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 faciet in suo quod nocere possit alieno;* and *Sic utere tuo ut alienum non lædas:* 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 CLOUDS[1]

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.

heat expanded the lower atmosphere, the upper cloud-stratum would be lifted, flattened, and broken into patches, the result being a mackerel sky. Should, however, the expansion in the lower atmosphere take place very slowly, it was possible that the cloud, though thinned, would remain unbroken. Rapid motion of the atmosphere would elongate the cloud in the direction of motion; and, if accompanied by expansion from below, would rupture the cloud into ribs or bars at right angles to the current. If the mass of the cloud were stationary or moving slowly, prominent parts might be drawn out into "mares'-tails."

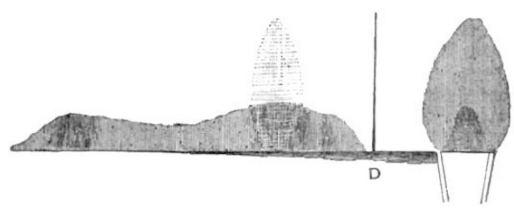
FURTHER EXPERIMENTS ON FLAME

IN my former paper, published in NATURE, vol. xxxi. p. 272, I showed that there are two classes of continuous spectra, viz. those due to an incandescent precipitate, in which case the flame has the power of reflecting and polarising light; and, secondly, flames that possess no reflecting power, but give a soft continuous spectrum without maxima or minima.

Of this second class is carbonic oxide, which gives, at normal pressures, a fairly bright, and at increased pressure, according to Dr. Frankland, a very bright, continuous spectrum. I have observed its spectrum recently under reduced pressure, using an apparatus similar to that described by Dr. Frankland in his "Experimental Researches," p. 884 *et seq.*

I had considerable difficulty at first in keeping the flame alight at anything like low pressures, and finally adopted a glass jet, of a trumpet shape, increasing very gradually from 1 millimetre to 3 millimetres in diameter, the flame being farther shielded from draughts by a wide disk of cork 10 millimetres below the mouth of the jet.

Experiment 1.—Carbonic oxide was burnt in oxygen. The flame was densest close to the jet, and diminished in brightness



Flame of carbonic oxide burning in oxygen at 60 mm. pressure, with spectrum showing maxima. The continuous spectrum at the bottom is given by the red-hot top of the glass jet.

to the tip, without any definite separation into mantles with a space between. At normal pressure every part of it gave a continuous spectrum.

At about 260 millimetres there began to be a noticeable concentration of the light in the violet and the green in the position of the principal bands of the carbon spectrum. At 120 millimetres the concentration was unmistakable, but the spectrum was still continuous. At 60 millimetres it presented the appearance shown in the sketch. There appeared to be a second maximum in the green—not, however, at all well defined—but the principal maximum was continued upwards into a faint green cloud corresponding to the very faint tip of the flame; this cloud was perfectly isolated, but, unlike the carbon bands, was brightest in the middle.[1] I failed to see a similar cloud over the maximum in the violet, but this might be owing to insufficient light, my pumps being only able to maintain so high a vacuum against a very small flame. Mr. T. Legge, of Trinity, who was with me, observed that the comparative absence of the blue was very remarkable.

My supply of oxygen becoming exhausted, I had to use air. The flame became less bright, and the maxima less marked. By turning it very low, we brought the gauge down to 40 millimetres. The flame still burnt steadily.

Finally, at 60 millimetres pressure, I adjusted the flame to a height of three-quarters of an inch, opened the air-taps, and checked the pumps. The flame increased in brightness and decreased in size to rather more than a quarter of an inch at normal pressure, the spectrum becoming again perfectly continuous.

[1] It is impossible in a woodcut to give a true idea of the extreme faintness of this isolated cloud. It is only visible when the brighter part of the spectrum is hidden from the eye, and the room is perfectly dark.

Experiment 2.—Having the apparatus ready, I repeated Dr. Frankland's experiment of burning coal-gas in air under reduced pressure. He says that "finally, at 6 inches pressure, the last trace of yellow disappears from the summit of the flame, leaving the latter an almost perfect globe of a peculiar greenish-blue tint."

He used a jet contracted at the mouth to 1·5 millimetres. With my much wider trumpet-shaped jet, by turning on more gas I could produce smoke at 160 millimetres so as to blacken the glass chimney. At 120 millimetres the light was noticeably less vivid, the flame having a diluted appearance, but the spectrum showed the usual carbon lines much more sharply defined, the mantles being very much thicker than at normal pressure. With this exception there was no difference caused by the reduction of the pressure to 60 millimetres, and even then, on turning up the gas a little, the ellipsoidal flame became pointed, and the yellow light, giving the incandescence spectrum, re-appeared in the tip of it. It is evident that the trumpet-shaped jet allows carbon to be precipitated in the flame at much lower pressures than the contracted jet. In the same way alcohol heated in a bulb tube burns from the mouth of it with a bright and even smoky flame, whereas it burns from a wick with a blue one.

One phenomenon observed by Dr. Frankland I was disappointed not to see. He says: "Just before the disappearance of the yellow portion of the flame there comes into view a splendid halo of pinkish light forming a shell half an inch thick around the blue-green nucleus; . . . the colour of this luminous shell closely resembles that first noticed by Gassiot in the stratified electrical discharge passing through a nearly vacuous tube containing a trace of nitrogen." He does not speak of having used the spectroscope to determine the nature of this pink glow.

I went considerably below the lowest pressure mentioned in his paper, viz. 4·6 inches, but entirely failed to reproduce it. But I have noticed that very small flames from capillary tubes, observed under a power of 100 in the microscope, are sometimes tinged with rose-colour in the outer mantle, from a very faint trace of sodium orange light mingling with the blue of the soft outer mantle; and I think that the jet he used or the glass chimney may have been sufficiently heated to give a rosy tinge to the flame.

One other point I would call attention to. The appearance of the gas-flame at low pressures is precisely like that of a very small gas-flame under the microscope. The inner mantle appears to be bordered with bright green light, due to the principal green band of the carbon spectrum extending slightly beyond the others. Beyond this, again, comes a zone of violet light due to the band in the violet, and in most cases this extends nearly, if not quite, to the outer mantle. At ordinary pressures this can only be seen with a magnifying-glass, except with a special burner; but the *in vacuo* flame is, as it were, magnified as to its structure, which is thus visible to the naked eye. This fact suggests that flames may in a sense obey Boyle's law, *i.e.* that the space required for complete combustion under given conditions varies inversely as the pressure. I am continuing my experiments. GEORGE J. BURCH

SOCIETIES AND ACADEMIES

LONDON

Royal Society, November 18.—"The Coefficient of Viscosity of Air. Appendix." By Herbert Tomlinson, B.A. Communicated by Prof. G. G. Stokes, P.R.S.

In the previous experiments by the author on this subject, the coefficient of viscosity of air was determined from observations of the logarithmic decrement of amplitude of a torsionally vibrating wire, the lower extremity of which was soldered to the centre of a horizontal bar. From the bar were suspended vertically and at equal distances from the wire a pair of cylinders, or a pair of spheres. The distances of the cylinders or spheres from the wire were such that the *main* part of the loss of energy resulting from the friction of the air may be characterised as being due to the *pushing* of the air.

Acting on a suggestion of Prof. Stokes, the author proceeded to determine the coefficient of viscosity of air by suspending a hollow paper cylinder about 2 feet in length and half a foot in diameter, so that its axis should coincide as to its direction with the axis of rotation. The cylinder was supported by a light hollow horizontal bar, about 7 inches in length, to the centre of which the vertically suspended wire was soldered. The wire