about 500 specified houses and groups of buildings as unfit for occupancy, and infected beyond the possibility of renovation; the vacation of a still larger number, pending alterations necessary to fit them for healthful occupation; and the passage of an ordinance forbidding the future erection of buildings unprovided with proper means of subvention and other sanitary requirements.

3. A radical change in the water-supply, involving the total abandonment of all existing wells, and many of the underground cisterns, and the substitution of Mississippi river-water for the water of Wolf river, now supplied by the waterworks.

4. An equally radical change in the disposal of excremental and other refuse, and domestic and manufacturing wastes, this to be begun at once by emptying, disinfecting, and filling with dry clean earth all existing privy vaults, and substituting therefor some cheap and convenient form of dry-earth closet.

5. The complete sewerage and subsoil drainage of the town.

6. The reclamation of Bayou Gayoso and its tributaries by the acquisition of the ground on either side for a sufficient space to prevent fouling of the contained waters, and the erection of a dam, with suitable valves and a steam pump, to keep the Mississippi river from flowing up into the town in high water, which at present is a potent source of soil saturation.

As regards the streets, the Board remarked that, with the exception of those devoted to heavy traffic, it was advisable that all streets should be constructed of Paducah gravel, laid on a properly-shaped road bed, after subsoil drains had been established, and that the gutters and curbs should be made of concrete. And they added that few places possessed greater natural advantages than the city of Memphis for drainage, removal of excrement, garbage, &c., to secure that healthfulness so necessary to commercial prosperity; and that by carrying out the above recommendations and by availing itself fully of what was then known as the causes of disease in excess, and the methods of avoiding or destroying those causes, Memphis might soon become one of the healthiest cities in the valley of the Mississippi.

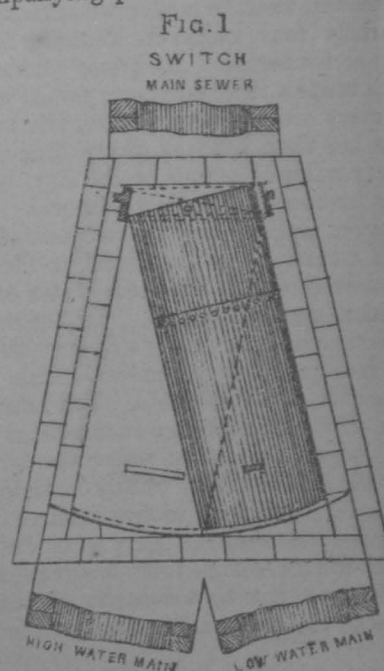
The Municipal authorities set to work immediately after the epidemic of 1879 to remove the sources of impurity pointed out by the National Board of Health.

They obtained plans for the drainage of the town, but those drawn up upon the ordinary systems of town sewerage were estimated to cost from 300,000% to 600,000%. In the bankrupt condition in which Memphis found itself, expense was a material consideration. Under these circumstances, Colonel Waring, of Newport (Rhode Island), the well-known Sanitary Engineer, proposed that, under the special circumstances of the configuration of the town of Memphis, the sewers should be constructed for sewage water alone, rigidly excluding all surface and subsoil drainage, the amount of water necessary to furnish conveyance for such solid matter as enters the sewers being introduced from another source.

The system he proposed was estimated to cost about 50,000% only.

This estimate included not only the cost of a sewerage system but also other sanitary work; the laying of about forty miles of subsoil drainage, and also the reclamation of the bayou, by shutting out the high water of the Mississippi by means of a dam with proper valves, and a steam pump to pump out the bayou during the period when the level of the river was high.

The accompanying plan shows the general arrangement of the sewers. (See map.)



The new system has an outlet through a large iron pipe draining the county jail, which delivers into Wolf river. This outlet is to be used permanently only during high stages of the river, when the backwater in the long permanent main would cause a liability to deposit. The permanent main discharges below low water into the Mississippi river, at the foot of Winchester Street, south of the mouth of Wolf river. Its lower end is of cast-iron pipe, with lead joints, and so much of it as is made in high and dry ground is of brick. Its diameter is twenty inches. The flow can be turned at pleasure into the jail sewer or into the permanent main by a swinging section of pipe or switch working in a brick chamber. (See sketch, Fig. 1.) The twenty-inch brick main continues as far up as Jackson Street; here it is forked to receive a twelve-inch vitrified pipe main running along the east side of the bayou, and a fifteen-inch vitrified pipe main west of the bayou.

The extension of these mains beyond Gayoso Street and a few sub-main branches are of smaller pipe. There are man-holes along these main lines, by which their working may

be inspected. These two mains (twelve-inch and fifteen-inch) constitute the outlet channels for the whole area of the city, the lateral sewers entering on courses oblique to the direction of the flow, so that the discharge of each lateral, having considerable velocity from its rapid descent, will increase rather than retard the velocity of the current in the main, which it was necessary to lay with a comparatively slight fall, that of the fifteen-inch pipe being only two inches in 100 feet.

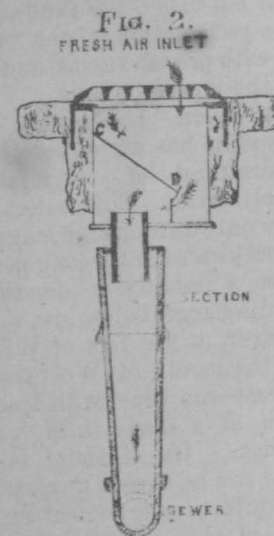
The lateral sewers are almost invariably six inches in diameter. In rare cases, where they serve as the outlets for more than 3,000 feet in length, they are increased to eight inches.

So far as the conformation of the ground and the division of property would admit, they have been laid in the alleys and not in the streets, thus affording direct communication with the backs of houses, and avoiding the necessity for carrying house drains under the buildings, the plumbing appliances of houses at Memphis being almost universally at the rear. In some cases the lots do not run through to the alley, and to accommodate houses so situated subordinate sewers have been laid in the streets, these being, where only one or two houses are to be accommodated, only four inches in diameter.

The sewers were laid on an average about 6½ feet below the surface; as but few buildings had cellars, this depth was amply sufficient. In some cases, as at street crossings, where the sewer came so near the surface as to endanger the crushing in of the vitrified pipe sewer at times when the ground is very soft, a few lengths of iron pipe were used.

At every point along each line where it is at all likely that at any future time a house may be built, an oblique junction piece is built in with the sewer, its mouth being temporarily closed. Wherever a house is now standing, in order to protect the sewer from injury at the hands of careless workmen, to avoid the necessity for digging up the street, and to make the connection less costly to the householder, a four-inch branch is carried up to the lot line at a depth of three feet below the surface of the ground, which in that climate is a sufficient depth to protect house drains, as there is little frost. By this arrangement the householder, in making his connection, finds the public sewer connection at the limit of his own property. It has been the custom heretofore to make the connection between the house drain and the sewer by a branch piece of the same diameter as the house drain, entering the sewer above its bottom and below its top. The house-connection branches used in Memphis are funnel-shaped, the top and bottom lines being tangent to the circumference of the sewer, so that the house drainage is delivered at the very bottom of the flow of the sewer, with a tendency to increase its velocity, whilst the ventilation of the sewer reaches its very top.

The lateral sewers have no man-holes or lamp-holes, or communication of any sort with the surface of the street, except at one point near the lower end of each, where there is a fresh air inlet, which may also serve for the inspection of the working of the sewer. This fresh air inlet has a communication with the surface of the ground through a large and very open grating, beneath which a slanting plate of iron is placed to prevent dirt from falling into the sewer, this plate throws it into a receptacle at the side, from which it may be easily removed (see sketch, Fig. 2). This sloping plate CD need only be lifted to a vertical position to give a clear view of the sewer below. Aside from the fresh air inlets indicated to supply a current for ventilation, it is a fundamental principle of the ordinance regulating house connections that every connection, of whatever character, shall be continued without an intervening trap, by a pipe fully four inches in diameter to and above the top of the house so connected. As house connection is compulsory, and as it is made a misdemeanour not to have at least one water-closet for every occupied house, when the work is completed there will be not less than 7,000 of these four-inch ventilating pipes for the forty miles of sewers of the city, being an average of one ventilator for every thirty feet of sewer.



The rain-water, either from the surface of the ground or from the roofs of houses, is not admitted to the sewers. They serve solely for the removal of the waste water of houses, manufacturing establishments, stables, &c. Under no circumstances is the pipe connecting a house of any size with the sewer allowed to be more than four inches in diameter. This is amply large for the most extensive establishments. For example, a gauging of the flow of the main sewer of the Grand Union Hotel in Saratoga in the height of the season, at the hour when the proprietor thought that the largest amount of water was being discharged, and when there were 1,300 inmates in the hotel, showed a stream barely sufficient to fill a pipe 2½ inches in diameter. A rigid adherence to this limit of four inches insures the exclusion of matter, enough to clog the six-inch sewer, and throws the responsibility of excluding rubbish or grease upon the householder, as he alone will suffer inconvenience from his neglect.

At the head of each sewer there is built a flush-tank, having a capacity of about 112 gallons. This tank is built of mason work under the surface of the ground, but above the level of the head

of the sewer. It is supplied by a constant stream of water from the public water-supply, barely sufficient to fill it once in twelve to twenty-four hours. It is furnished with Field's automatic siphon (see sketch, Fig. 3), which, however slight the flow, is sure to be brought into operation when the tank is filled to the top of its outlet pipe; the whole amount of water in the tank is then discharged rapidly (in from thirty-five to forty seconds), and rushes down the sewer with a force sufficient to carry before it every substance, of whatever character, the four-inch pipe may have been capable of admitting.

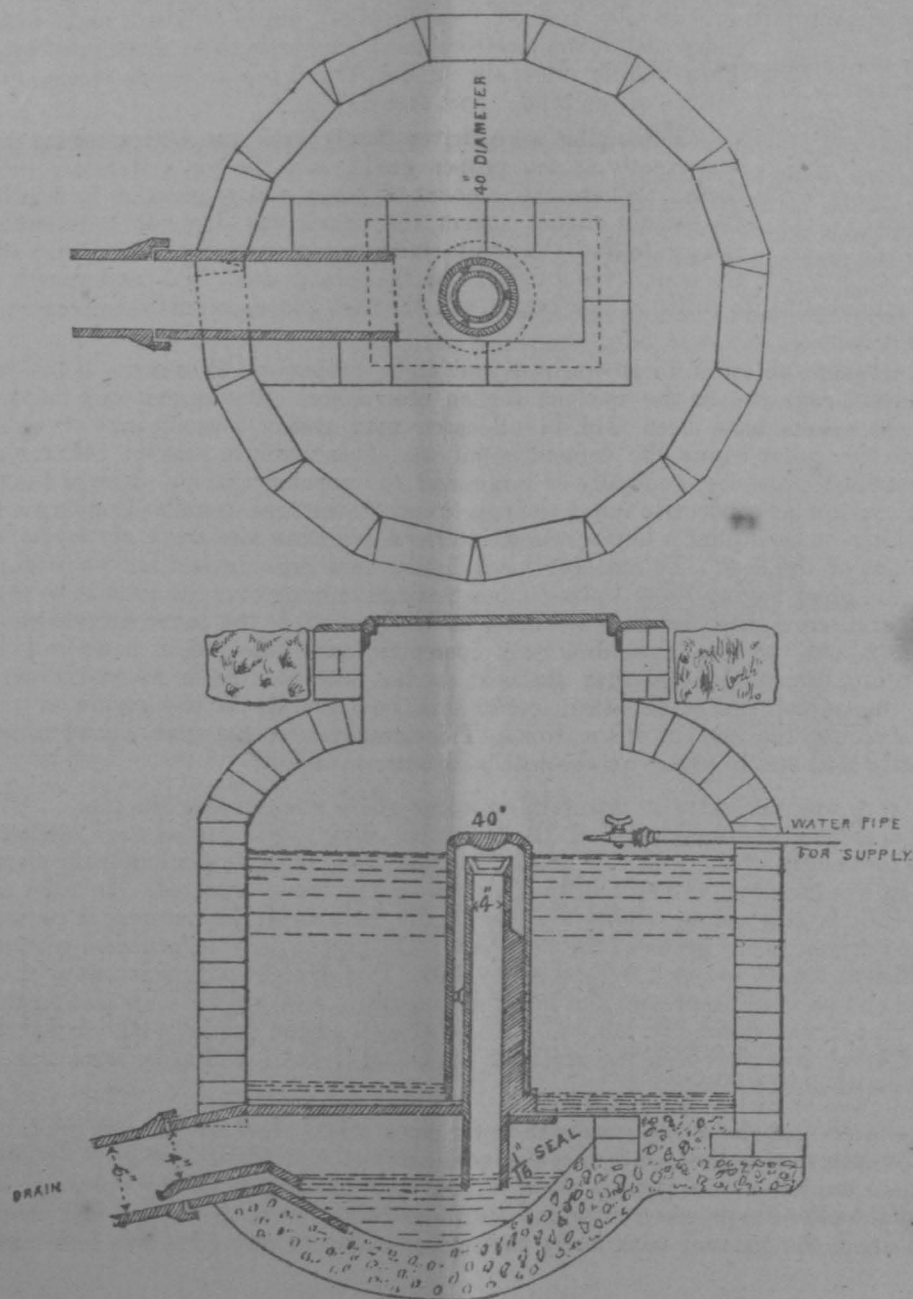
The flushing stream, according to observations made in Memphis, fills the sewer more than half full 900 feet from the tank. This distance must, of course, depend on the fall of the sewer. At a fall of 1 in 200 it is ample to wash all filth forward to a point where the natural flow is able to take care of it. Each tank has only the dead end of its own sewer to flush.

It is thus immaterial whether all the flush-tanks go off at once or irregularly.

This flush-tank is one of the essential features of the combination; indeed, without it the use of any sewers not receiving storm-water would be extremely unsafe.

Aside from this means of assuring the removal of obstructions before they can accumulate to a dangerous extent, the use of the flush-tank has the further very important effect of carrying forward to the outlet, at least once in twenty-four hours, all organic matter which, if allowed to remain a longer time, would enter into a dangerous decomposition, for even in a six-inch pipe

FIG. 3.



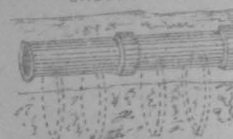
there is a tendency to deposit faecal matter and other solid substances toward the upper ends of the sewers where the regular flow has not yet accumulated sufficient volume to sweep them forward. In the Memphis works such deposits are rendered impossible, and the production of sewer-gas as a consequence is substantially prevented.

Some of the details of the construction of these sewers are different from those in common use. Ordinarily pipe sewers are laid from the lower end of the drain upward, so that water accumulating in the trench is carried off by the sewers as they are laid. But it is impossible to make a tight joint when the pipe is required to carry water before the cement hardens. Then, too, with the small diameter here used, absolute cleanliness is very important. Therefore the laying of each line was begun at its upper end, every effort being made to exclude soil-water absolutely. This was effected by a system of subsoil drainage carried on in connection with the sewerage. Agricultural tiles, varying from 1½ to 3 inches diameter, were laid in the trenches by the side of the sewers. The joints were covered with paper, to prevent the loose filling from stopping the joint. In very wet soil it was necessary to lay these tiles in advance of the sewers by digging a narrow trench below the grade of the sewer. Into this trench the tiles were laid and covered with boards to prevent their being disturbed while laying the pipes. These subsoil drains were provided with an outlet into the bayou.

Although the natural soil of Memphis is generally very good and firm, in many places in grading the streets and alleys old bayous and depressions have been filled. In such places the bottom is as bad as possible. In several instances the lower part of the trench was actually dug with buckets, and in one case the man laying the pipes sank in the slush until his knee was down to the level of the flow line of the pipe. The method devised to get over the difficulty was to support each pipe on two piles, termed "saddle piles," made of boards eight inches wide, sharpened at the lower end, and long enough to drive into firm ground. These saddle piles are cut out at the top to a half circle, fitting the outside of the pipe. (See sketch, Fig. 4.)

FIG. 4.

SADDLE PILES



These piles were driven firmly until the bottom of the half circle was exactly at the proper grade, and the pipes were supported upon them. Where the amount of water was so great as to interfere with the setting of the cement, the trench was dug out considerably below the grade line, the joints standing high and dry until firmly set. After the sewer was finished and the subsoil drain laid underneath the main

sewer and extended to its outlet in the bayou, all the wet places referred to became speedily drained.

It is a frequent objection to pipe-sewers that slight projections of cement at the joints act, by catching lint, rags, &c., as the nucleus for an obstruction. To prevent such asperities the joints of these sewers have been laid, in all cases, with gaskin, a small rope of oakum being crowded into the collar before the cement is put on. It is found in practice that the collars or sockets of vitrified pipes are generally so large and so irregular that the bore of the pipe does not make a continuous concentric tube, the spigot end of the pipe usually dropping a little out of line, making at each joint a hump which interferes with the continuity of the fall and with the smoothness of the flow. To remedy this difficulty there was devised an "adjustor," to be inserted in the pipe, having three India-rubber bearings lapping over the joint to be made. By the turning of a screw these bearings are brought firmly against the inner circumference of the pipe, and they hold the two pipes absolutely concentric until the gaskin is wedged in place, this joint being cemented only after the next one has been secured by its gaskin, so that any jarring in the adjustment of the third joint shall be taken up by the gaskin of the second without disturbing the cement of the first. This arrangement has been found in practice to work perfectly well and to secure an absolutely concentric conduit.

Great care was necessary in maintaining a true grade while laying the pipes. On account of the very small natural inclination of the bayou but very slight grades were attainable; for nearly half the length of the west side main the grade is one foot in six hundred, above that it is one foot in five hundred, and still further up one foot in three hundred. In order to lay the sewers carefully to this grade, stakes were set in the bottom of the trenches at stations every 12½ feet, and driven to the grade of the flow line. The pipe-layer was furnished with a straight edge of sufficient length to reach from stake to stake; this straight edge was just so much wider at the lower end as would represent the fall for its length, and was used by placing the narrow end in the pipe it was desired to test, and the other end on the nearest stake below the pipe; then a spirit-level was placed on the straight edge, and if not found to be level, the pipe was raised or lowered until it became so.

It is believed that the whole system of sewer pipes is laid absolutely true to grade; that the pipes are absolutely concentric, and that the continuity of the whole system is mathematically exact. An examination of a certain piece of very bad ground, made by opening the trench, showed that the piles above referred to had performed their work perfectly, and that the tile drains had dried the ground completely under the drain. Every joint was firm and without

crack, and the work completely satisfactory. The outlet of the tile drain showed a small stream running continuously.

So far as the healthfulness of Memphis is concerned, the natural wetness of much of the soil, and the springy condition resulting from the filling in of old bayous and swamps, was very detrimental. The draining of the soil was therefore thought to be as important as the building of sewers.

It has been mentioned that this soil drainage has been accomplished by the use of agricultural drain tiles, delivering, not into the main sewer, but beyond it into the bayou. But as the sewers are between three and four hundred feet apart—too far for a complete draining of the subsoil by this means—a tile drain has been laid under the edge of the side walk at each side of each street leading from the river toward the bayou. From the experience gained to the present time the result is satisfactory.

The cost of the drainage and sewerage, including labor, material, engineering, and incidentals, has been about \$137,000, or about 28,000*l*. The average cost per foot of the six-inch sewers for pipes, house-connection branches, ditching, laying, and back filling, not including engineering and inspection, is estimated at 60 cents.

In addition to these works, the improvement of Bayou Gayoso is being proceeded with.

Bayou Gayoso is a deep winding gully through the heart of the city, and serves as the outlet for a water-shed of about 5,000 acres. In many parts its shores were lined with privies, whose contents flowed down its sides, and it was a convenient receptacle for all manner of filth from the houses along its course. It also received a number of drains, bringing water-closet and other refuse from houses sometimes at a considerable distance from it. All these things rendered it a foul open sewer, of a most objectionable character. These evils have been removed by the sewerage works.

But, in addition to this, it served as a channel for the penetration of the flood-waters of the Mississippi quite up to the heart of the town. This flood-water had no perceptible flow, and it stood at such a height as to lead to the complete saturation or overflowing of wide areas of occupied ground. Many houses near it are built on piles, and during the months of high water nearly every year they were entirely underlaid by a greater or less depth of foul, stagnant, scum-covered water. The district so affected was notoriously the worst, in its sanitary condition, of the whole city.

The improvement consists of a dam for excluding the flood-water of the river, a low valved outlet for the removal of the natural stream during low stages of the river, a steam pump to discharge the natural stream during high stages, and large flood-gates to discharge the water of heavy storms at all seasons. The pump to be used is a most simple and ingenious device for forcing water forward against a head, while allowing a free natural flow at ordinary stages of the river. This pump (the invention of Mr. Fijuje Van Salverda) has been largely used in Holland for more than thirty years.

This account of the sewerage will suffice to explain generally the system which has been adopted; it is too recent to enable a decided opinion to be expressed upon its permanent success, but so far as experience goes it has proved effectual. It presents several novel features which require to be tested by further experience before they could be recommended for general adoption. For instance, it may be questioned whether the mode of supporting the pipes on collar piles in crossing deposits of silt or soft ground will permanently secure a sufficiently durable foundation for retaining the pipes at a true grade; it is alleged that, when the soil under the pipes so laid has been examined after a few months, it has been found to be perfectly sound, but until further experience has been acquired by the lapse of time, it remains a question whether a better foundation and the use of iron pipes would not have been preferable in these positions. It may also be observed that it would have been desirable that the main sewers should have been true in line and in gradient, with man-holes provided with movable and ventilating covers at each change of direction, and for the main sewer to have been amply ventilated according to the most recent English practice. The ample flushing arrangements for the small drains seem to be worthy of approval, and there would be little ground for objection to the direct communication which exists between the house drains and the sewers, by which the house drains become ventilators for the town drains, so long as ample ventilation as above mentioned is provided for the main sewers, and so long as the sewers are kept thoroughly free from deposit, but further experience will show whether freedom from deposit has been thoroughly secured.

The water-supply of the town has been improved by obtaining water from a pure source.

Whilst it is to be hoped that Memphis may not again suffer from such severe epidemics as have occurred in late years, there must remain for some time a serious ground for apprehension owing to the large extent of subsoil pollution of the site of the city. Because although the old cesspits have been cleaned out and filled with fresh earth, yet there necessarily must still be present in the subsoil a large amount of the polluted matter which has been gradually accumulating in the subsoil for so many years.

READ—again G.O., dated 30th November 1881, No. 1636, Public.

Order—dated 30th November 1881, No. 1636, Public.

Distribution of seventy copies of Drainage of Memphis, in the United States of America—

President, Municipal Commission, Madras	1
Surgeon-General with the Government of Madras, for distribution ..	15
Do. British Medical Service, for distribution	7
Sanitary Commissioner, for distribution	40
Government Office	7
Total	70

(Signed) E. S. LAFFAN,
Asst. Secy. to Govt.

READ—the following letter from Deputy Surgeon-General M. C. FURNELL, M.D., F.R.C.S., Sanitary Commissioner for Madras, to the Chief Secretary to Government, dated Madras, 23rd December 1881, No. 3472 :—

I have the honor to forward, herewith, for the information of Government, my Inspection Notes of the towns in Coimbatore, Salem, Malabar, and South Canara Districts.

2. Copy of the notes have been forwarded to the several Presidents concerned.

READ—the following letter from Deputy Surgeon-General M. C. FURNELL, M.D., F.R.C.S., Sanitary Commissioner for Madras, to the Chief Secretary to Government, dated Madras, 9th February 1882, No. 119 :—

I have the honor, with reference to Order of Government, dated 27th January 1882, No. 111, touching Tirupati, to forward the accompanying notes from information which has reached me.

2. It will be seen that in a good number of cases cholera broke out amongst pilgrims returning from Tirupati and was by them disseminated in their native places.

3. When I first became aware of this I was on tour in the Western Coast, but I at once wrote to, and ordered, the Deputy Sanitary Commissioner, Dr. Price, who was in Madras, to proceed to Tirupati and report on the state of things.

4. He visited Lower Tirupati, which he reported to be clean and free from any cholera, but he was unable, he informed me, to visit Upper Tirupati. I have not his letter by me, but speaking from memory I fancy he said he was not permitted to ascend the hill. He is away on tour just now, but I have addressed him on the subject.

5. As the Surgeon-General points out, we were aware cholera was steadily making its way down from Bombay and the North-West and all the precautions possible had been taken. Early in September I visited Raichoor, the station up the line where the first case occurred, inspected the wells, filters, and camping grounds, and addressed the Railway authorities on the subject. During September the Presidency remained so free from cholera it seemed probable we should escape, when this sudden outbreak and spread from Tirupati shattered our hopes.

6. I am confident, from all I have heard, that the Hospital Assistant's account of what takes place in the Upper Hill is not exaggerated. The other large religious festivals throughout the Presidency have during late years, owing, it is presumed, to stringent sanitary regulations, passed over without any epidemic, and it is reasonable to suppose the same precautions taken here would meet with the equally happy results.

ORDER—dated 18th March 1882, No. 303, Financial.

Communicated to the officers below-mentioned with reference to the questions raised in relation to subsoil drainage.

(True Extract.)

R. DAVIDSON,
Chief Secretary.

(True copy)

Quarto
By Chief Secretary.

To the Board of Revenue.

- " Presidents of all Municipalities.
- " Surgeon-General with the Government of Madras.
- " Sanitary Commissioner.
- " Inspector-General of Jails.

" *Public Works Dept.*

J. W. C. No. 2723

Govt. of [1882] Madras.

FINANCIAL.

B No 1103 W. d. 2nd May 82.

Recorded.

[Signature]

29. 4. 82

Recd. 1 May 82

Order, dated 18th March 1882, No. 303.

Municipal—Sanitary. — Communicating letters from the Sanitary Commissioner regarding the cholera invasion of 1881 into this Presidency, with reference to the questions raised in relation to subsoil drainage.

Entd. in Receipt Re

with order

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with order