medical men in Calcutta did return their incomes as being over Rs. 10,000, and they hold receipts from the Collector of the Income-tax, showing they paid their tax accordingly.

The world knows that private practice in Calcutta yields more than Rs. 10,000 a year, and we cannot concur in thinking that a transparent mistake in some Office or Secretariat, should be made the cause and occasion of a derisive and damaging remark of this kind. We hope that our leading confrères in Calcutta will not allow this imputation, whether issued in jest or in earnest, to remain on record unrefuted and unrepealed. Merry writing in high places is unusual and tickles the public fancy for a time; but we object to merry writing when it covers an implication regarding the integrity of a body of professional gentlemen, and by contrast conveys a half earnest jeer as to the elasticity of their sense of moral obligation.

THE MAIN DRAINAGE WORKS OF LONDON.

[Contributed by a valued correspondent in England.]

DURING a recent visit of inspection to the metropolitan sewage and drainage works, it occurred to me that a short notice of the subject might be interesting to the readers of the *Indian Medical Gazette;* especially to those who, like myself, fully appreciated the great works which are being executed at Calcutta, on the same plan as those in operation in this city, and who believe that the application of the system to the great cities of India, is the only thorough and practical form of true sanitary improvement.

The majority of the inhabitants of cities and towns are generally unconscious of the magnitude, intricacy and extent of the underground works which have been designed and constructed at great cost, and are necessary for the maintenance of their health and comfort. The able paper on the drainage of Calcutta read at the Meeting of the Bengal Social Science Association in February last, by Mr. W. Clarke, has shewn us in this country how much has been effected in the metropolis of India by the skill and energy of one man, and it is to be hoped that, as the knowledge of the principles on which he worked—identical with those in existence in London—become better known, no further obstacles will be put forward to the extension of the drainage to the whole of Calcutta. It is nearly two hundred years since the plan for improving drainage by sewers, was proposed by Sir Christopher Wren for the city of London, and from that time various measures have been in operation for the furtherance of similar views: we need not deal with these, suffice it to say that for many years previous to 1847, London had eight different commissions of sewers within its boundaries—each being an independent body; each appointed its own officers, and carried out its own drainage works, regardless of the effect thereby produced upon the neighbouring districts through which the sewage flowed. In the year 1847 these eight commissions of sewers were superseded by the one "Metropolitan Commission of Sewers," whose members were nominated by the Government. This commission directed its energies mainly to the introduction of pipe sewers of small dimensions in lieu of the large brick sewers previously in vogue; to the abolition of cess-pools; and to the diversion of all house drainage by direct communication into sewers, making the adoption of the new system of drainage compulsory; so that within a period of about six years, thirty thousand cess-pools were abolished, and all house and street refuse was turned into the river Thames. Similar systems were, about the same period, to a large extent, adopted in the provincial towns, by which means their drainage has been vastly improved; but the rivers and streams of the country gradually became very generally and seriously polluted.

In the nine years following the appointment of the Metropolitan Commission, it was six times superseded, and six new and differently constituted commissions were successively appointed; and it was not until the formation of the present Metropolitan Board of Works in 1856, that present general system of the main drainage and sewerage of London became practically adopted. The main drainage scheme was designed by Mr. Bazalgette, and in 1859, the Board of Works commenced the perations.

In a paper read before the Institution of Civil Engineers in 1865, Mr. Bazalgette pointed out how incompletely and ineffectually the drainage had been hitherto carried out, owing to the ignorance of some, the carelessness of others, and to the great increase required under modern improvements and the extension of the London suburbs. He had, therefore, to adapt his plan for the requirements of localities heretofore faultily drained or not provided with any out-let whatever, to provide ample means for the discharge of the large and increasing water-supply consequent on the universal adoption of water closets, and of the ordinary rain-fall and surface drainage at all times, and to afford to the low-lying districts a sufficiently deep out-fall, to allow of every house being effectually relieved of its fluid refuse; or, to quote his own words, "the objects sought to be attained in the execution of the main drainage works were the interception, as far as practicable, by gravitation, of the sewage, together with so much of the rain-fall mixed with it as could be reasonably dealt with, so as to divert it from the river near London; the substitution of a constant instead of an intermittent flow in the sewers; the abolition of stagnant and tide-locked sewers with their constant accumulation of deposit; and the provision of deep and improved out-falls for the extension of sewerage into districts previously, for want of such out-falls, imperfectly drained". The new lines of sewers were, therefore, laid in a direction at right angles to that of the existing sewers and a little below their levels, so as to intercept their contents and convey them to out-falls at least 14 miles below London Bridge. As large a proportion of the sewage as is practicable is by this means carried away by gravitation, and for the remainder, a constant discharge is effected by lifting pumps. At the outlets, the sewage is delivered into reservoirs, situate on the banks of the Thames, and placed at such a level as will enable them to discharge into the river at or about the time of high water. By this arrangement, the sewage is not only at once diluted by the large volume of water in the Thames at high water, but is also carried by the ebb tide to a point in the river, 26 miles below London Bridge, and its return by the following flood tide to within the metropolitan area, is effectually prevented.

To carry out the above principles, three lines of sewers were constructed on each bank of the Thames, termed respectively the high level, middle level, and low level; the two first discharge by gravitation, the third by the aid of pumping only.

On the north bank of the river, the three lines of sewers converge to and unite at Abbey Mills, east of London, in the Bow and Stratford districts, the contents of the low level being here pumped up into the upper level sewer, and the aggregate stream flows on through the northern out-fall sewer, over 4 miles long, which is carried on a concrete embankment, 40 feet wide, across the Plaistow marshes, being in some places 25 feet above their level, to Barking Creek, and there discharges into the river by gravitation.

On the south side of the Thames, three intercepting lines unite at Deptford Creek, and the contents of the low level are there pumped into the upper level sewer, and the united streams of all three flow in one channel through Woolwich under the Erith marshes to Crossness Point on the south bank of the river, about two miles below Barking on the opposite bank.

To give an idea of the immensity of these operations designed to carry off the débris of $3\frac{1}{4}$ millions of people, it may not be uninteresting to relate, in short detail, the size of the area drained, and the length, &c., of the sewers.

NORTH BANK OF THE THAMES.—*The high level sewer* commences by a junction with the old "Fleet Sewer" at the foot of Hampstead Hill. It is about 7 miles long, and intercepts the sewage of Hampstead, Kentish Town, Highgate, Hackney, Clapton, Stoke Newington, and Holloway, comprising about ten square miles; at the upper portion its fall is rapid, ranging from 1 in 71 to 1 in 376, and from 4 to 5 feet per mile at the lower end.

The middle level sewer.—The area intercepted by this channel is $17\frac{1}{2}$ square miles in extent, and is densely inhabited. It commences near the Harrow Road at Kensal Green, passes under the Paddington Canal at Notting Hill, along Oxford Street, across Clerkenwell Green to Shoreditch, and under the Regent's Canal and North London Railway to a junction with the high level sewer at Bow. The length of this main line is $9\frac{1}{2}$ miles; one large branch or feeder, under, draining Piccadilly, Leicester Square and Lincoln's Inn Fields, &c., is two miles long, and there are several other feeders of shorter lengths. The fall varies from $17\frac{1}{2}$ feet per mile at the upper end, by a gradual reduction to 2 feet per mile at the lower end.

The low level sewer, besides intercepting the sewage from the

low level area which contains 11 square miles, commencing from Fulham and including Hammersmith, Brompton, Kensington, &c., &c., is also the main outlet for a district of about 14½ square miles, forming the western suburb of London, which is so low that its sewage has to be lifted up at Chelsea a height of 17½ feet into the upper end of this, the low level sewer. This sewer after receiving the above drainage, may be said to commence at Chelsea, passing under Pimlico to Vauxhall Bridge; on to Westminster Bridge, it passes under the Thames Embankment to Blackfriars; thence to the Mansion House and Tower Hill, and on by Mint Street to Blackwall, Limehouse, &c., ending at the Abbey Mills pumping station by its sewage being pumped up 36 feet into the high level sewer, as before described. The length of the main line is 8¼ miles; that of its branches or feeders 4 miles. One large branch has so effectually drained the Isle of Dogs—formerly a dismal swamp—that the island is now the site of extensive works and factories, and is closely populated by artisans and workmen.

The Abbey Mills pumping station is the largest establishment of the kind on the main drainage works. The buildings are very handsome in appearance, and look in the distance like an immense mosque, the two tall and imposing looking chimneys having the appearance of eastern minarets. All is built of white brick, properly ornamented with red ones: and the combination is very pleasing to the eye. The interior of the main building is a splendid coup d'œil. It is cruciform in plan, containing two engines in each arm of the cross, the centre portion being octangular, and the iron work most imposing and highly ornamented. There are 8 engines, aggregating 1, 140 horse power, and are designed to lift a maximum quantity of sewage and rain-fall of 15,000 cubic feet per minute, a height of 36 feet.

The whole of the sewage of London and suburbs on the north side of the Thames is thus conducted to Barking Creek, about 1¾ mile below Woolwich. There it is received into a reservoir covering altogether about 9½ acres. The reservoir is above the general surface of the ground, and is covered in by an embankment of earth. There are 4 compartments, each of which can be flushed by the tide whenever necessary. The arrangements for the discharge of the sewage into the river are of the most perfect description.

SOUTH BANK OF THE THAMES.—*The high level sewer*, and its southern branch of 4½ miles long, correspond with the high and middle level sewer on the north side of the Thames. The main line commences at Clapham, drains Tooting, Brixton, Dulwich, Camberwell, Norwood, Sydenham, and part of Greenwich. The two lines drain an area of about 20 square miles; the fall commences with about 50 feet per mile, gradually decreasing as they proceed eastward to between 2 and 3 feet.

These two channels empty themselves by gravitation into the southern out-fall sewer, presently to be described.

The low level sewer commences as high up the river as Putney, opposite the commencement of the low level sewer of the north bank at Fulham, both points being in a straight line, about six miles west from Temple Bar in the city of London.

This sewer passes through low ground, once forming the bed of a second channel of the Thames, and drains Putney, Battersea, Lambeth, Southwark, Rotherhithe, Deptford, &c., comprising an area of 20 square miles, and is about 10 miles long, with a fall of from 4 to 2 feet per mile. The surface of this area is mostly below the level of high water, and is, in many places, 5 or 6 feet below it, having at one time been completely covered by the river. The science of draining has been estimated to have raised this area as equivalent to raising the actual surface of the ground to a height of 20 feet, and has rendered the above districts, previously most unhealthy, as dry and as healthy as any portion of the metropolis.

The Deptford pumping station is another of the handsome series of works belonging to this grand scheme. It is designed to lift the sewage from the low level sewer a height of 18 feet, and to empty it into the southern out-fall sewer. There are 4 engines in the building, each of 125 horse power, capable together of lifting 10,000 cubic feet of sewage, &c., per minute, the height of 18 feet.

The southern out-fall sewer conveys the sewage which flows into it from the high level sewer by gravitation, and that which is pumped into it from the low level sewer, from Deptford through Greenwich and Woolwich to Crossness Point on the bank of the river in the Erith marshes. It is constructed entirely underground for its whole length of 7¾ miles, and has a fall of about 2 feet per mile.

The Crossness reservoir and pumping station is an imposing looking and handsome mass of buildings on the river side, above 3½ miles below Woolwich. It gains in appearance from the elevation of the reservoir above the low land, originally reclaimed from the Thames in the reign of Edward I.

The buildings are of white brick with interlacements and ornamentations of red brick; the reservior is 6½ acres in extent, and over and around it are built twenty-one cottages for the officials and laborers employed. The chimney of the engine house is 200 feet in height.

The sewage of all the south side of the Thames having arrived here could be discharged into the river by gravitation about the time of low water, but the outlet of the sewer is ordinarily closed, and its contents are raised by pumping into the reservoir, which is built at the same level as that on the north side, and, like it, stores the sewage, except for the two hours of discharge after high water. There are four engines, each of 125 horse power, and designed to lift a maximum quantity of sewage of 10,000 cubic feet per minute; the lift at this station varies from 10 to 30 feet according to the level of fluid in the sewer, and in the reservoir into which it is lifted.

There are about 1,300 miles of sewers in the districts above described; while the main intercepting sewers, whose course has been detailed, are 82 miles long: the expenditure of coals for the pumping power is about 20,000 tons annually.

The sewage on the north side of the Thames at present amounts to ten millions cubic feet per day, and on the south side to four millions, but provision is made for an increase up to 11½ millions on the north side and 5¾ millions on the south in addition; the drainage is designed to clear away, daily, 28½ millions of cubic feet of rain-fall on the north side, and 17½ millions cubic feet on the south; which is equal to a lake of 482 acres, 3 feet deep.

The faulty part of the whole system is that so much valuable manure should be thrown away into the Thames. No attempt is made to utilize the sewage either at Barking or at Crossness, except in a small way at the latter station, where some few fields produce splendid grass crops under the management of the superintendent. The A. B. C. Company are, however, building works in the neighbourhood of that out-fall, and have contracted to take over 500,000 gallons daily from July next for the prosecution of their patent: their system is, however, one of very doubtful utility.

But the time is fast approaching when the value of sewage as manure will be practically appreciated; as yet England is not more advanced than Calcutta in the disposition of this manure. At present, Acts of Parliament enjoin the discharge of sewage into rivers simply to get rid of it, thus poisoning the fish, and the inhabitants of towns situatated lower down on the banks In the present instance—and in most tidal rivers—the discharge is innocuous, because from the volume of water, great rise and fall of tide, and the distance the towns at the mouth of the Thames are from its banks, no evil effects are experienced. It is certain that within a few years this pollution of rivers will cease. The Court of Chancery can even now step in and prohibit towns from doing what the Acts enjoin—*viz.*, the discharge of offensive matters into streams—on the application of persons interested in the purity of the water. There is still some difficulty in dealing with the pollution caused by manufacturing processes; but modern researches have determined the proper disposal of sewage. It is definitely and finally proved that the poison of the water is the food of the land, which in turn repays the benefit by depriving the substances which enrich it of all noxious qualities, and the increased produce of land to which sewage is applied may be considered an unmixed gain.

The present authority on the utilization of sewage, by surface irrigation, is Mr. W. Hope, v.c., who, in September 1869, took the lease of a farm of 120 acres at Romford in Essex, to give practical effect to the opinions he advocated. He has recently demonstrated the innocuous nature of his system,* and the profit that is to be gained by the cultivation of all sorts of produce under sewage irrigation, properly conducted. He has also proved that nearly equally good crops can be grown by the application of sewage to land on which 4,000 tons of pure sea sand had been spread 2½ feet deep over an acre, and the London sewage applied to it from the Barking out-fall.

In fine, Mr. Hope has fully demonstrated the solution of the problem of the profitable utilization of sewage to land by surface irrigation in such a manner as to fulfil every sanitary requirement. Several of the large towns in England are now

* Lecture on sewage irrigation, by W. Hope, Esq., v.c., Standford, Charing Cross, 1871.

adopting his principles, and employing him to lay out the lands farmed by them for the economic disposal of their sewage, and the experience of the next few years must practically dispose of this much-disputed question.

23rd May, 1871. T. R.

Reviews.

Recent contributions to the literature of Asiatic Cholera. By C. MACNAMARA.

BEFORE discussing, however, the circumstances of Pettenkofer's theory of cholera, it may be well to ascertain the views of the various sanitary authorities in India, whose reports for the year 1869 were referred to at the commencement of this review; under their guidance we ought to be able to arrive at definite conclusions regarding these matters, and I have, therefore, given extracts from these reports in parallel columns in order that the reader may judge for himself as to the unanimity or otherwise of the opinions held by sanitary officers regarding the principles and facts, upon which they are working at the present time, in hopes of determining the laws which govern the dissemination of cholera over this country.

Army Sanitary Commission on Dr. Bryden's report on cholera, War Office, May 1870.—"There is a most interesting series of maps in the report, illustrating the laws of progress of cholera as deduced from the available statistics over the North-West and West of India. These maps show cholera always present within the endemic area already described. In the first year of its epidemic progress, it is shown as overstepping the endemic boundary, and occupying a certain region of country to the westward; next year as occupying more ground." P. 8.

Idem, p. 4.—Dr. Bryden appears to consider "that the force which moves an epidemic of cholera is the wind. He doubts altogether the alleged fact that an epidemic has ever progressed in a direction contrary to the wind."

Dr. J. L. Bryden, report on the cholera of 1866-68, *p.* 76.—"The prevailing wind is the agency which directs the course of an advancing epidemic, and determines its limitation in geographical distribution; the assertion that cholera may advance against a prevailing wind is contrary to fact."

Cholera in Southern India by Surgeon W. Cornish, F. R. C. S., Sanitary Commissioner for Madras, p. 15.—"It is somewhat strange that a cholera map should have been drawn for 1859, so as to show a complete exemption of the western and southern tracts, the more especially as it is evident Dr. Bryden was acquainted with the fact of the invasion of Bombay in that year. *The map* in question *is wholly misleading,*" page 31.—"The map drawn by him (Dr. Bryden) to illustrate the annual report for 1868 of the Sanitary Commissioner with the Government of India does not, however, represent the whole truth."

Idem, p. 22.—"If we look to the Bombay mortuary returns for 1863-64, we shall see a great increase of cholera mortality as early as July 1863, with a later increase in December. Dr. Bryden holds that the invading cholera of the Central Provinces did not reach Bombay until December, but it must be remembered that gentleman supports a theory that invading cholera cannot move against a monsoon wind, and this may explain, perhaps, why the month of December has been pitched upon as the month of new invasion. If it be a fact that cholera can cross the peninsula of India in June and July, in the teeth of the south-west monsoon, all theories founded on the dogma that cholera invasion cannot progress against prevailing winds must necessarily fall to the ground." Page 142.—"It is manifest that the same wind that takes cholera from Bengal to the Punjab, cannot be instrumental in sowing the seeds of cholera over Burmah and China."

J. M. Donnelly, Esq., Sanitary Commissioner, British Burmah. No. 14 *of* 1871.—"All that can be shown is that the disease travelled in the highway of human intercourse and against a strong south-west wind. In a report of the disease last year in Sandoway District, Mr. Foracy, Deputy Commissioner, points out how its course lay in the teeth of the south-west monsoon as a most noteworthy fact."

Dr. Townsend, Sanitary Commissioner, Central Provinces, report for 1869, *p.* 177.—"While, therefore, I by no means deny the probability that the dejections of cholera patients contain the specific virus of cholera, I believe the instances in which the disease is communicated by water contaminated with this form of pollution to be comparatively rare."

Idem, p. 182.—"The contagion of cholera depends for its action in individuals on a susceptibility which, as regards the native population, is commonly, if not always, induced by the use of water contaminated with animal organic impurities."

Dr. Cuningham, Imperial Sanitary Commissioner for British India, Proceedings, August 1870, *p.* 250.—"Any merely theoretical discussion of the cause of cholera would be out of place in this letter, but I would remark that, however much opinions agree as to the importance of a good pure water-supply, the belief that the presence in water of a special poison, derived from a previous case, is the great medium of spreading the disease, by no means rests on such a sound base as that which Dr. Macnamara claims for it."

Dr. Muir, Inspector-General H. M.'s British Forces, 2nd August 1870.—"That drinking water is a medium by which cholera is propagated, although a very good practical doctrine has never to my mind been satisfactorily demonstrated, and must, therefore, be considered at present as a mere hypothesis."

Dr. Cornish, Sanitary Commissioner, Madras, p 147, *report on cholera in Southern India.*—"I am disposed to think that the facts as to the great prevalence of fever in certain tracts untouched by cholera, seem to shew a possible antagonism in the common pestilential diseases of the east, so that the marked prevalence of one disease, such as fever or small-pox, may be a cause of the temporary exemption of a locality from another disease, like cholera."

Dr. S. C. Townsend, Sanitary Commissioner, Central Provinces, report for 1869, *p.* 167.—"The cholera influence could not have been brought up by the south-west wind from the coast, for the places on the coast were attacked last in the series; it could not have spread over the country by currents of air from the Ganges valley or from the site of the first outbreak, for, for a month previously, and for the whole period during which the epidemic prevailed, the prevailing winds were contrary to its course."

Dr. A. J. Cowie, Sanitary Commissioner, British Burmah, report for 1869, *p.* 65.—"Imagine the consequences of a native affected with cholera dipping his soiled vessel into a public well. By this means, the disease might be spread throughout the quarter in which the well water was used. To believe that the wells and tanks are not contaminated directly or by percolation through the soil with excrementitious and other foul matters, is impossible."

Dr. C. DeRenzy, Sanitary Commissioner, Punjab, report for 1869, *p.* 103.—"But at times it (cholera) is severe in a place where the water-supply is entirely exposed to excremental pollution; thus it brings forth fruit a hundredfold, for where this exists no amount of personal precautions can bar its entrance into the stomach." "Water is the chief medium for the dissemination of cholera."

Mr. Simon's twelfth report to the Privy Council, p. 21.—"Not only is it now certain that the faulty public water-supply of a town may be the essential cause of the most terrible epidemic outbreak of cholera."

Army Sanitary Commission on Dr. Bryden's report.—"Besides cholera, the population of this endemic area (Lower Bengal) suffers intensely from the whole group of miasmatic diseases and their consequences."

Dr. Townsend's report for 1869, *p.* 170.—"In 1868-69, the period of epidemic accession of cholera and of small-pox have fallen together.' The statement appended to this report shows that over the whole province both diseases were very prevalent, but they raged together with exceptional violence in the northern division of the provinces; the two epidemics ran their course simultaneously."