

containing thus, with the first Armagh Catalogue, a complete record of all the meridian work accomplished at the Observatory since 1827; for the results published in the *Transactions* of the Royal Dublin Society in 1872, and forming a catalogue of 1000 stars, have been incorporated in the present work, as there were numerous unpublished observations of many of the stars there given.

The R.A.'s of the present Catalogue depend on the standard stars of the *Nautical Almanac*, four or five of which were observed on each night, whilst the N.P.D.'s depend upon observations of the nadir point, the adopted being $54^{\circ} 21' 12'' \cdot 70$. Dr. Robinson's investigation of the division-errors of the circle (*Mem. R.A.S.*, vol. ix.), and also his refraction-tables (Armagh Catalogue, pp. 834-35) have been used. The details of the construction of the refraction-tables, which may be considered as identical with Bessel's, are given in the *Transactions* of the Royal Irish Academy, vol. xix. The places of the stars are reduced to the epoch 1875.0, with Struve's constant, but proper motions were never taken into account. The Catalogue, which is very clearly printed, and forms a very compact and neat-looking volume, contains for each star its number in Lalande, its magnitude, generally from the DM., its mean R.A. and N.P.D. for 1875.0, together with the annual precession, the number of observations, the epoch and references to other modern star catalogues, this last column being very complete. The secular variation has been omitted. The introduction also contains a comparison between the present Catalogue and Prof. Grant's Glasgow Catalogue of 6415 stars, not only because it was deduced from observations made nearly at the same time as the Armagh observations and depended in R.A. on the *Nautical Almanac* stars, but also because it had already been rigorously compared by Prof. Auwers with his "Fundamental Catalogue." From the comparison of 539 which the two catalogues have in common, it would appear that the Armagh and Glasgow Catalogues, though perfectly independent of each other, are in fair agreement, so far as N.P.D.'s are concerned. But the R.A.'s appear less satisfactory, as considerable discordances are evident. These Dr. Dreyer thinks may be readily accounted for, partly by the one-sided character of the instrument, partly by the conjecture that perhaps the azimuth found by observing the meridian mark may not be strictly applicable on the opposite (south) side of the zenith. The comparison with Auwers's "Fundamental System" gives a similar result, the N.P.D.'s agreeing much better than the R.A.'s. The probable error of a single observation found from 400 observations of 80 stars between 30° and 100° N.P.D. was R.A. ± 0.08 ts., N.P.D. ± 0.85 .

Great credit is due to Mr. Faris for his perseverance in continuing and reducing the observations during thirteen years, and to the present Director for his energy in completing and publishing the entire results, which will not fail to be a useful addition to our star catalogues.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 DECEMBER 19-25

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on December 19

Sun rises, 8h. 4m.; souths, 11h. 57m. $21^{\circ} 55'$; sets, 15h. 50m.; decl. on meridian, $23^{\circ} 26'$ S.; Sidereal Time at Sunset, 21h. 43m.

Moon (one day after Last Quarter) rises, 0h. 42m.; souths, 6h. 52m.; sets, 12h. 51m.; decl. on meridian, $1^{\circ} 8'$ S.

Planet	Rises		Souths		Sets		Decl. on meridian
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	
Mercury	6	3	10	26	14	49	$18^{\circ} 54'$ S.
Venus	8	25	12	14	16	3	$23^{\circ} 58'$ S.
Mars	10	0	14	2	18	4	$22^{\circ} 4'$ S.
Jupiter	2	53	8	3	13	13	$10^{\circ} 31'$ S.
Saturn	17	35*	1	39	9	43	$21^{\circ} 38'$ N.

* Indicates that the rising is that of the preceding evening.

Occultations of Stars by the Moon (visible at Greenwich)

Dec.	Star	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image	
					h. m.	h. m.
19	γ Virginis	2 $\frac{1}{2}$	1 50	2 34	74	170°
19	B.A.C. 4277	6	2 55	3 21	100	148

Dec.	h.	...	...	...
20	15	...	...	Jupiter in conjunction with and $3^{\circ} 24'$ south of the Moon.
21	—	...	...	Sun at greatest declination south; shortest day in northern latitudes.
22	14	...	...	Mercury at greatest elongation from the Sun, 22° west.

Variable Stars

Star	R.A.		Decl.		h. m.
	h. m.	o'	o'	h. m.	
U Cephei	0	52.2	81	16 N.	Dec. 23, 0 44 m
Algol	3	0.8	40	31 N.	" 24, 4 9 m
λ Tauri	3	54.4	12	10 N.	" 20, 6 42 m
U Monocerotis	7	25.4	9	32 S.	" 24, 5 35 m
W Virginis	13	20.2	2	47 S.	" 22, M
δ Libræ	14	54.9	8	4 S.	" 24, 21 30 m
U Coronæ	15	13.6	32	4 N.	" 20, 20 33 m
V Ophiuchi	16	20.4	12	10 S.	" 23, 4 24 m
R Scuti	18	41.4	5	50 N.	" 24, 6 48 m
δ Cephei	22	24.9	57	50 N.	" 22, M

M signifies maximum; m minimum.

Meteor-Showers

Ursa Major supplies a couple of radiants at this season—one near γ , R.A. 131° , Decl. 48° N., the other near α , R.A. 157° , Decl. 64° N. December 19 and 21 are fireball dates.

SANITARY PROGRESS DURING THE REIGN OF THE QUEEN¹

IN opening the meetings of the One Hundred and Thirty-third Session, it appeared to me that, as we are entering upon the jubilee year of the Queen's reign, it might be interesting to take stock, as it were, of the progress which has been made by the nation in some one of the branches of usefulness to which the proceedings of this Society have contributed; and it occurred to me that the most fitting subject to select would be that of the progress which has been made in sanitation during Her Majesty's reign.

The year 1838 was the first complete year of registration.

The first report of the Registrar-General brought forward the sanitary condition of different parts of the country, and of different classes of the population. Disease was as prevalent amongst the labouring population in rural villages as it was in the most crowded and filthy districts in towns, and, on the motion of the Bishop of London, the House of Lords, in August 1839, presented an address to the Queen, begging her to direct an inquiry into this prevalence of disease. From this period may be said to date that great social and sanitary movement which has tended so largely to ameliorate the moral as well as the physical condition of the people of this island, and which forms one of the most prominent features of the Queen's reign.

The Poor-Law Commissioners were directed to report upon the condition of the labouring classes; and the direct evidence of much preventable disease, which the records of disease and death furnished from all parts of the country, formed the basis on which the Commission founded their recommendations. In towns, the people were crowded in courts and alleys; they swarmed in cellars which were neither ventilated nor drained. In 1837, it was calculated that one-tenth of the population of Manchester, and one-seventh of the population of Liverpool, lived in cellars.

The dead were buried in overcrowded churches, chapels, and churchyards in the middle of towns. The rural districts were no better.

In the towns this condition of things arose from the great increase of population which had been taking place for some years previously, coincident with the rapid expansion of our trade and manufactures, coupled with the absence of legislative provisions to meet the new exigencies which had arisen, and with which the older laws, in consequence of that increase, were unable to cope.

But there were other active causes. For instance, the Commissioners state that parochial administration operated mischievously in degrading the habitations of the labouring classes,

¹ Abstract of Address by Capt. Douglas Galton, C.B., F.R.S., at the opening of the Session of the Society of Arts.

and in checking tendencies to improvement. The depression of the tenement depressed the habits and condition of the inhabitants.

In speaking of the insanitary condition of houses, we must not forget the effect of the window tax. This tax had been established for 150 years. Air and sunshine are the first requirements of healthy dwellings, and the window tax induced every builder to shut out the sun and exclude the air, so that poor men were unable to afford the luxury of adequate windows for their dwelling-rooms, or of any windows for their closets. Darkness and dirt go hand in hand, and in the class of houses above the cottages, darkness and want of ventilation were much fostered by the window tax. This tax was not abolished till 1851.

At the commencement of the Queen's reign, drainage over the whole country was provided for by various Commissions of Sewers. Their duty was limited to causing "to be made, corrected, or repaired, amended, put down or reformed, as the case shall require, walls, ditches, banks, gutters, sewers, gates, cullises, bridges, streams, and other defences by the coasts of the sea and marsh ground."

The Highway Acts provided for road cleansing and road structure; and there was a law for cleansing of ditches, which forbade throwing offal and foul refuse into the ditches which might lead to the pollution of streams.

The most important, perhaps, because the most cheap and accessible, authority for enforcing the execution of the law for the protection of the subject against nuisances, and for punishing particular violations of it, was vested in the Courts Leet. The juries, commonly called "annoyance juries," impanelled to serve on courts leet in towns, perambulated their districts to judge of nuisances upon the view; but the Commissioners reported that, with all this legal strength, there was scarcely one town in England found in a low sanitary condition, or scarcely one village marked as the abode of fever, that did not present an example of standing violations of the law, and of the infliction of public and common as well as of private injuries, the tenements over-crowded, streets replete with injurious nuisances, the air rendered noisome by these and by the smoke from factory chimneys, and the streams of pure water polluted.

As regards smoke, most of the then modern private Acts contained penalties on gas companies, prohibiting their washings to contaminate streams, or using for steam-engines furnaces which did not consume their own smoke. The general statute, 1 and 2 Geo. IV., c. 41, empowered the Court to award costs to the prosecutor of those who used such furnaces; but the duty of informing was not placed on public officers, and private individuals were unwilling to become informers.

The provision of pure water, and the disposal of the water after it had been fouled, had scarcely been thought about. No doubt, in London, and in some large towns, water was provided by public companies or by the corporation; but in almost every country town the water supply was defective.

The report on the sanitary condition of the labouring classes states that it was difficult to conceive the great extent to which the labouring classes are subjected to privations, not only of water for the purpose of ablution, house-cleansing, and sewerage, but of wholesome water for drinking and culinary purposes. Whilst, however, the water supply was insufficient even in London, on the other hand the necessity for providing means for getting rid of the fouled water was generally ignored.

It is stated, in the report of 1842, that the courts inhabited by the poorer classes in towns are generally not flagged; they are paved with a sort of pebbles; they are always wet and dirty. The people, having no convenience in their houses for getting rid of waste water, throw it down at the doors; that scarcely one house for the working classes will be found in which there is such a thing as a sink for getting rid of the water. It mentions, in a typical case, that, where in one locality a large sewer had recently been made, the landlords are not compelled, and do not go to the expense of making any communication from the courts to the sewer; the courts are as wet and dirty, and in as bad a condition as they were before the sewer was constructed; and it is added that this miserable accommodation in the wretched courts pays a better percentage than any other description of property; it pays as much as 20 per cent. in many instances.

With regard to faecal matter, the general practice had been for each house to have its cesspit, which was emptied at intervals by night men; but in the poor districts the soil was allowed by the occupiers to accumulate for years to avoid the expense of emptying. Within the preceding twenty years water-closets had

been introduced into the better class of houses. The refuse from these was generally allowed to flow into the cesspits; but, to avoid the expense of frequent emptying, an overflow was made, where practicable, into sewers or adjacent ditches; in other cases the refuse was turned directly into the sewers, and created a dangerous deposit.

The danger had begun to be noticed long before; for in 1834 one medical witness stated to a Committee of the House of Commons that of all cases of severe typhus that he had seen, eight-tenths were either in houses of which the drains from the sewers were untrapped, or which, being trapped, were situated opposite gully holes; and the report of the Poor-Law Commissioners remarks that this recent mode of cleansing adopted in wealthy and newly-built districts by the use of water-closets, which discharge all refuse at once from the house through the drain into the sewers, whilst it saves delay, prevents accumulation, and also saves the expense of hand labour; yet has the objection that if much extended it may pollute the water of the river into which the sewers are discharged. They, however, recommend that this danger should be incurred, as a lesser evil than the retention of the refuse in houses; adding that—

"It is possible to remove the refuse in such a mode as to avoid the pollution of the river, and at the same time avoid the culpable waste of this most important manure."

The conditions under which the drains had been constructed were entirely different from those which became necessary with the increase of population. The sewers had been constructed for land drainage, and only with reference to the wants of the immediate locality, so as just to drain it to the nearest outlet, without any reference to any general plan of sewerage. The sewers were generally flat at the bottom, of stone or brick; the joints were not specially water-tight, so that much of the liquid passed into the surrounding soil, and the floor of the sewers was covered with deposit, which had to be removed at much expense by hand, and in many cases the size and form of the sewers were adapted to enable the workmen to enter for cleansing purposes. When new lines of houses were built, new sewers were required for which outlets into the old sewers did not afford sufficient fall, and they then became choked with deposit. The cleansing of streets was not performed with uniformity or rapidity; and the condition of many of the back streets and courts was deplorable. They were not properly paved, and had no conveniences.

The Poor-Law Commissioners recommended, in the report already mentioned, that the expensive and slow process of the removal of the surface refuse of the streets by cartage might be dispensed with, and the whole at once carried away by the mode which is proved, in the case of the refuse of houses, to be the most rapid, cheap, and convenient, namely, by sweeping it at once into the sewers, and discharging it by water. This recommendation was largely adopted.

In order to convey some idea to your minds of the difficulties which would necessarily be caused by turning the street sweepings, which consisted largely of mud from macadamised roads directly into the sewers, I may mention that at the present time in London every effort is made to stop the road material from passing into the sewers by sweeping the streets, and by placing catchpits at the gullies and cleansing them frequently, and that in the metropolis the quantity of dirt from roads and gullies, and of deposits from sewers, removed annually, amounts to nearly 1,000,000 tons, and the annual quantity in those days cannot have fallen far short of 350,000 tons. The combined effect of turning the street sweepings and the water-closet refuse into sewers, with uneven falls and flat bottoms, naturally added to the deposit, and intensified the evils in such a manner as finally to force on improvements in the construction of the sewers.

The difficulties as to drainage and the removal of refuse were principally entailed by the absence of any legal machinery to enable the inhabitants of a locality to combine for sanitary purposes, and to share the expenditure necessary for improvements.

Another important insanitary condition was caused by the fact that the vagrant population of the kingdom resorted to common lodging-houses, which were under no sort of supervision, and which were *foci* for the propagation of epidemic disease, as well as of moral depravity.

The general conclusions at which the Poor-Law Commissioners arrived in their report on the condition of the working classes were that disease originating in, or propagated by means of, decomposing refuse and other filth, and damp, close, and over-

crowded dwellings, prevailed generally among the working classes in all parts of the kingdom; and that whilst these diseases could be abated by improved sanitary conditions, they were not removed by high wages and abundant food if sanitary conditions were absent. They also pointed out that owing to the defective water-supply cleanly habits were impossible.

In illustration of the loss caused to the nation by these preventable diseases, they mentioned that out of 43,000 widows and 112,000 destitute orphans relieved from the poor-rates, the greater number had lost their husbands or fathers from preventable diseases; and that the youthful population of either sex brought up in crowded, unwholesome dwellings, and under the adverse circumstances described, were deficient in physical strength and moral conduct, and grew up improvident, reckless, and intemperate, caring for nothing but sensual gratification. They pointed out that the expenses of local public works were unequally and unfairly assessed, oppressively and uneconomically collected by separate collections, and wastefully expended by unskilled and irresponsible officers, and that the existing law for the protection of the public health, and the constitutional machinery for its execution, such as the Courts Leet, have fallen into desuetude.

The Commission then went on to state the conditions required for improving the sanitary condition of the labouring classes.

This report was thus one of the early fruits of the system of vital statistics which commenced at the accession of the Queen, under the able supervision of our late eminent member, Dr. Farr. The report itself was drawn up by another eminent member of this Society, Mr. Edwin Chadwick, C.B. It is a remarkable tribute to the foresight of Mr. Chadwick that, during the last half-century, almost all the sanitary principles laid down in the report have been recognised by the Legislature as necessary to the welfare of the community, and have become matters of ordinary practice. The conclusions of the Poor-Law Commissioners, and the general interest awakened in the subject, led to various sanitary investigations, both by Royal Commissions and Committees of the Houses of Parliament.

When the Registration Act came into operation, an epidemic of small-pox was advancing over this island. It attained its maximum in the spring of 1838, and destroyed 30,819 persons. Dr. Farr mentions that vaccination protected a part of the population, but that there is reason to believe that inoculation led to the extension of the epidemic by diffusing the infection artificially. In 1840 and 1841, the first Vaccination Acts were passed. These prohibited inoculation, and empowered the Guardians to provide means for vaccination, and to charge the expense on the rates; and enacted that vaccination was not to be considered parochial relief, thus recognising the fact that the community should bear the cost of measures which are found necessary to secure the public health. It was not, however, till 1853 that vaccination was made compulsory.

The reports of the various Commissions and Committees of Parliament which inquired into the condition of the people showed the great importance of cleanliness of person and clothing to health, and the difficulties which the poor suffered in respect of it; and in 1844, private associations, not only in London, but in Manchester, Liverpool, and other large towns, were formed to encourage cleanliness amongst the working classes by establishing public baths and wash-houses, and lending out pails, brushes, and whitewash to the poor to cleanse their dwellings; and in 1846, the Bishop of London brought in a general Act empowering local authorities to establish public baths and wash-houses, the expense of which was to be defrayed out of the rates.

As regards general sanitary legislation, it is probable that the recommendations in the Poor-Law Commissioners' report and in the reports of these several Royal Commissions and Committees of the Houses of Parliament, would have remained long in abeyance had it not happened that the nation was threatened with an epidemic of cholera.

In 1832-33, the cholera had visited our shores and snatched 16,437 victims. It again appeared in London on September 22, 1848, and in Edinburgh in the beginning of October, 1848. So long as the insanitary conditions remain, epidemics invariably haunt the same localities, and the first appearance of the cholera in Bermondsey in 1848 was close to the same ditch in which the earliest fatal cases occurred in 1832. The first case of cholera that occurred in the town of Leith took place in the same house and within a few feet of the very spot from whence the previous epidemic of 1832 commenced its course. On its

reappearance in 1848 in the town of Pollockshaws, it snatched its first victim from the same room and the very bed in which it broke out in 1832. It did not, however, attain its full intensity until 1849, and it ceased on December 22, 1849. Its progress fully corroborated the report of the Poor-Law Commissioners. It attacked those towns and houses which offered to it the best inducements to visit them, in their filth, decaying refuse, crowded and dirty population, bad water, damp polluted sub-soil, or any other of those conditions which lead to bad health in a population, and which, when cholera is absent, afford an evidence of their existence by the prevalence of scarlet fever, small-pox, typhoid and other fevers, measles, whooping-cough, &c. The total number of victims was 53,293.

The near approach of the cholera led Parliament, in 1848, to the conclusion that—

“Further and more effectual provision ought to be made for improving the sanitary condition of towns and populous places in England and Wales, and it is expedient that the supply of water to such towns and places, and the sewerage, drainage, cleansing, and paving thereof, should, as far as practicable, be placed under one and the same local management and control, subject to general supervision.”

An Act was passed creating a General Board of Health. The main feature of this Act was, that when the Registrar-General's returns showed that the number of deaths on an average of the preceding seven years exceeded 23 per 1000, the General Board of Health were empowered to send an inspector to make a public inquiry as to the sewerage, drainage, water supply, burial-grounds, number and sanitary condition of inhabitants, and local Sanitary Acts in force; also as to natural drainage areas, the existing local boundaries, and whether others might be advantageously adopted. The General Board were empowered to issue provisional orders, creating a system of local administration by means of Local Boards of Health, consisting partly of municipal authorities and partly of elected members. These Local Boards were empowered to appoint necessary officers, including medical officers of health, surveyors, and inspectors of nuisances. The public sewers were vested in the Local Board, and they were to maintain, cleanse, and regulate the use of sewers. All houses rebuilt were required to be provided with drains approved by the surveyor; and, before any new house was commenced, the levels of the cellars or lowest floors, and the position and character of the drains or cesspools, were to be approved by the surveyor. The occupation of cellars as dwellings was prohibited. Water-closets, or privies, and ash-pits were to be provided to all houses and workshops. The Local Board was also required to manage, repair, and clean the streets, and to provide for removal of refuse. They were to abate nuisances, regulate slaughter-houses, register and make by-laws to regulate common lodging-houses. The local authorities were empowered to provide public recreation-grounds, and to provide a water supply, except where a water company would supply on reasonable terms. They were also to provide mortuaries; to obtain power to close burial-grounds which they considered to be unhealthy, and to open new ones.

The Local Boards were empowered to make by-laws and impose penalties, subject to confirmation by the Secretary of State, and to levy rates, to mortgage the rates, and to borrow from the Public Works Loan Commission. The Act also provided for sewers, wells, pumps, &c., to be made where desired by the inhabitants in parishes containing less than 2000 persons. The metropolis was exempted from the operation of this Act.

The General Board of Health came into existence in 1848, just before the outbreak of cholera in this country, and it took measures at once to check the disease, and proclaimed the principles upon which the preventive and other measures for meeting the epidemic ought to be conducted. Amongst these measures, probably the one which had the greatest effect in promoting subsequently a general feeling of the necessity for sanitary improvements, and which awoke in the nation the needs of moral improvement, was that requiring house-to-house visitation, and the cleansing of the houses and streets, and obtaining an adequate water supply.

This epidemic also brought into notice the necessity of appointing efficient medical officers to supervise the sanitary condition of the different towns and districts.

Further Acts for regulating the public health were passed in 1858, 1861, and subsequent years; and all their provisions were embodied in a General Act in 1875, from the operation of which the metropolis was exempted. Subsidiary to these may be mentioned the Acts regulating rural water supply, the Artisans'

and Labourers' Dwellings Acts, or what have been more recently termed the housing of the working classes, and also Acts for checking the adulteration of food, as well as other Acts relating to the diseases of animals. This general legislation has been largely supplemented by by-laws issued by local authorities, with the sanction of the Local Government Board, and by means of Local Acts obtained by various towns.

The Act of 1848 initiated the system which subsequent legislation has supplemented, under which many towns and rural districts have borrowed money for and have executed public sanitary works during the last forty years. The importance of this measure may be gauged by the fact that the money borrowed since that time for sanitary works, and not yet repaid, amounts to over 130,000,000*l.*, in addition to very large sums spent out of current rates; and in addition to an enormous private expenditure, which is beyond the reach of calculation, for the reconstruction of house drains. This legislation and expenditure have caused a complete revolution in that branch of engineering science connected with public health, viz. drainage and water supply, and has gradually established it on a scientific basis.

Modern sewerage may be said to date from the introduction of oval forms in sewers, by Mr. Roe and Mr. Phillips,¹ under the Commissioners of Sewers, in 1845; the construction of impervious clay pipes for smaller drains; the recognition of the necessity that sewers and drains should be water-tight and self-cleansing; and that junctions should be carefully made. Ventilation of the sewers followed a severe outbreak of typhoid fever, consequent upon the construction of a new unventilated sewer at Croydon. In 1849-50, Sir Robert Rawlinson introduced the system of constructing sewers and drains in right lines from point to point, with lamp-holes or man-holes at every change of direction or of gradient; this is now the recognised method of construction among all English-speaking races. The reconstruction of the sewers led to a reform in house drainage, of which the leading characteristics are imperviousness of material, free aération, and facility of inspection at all points.

The disposal of water-carried sewage began by leading to the widespread pollution of our streams and rivers, and the serious injury of the sea beach in many of our seaside health resorts. The problem was complicated by the doctrine that as the pollution was caused by a vast amount of fertilising matter, large profits might be made out of its removal. But those who made this assertion generally overlooked the fact that the conveyance of the refuse would have to be paid for just like any other work. The subject has been repeatedly discussed in this hall, but it is far too extensive for me to enter into here.

Let us now turn from the community generally to the metropolis, which was excluded from the operation of the Sanitary Acts of 1848 and 1875. The population of London was 960,000 in 1801. At the Queen's accession it had more than doubled, and amounted to about 1,900,000. At the present time it is very nearly 4,000,000. The metropolis has, from its situation, all the attributes of a healthy city. It lies in a valley through the centre of which the Thames sweeps from west to east, and the winds rushing over its water afford a continuous supply of fresh air to the middle of the City. But the advantages of this situation had been largely frustrated by the unopposed efforts of the landowners to accumulate the greatest possible number of houses on the least possible space, by which the free circulation of air was impeded in some districts, and the families of artisans were crowded in small, low, close rooms, without space for the safe retention of refuse; and there was no adequate machinery for its rapid removal.

London is now, undoubtedly, the finest capital in the world. It was far from being so at the beginning of the Queen's reign. Among other things, there were deplorable deficiencies in the sewerage. The drainage found its way through badly-formed, leaky drains into the old water-courses, and thence to the river; the sewage was floated up and down by the tide in the heart of London, until it was deposited on the shore at low water in fetid banks, which covered the foreshore from Blackfriars to Battersea.

One of the early effects on the metropolis of the report of the Poor-Law Commission, was a Metropolitan Building Act for improvement of drainage, and for securing a sufficient width of streets and alleys, and due ventilation of buildings, and to regulate the construction of buildings, authorising the vestries to appoint district surveyors.

¹ Mr. Phillips is at present employed in superintending the reconstruction of the drainage of the Houses of Parliament.

In 1846, a new Commission of Sewers was formed, and charged with the duty of revising the metropolitan drainage. The Commissioners applied for an Ordnance survey of the metropolis, which was commenced in 1847.

The water supply of London was furnished by water companies, who trenched upon each other's districts. Its volume may be assumed, at the Queen's accession, to have been about 36,000,000 gallons per twenty-four hours. It was estimated by Mr. Wicksteed, in 1845, at 45,000,000 gallons. Some was derived from the tidal part of the Thames, and was more or less filtered; but, from its doubtful purity, pumps in surface-wells, often adjacent to churchyards, were frequently preferred for drinking-water. In many of the courts and smaller streets water was obtained only from a small stand-pipe, where the water was turned on for an hour or less daily, when the inhabitants stood around waiting with whatever vessels they might have at hand for their turn to procure a portion of a miserably scanty supply, which was then stored for use in probably the only room occupied by a whole family. Amongst the poorer classes, almost the only receptacles that existed were wooden butts, frequently in a state of decay; and, as they were for the most part without covers, the water was placed under favourable circumstances for the reception of dirt and refuse and for the development of animal and vegetable growths.

After the cholera epidemic, the question of the purity and quantity of the water supply attracted notice; and in 1852, Parliament passed an Act forbidding the supply of water from the tidal part of the Thames or its tributaries, and requiring all river water to be filtered and to be kept covered after filtration; also requiring a constant service when demanded by four-fifths of the houses in a district. In 1858, the average daily supply had risen to 75,000,000 gallons. In 1871, another general Act was passed, to make further provisions for securing to the metropolis a constant supply of pure water; this Act defined the sources of supply of the several companies, and required, amongst other matters, efficient filtration, and the application of tests of purity.

The amount of water delivered into London by the water companies for September last was 178,196,597 gallons in twenty-four hours, of which about 90,000,000 gallons came from the Thames above Teddington Lock; its purity is ascertained by continual analysis; and it may now be said that the water supplied to London rivals that of any other city in purity.

It was not till 1852 that the Secretary of State was authorised to prohibit burials within the metropolis.

A new era in metropolitan sanitation was inaugurated in 1855. In that year the Metropolitan Board of Works was created. In this body was vested the main drainage of the metropolis, but the charge of the subsidiary parish sewers was left to the vestries, who were also charged with the care of the streets and roads, the Metropolitan Roads Commission being abolished, and all duties of lighting, control of removal of refuse, &c., were placed on the vestries.

Thus the formation of this new Board was somewhat of a retrograde movement, because the concentration of functions, which had been commenced under the Metropolitan Roads Commission and Metropolitan Sewers Commission, instead of being strengthened in the new Board, was abandoned, and something approaching chaos was introduced. This Board has, however, by degrees had remitted to it the care of London improvements, and certain other general municipal functions, as well as power to levy general rates. The City retained its individuality, excepting as to the main sewers, and effected improvements and opened out thoroughfares: in the part under its jurisdiction. The improvements in the other parts of London are mainly due to the action of the Metropolitan Board of Works. Great alterations have taken place in our thoroughfares. Many of those large tracts of London which were occupied by dwellings of the most wretched description, are now traversed by wide thoroughfares, and covered by artisans' dwellings erected by private enterprise. But there is no diminution of the rate at which the vast aggregation of population in London still continues to progress; and, unfortunately, many of the wretched crowded dwellings still remain, where those born in close rooms, brought up in narrow streets, and early made familiar with vice, are deteriorated in physique, and grow poorer from inability to work.

The reconstruction of the drains, the removal of the sewage from the midst of the population, the opening out of thoroughfares so as to admit ventilation into crowded districts, have all tended to improve the sanitary condition of London.

I have some interesting tables, prepared for me by the kindness of Mr. A. J. Mundy, of the Registrar-General's Office, which show the remarkable sanitary results of these various efforts. The death-rate of London in the five years 1838-42 was 25·57 per 1000. In the five years 1880-84 it was 21·01 per 1000; and the deaths from zymotic diseases, which in the decade 1841-50 had averaged annually 5·29 per 1000, were reduced in the years 1880-84 to 3·4 per 1000. If, however, we assume that there had been no change in sanitary conditions, and therefore that the death-rate had gone on increasing according to Dr. Farr's formula of increase due to density of population when the sanitary conditions remain unchanged, the death-rate of 1880-84 would have averaged 26·62 per 1000; that is, a saving of 5·61 per 1000 has been effected by sanitary measures.

If upon this basis we compare the saving in life which has resulted from sanitary improvements at different periods since 1838-42, we find that it amounted to an annual saving of 4604 lives during 1860-70; of 13,929 lives annually during 1870-80; and of 21,847 lives annually between 1880-84. The main drainage works were commenced about 1860, and terminated in 1878, and the increase in the saving of life in these consecutive periods may to some extent be taken as a gauge of the effect of the gradual construction and completion of these works. No doubt this London death-rate is far too high, and is an evidence that insanitary conditions still prevail all round us, that the housing of the working classes is still far from satisfactory, and that we are too careless about infectious disease. The Metropolitan Board of Works has never had a clear field for municipal action; yet when we compare the present condition of London with what it was at the Queen's accession, the Metropolitan Board of Works, in spite of the disadvantages of its constitution, will have a grand record to show, in the jubilee year of the Queen's reign, of metropolitan improvements and metropolitan sanitation.

The main principle which guided public administration, both before and during the earlier years of the Queen's reign, may be said to have been that of non-interference, and of allowing free competition to prevail; although, no doubt, some efforts had been previously made to regulate the labour of females and children in Factory Acts.

The practical application of the knowledge derived from the Registrar-General's statistics led to further investigation in particular cases by such men as Dr. Simon, Dr. Buchanan, Sir Robert Rawlinson, and others, and gradually caused a reaction from what may be called the *laissez-faire* system, to the spread of opinion in the direction of control over individual action in the interest of the community generally; and the result was the enactment of the successive laws, for regulating the sanitary condition of the people, which I have enumerated above.

This large amount of legislation is practically little more than the interpretation required by the increase of population, and by the complicated exigencies of modern life, of the common-law maxims, *Prohibetur ne quis faciat in suo quod nocere possit alieno*; and *Sic utere tuo ut alienum non ledas*: that is to say, no man shall do anything by which his neighbour may be injuriously affected, and each person must so use his property and his rights as not to harm any one else.

This common-law doctrine had become practically obsolete, because there was no machinery in existence to enforce it; and the present generation inherited a legacy of misery amongst the poorer classes, owing to the absence of regulations in the building of houses as the towns increased in size, absence of water supply and drainage, and other matters which I have mentioned.

Mr. Mundy's calculations show us what have been the general results of the sanitary improvement of the nation. The death-rate of 1838-42 for England and Wales was 22·07 per 1000; that of 1880-84 was 19·62 per 1000; and the deaths from zymotic disease, which averaged 4·52 per 1000 in the decade 1841-50, were reduced to 2·71 per 1000 in the years 1880-84. It is, however, curious to note that the improvement in urban districts does not appear to have kept pace with that in rural districts, for it appears that whilst the deaths from zymotic disease in certain urban districts have declined from 5·89 per 1000 in the decade 1851-60 to 5·12 per 1000 in the decade 1871-80, the deaths from zymotic disease in rural districts in the same interval have declined from 2·77 to 1·67 per 1000.

In order to form an estimate of the saving of life due to sanitary measures, we may assume that sanitation remained in abeyance, and calculate what the death-rate, according to Dr. Farr's formula, would have been in consequence of increased density of population, and compare that with the actual death-

rate; upon this assumption we find that the sanitary improvements only began to tell after the cholera epidemic of 1848-49. In the decade 1841-50, indeed, it appears that the death-rate was actually larger than that due to the increased density of population. But in the following decade, the sanitary improvements began to produce their effect, and this effect has gradually increased. In the decade 1850-60, the annual average saving of lives in England and Wales from sanitary improvements was 7789; in the decade 1860-70, it rose to 10,481; in the decade 1870-80, it was 48,443; and in the five years 1880-84, the average annual number of lives saved by sanitary improvements have been 102,240.

The present social condition of the people affords an equally striking evidence of general improvement. Food and clothing are cheap; the construction of streets and new buildings in our towns are regulated; houses are improved; overcrowding and cellar dwellings are prohibited; the common lodging-houses are controlled. Petroleum affords a brilliant light to the poor in country districts which are beyond the reach of gas or of the electric light, and who were formerly dependent on rushlights. Water supply is rarely deficient; removal of refuse is enforced. But there remains much still to be done. Numbers of the people are still crowded in wretched dwellings; our rivers are polluted and subject to floods; our infectious diseases are not properly cared for.

The main feature of the legislation of the past half-century is the recognition of the principle that when large numbers are congregated together in communities, the duty of preventing injury from this aggregation rests on the community; and if this principle is duly acted on, if in all aggregations of population free circulation of air is encouraged by preventing the crowding together of buildings; if refuse is immediately disposed of, so as to cause no injury to any one; if pure water be provided; if we isolate infectious diseases; and, above all, if we are fortunate enough to retain the blessing of cheap food and clothing, we shall not transmit to our posterity a similar legacy of misery to that which we inherited.

ON THE FORMS OF CLOUDS¹

THE object of the paper was to explain a theory with regard to the principles that may have the greatest effect in producing the leading cloud-forms. Neglecting occasional and exceptional influences, the author stated that the causes with which his paper dealt might be classed under three heads: (1) the diminished specific gravity of the air when more or less charged with invisible vapour, (2) the differential horizontal motion of the atmosphere, (3) the vertical motion in the atmosphere produced by the heat of the sun expanding the lower air. The first of these was universally recognised as the initial cause of the cumulus, or first-born primary cloud. It was produced when there was so much vapour generated in the lower atmosphere that the vapour-laden layer projected up within the limit of condensation. Of course the vapour below this limit would itself become condensed if cooled in the course of its travels. During the formation of the cumulus, calm was supposed to prevail. When the atmosphere was in motion, its differential horizontal movement produced the first important modification. Retarded by friction and other causes, the lower portion of the cumulus moved more slowly than the upper, and the cloud sheared over into a slanting position, and ultimately became the cumulo-stratus. A young cloud was thus distinguishable from those that had travelled even a short distance. In this climate large well-developed cumuli, though common in summer, were seldom seen in the cold season. The majority of the clouds of the first stage seen here were born in warm latitudes, and, coming as travelled cumuli, showed more or less the condition of the cumulo-stratus. The invisible vapour was subject to this same shearing motion, and far-travelled water-vapour would, on its rising, as it soon does in this climate, to the height necessary for condensation, at once take the shape of the stratus. In the next stratum above, Mr. Glaisher's investigations in his balloon ascents showed a rather rapid change to a drier atmosphere. Here were found the cirro-cumulus, and cirro-stratus. The differential motion of the atmosphere, though diminished, was still an important agent, and produced results that were not possible in the more bulky and dense clouds of the lowest range. When the sun's

¹ Abstract of a Paper read at the Birmingham meeting, 1886, of the British Association, by A. F. Osler, F.R.S. Communicated by Prof. Balfour Stewart, F.R.S.