Report on the air of Glasgow, chiefly relative to enclosed spaces and smoke / by Wm. J. Dunnachie in co-operation with the Medical Officer of Health.

Sanitary Department—Glasgow.

REPORT

ON THE

AIR OF GLASGOW,

CHIEFLY RELATIVE TO ENCLOSED SPACES AND SMOKE.

BY

WM. J. DUNNACHIE,

IN CO-OPERATION WITH THE MEDICAL OFFICER OF HEALTH.

PRESENTED TO THE COMMITTEE OF HEALTH OF THE MAGISTRATES AND COUNCIL OF GLASGOW, MAY, 1879.

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1879.

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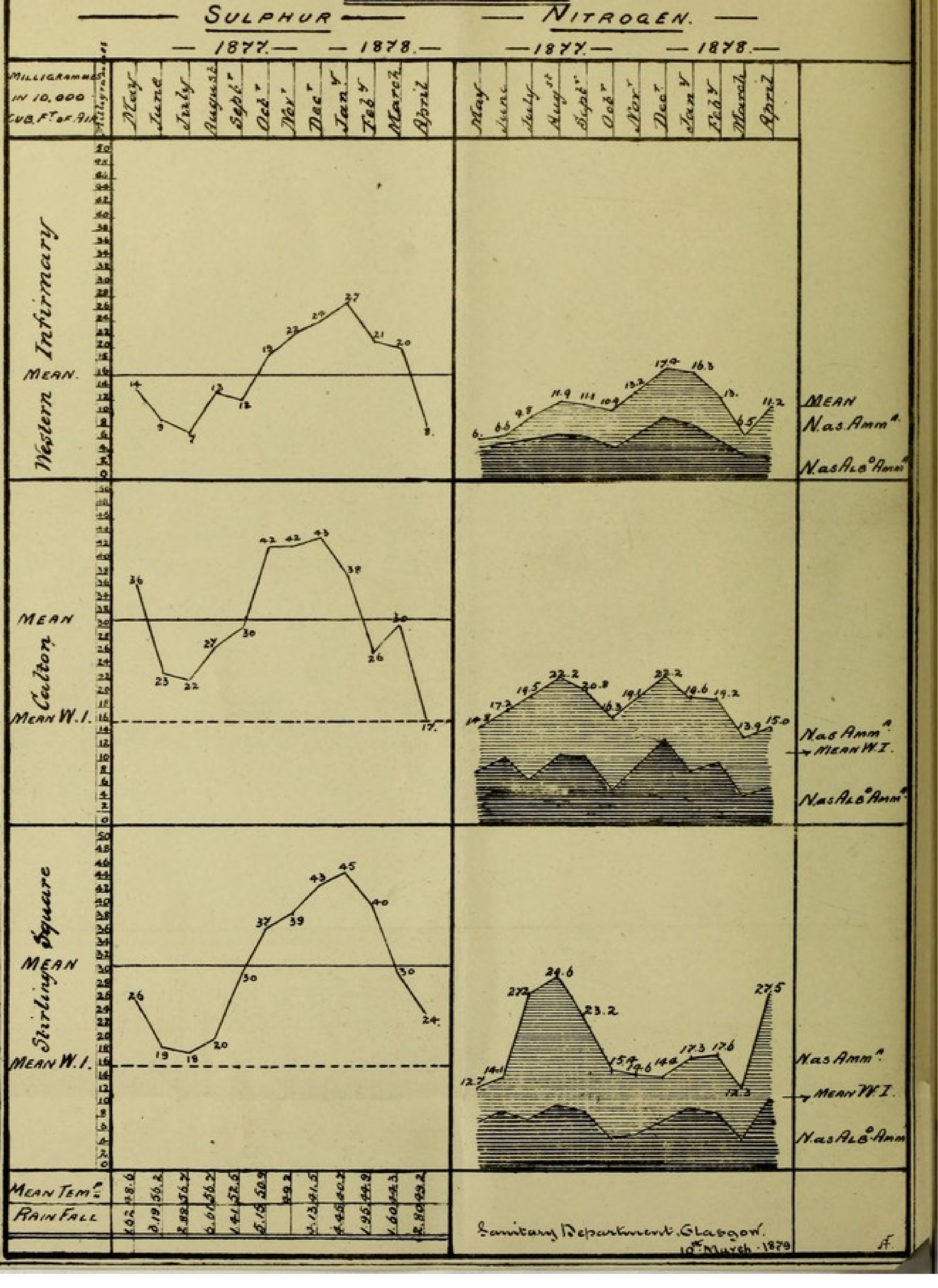
DIAGRAM showing monthly average of Sulphur & Nitrogen (as AMMONIA & ALBUMENOID AMMONIA) in AIR of Western Infirmary, Stirling Square & Calton Districts of Glasgow – 1st May 1877 to 30th April 1878.



Sanitary Department. Glasgow.
10th March - 1879

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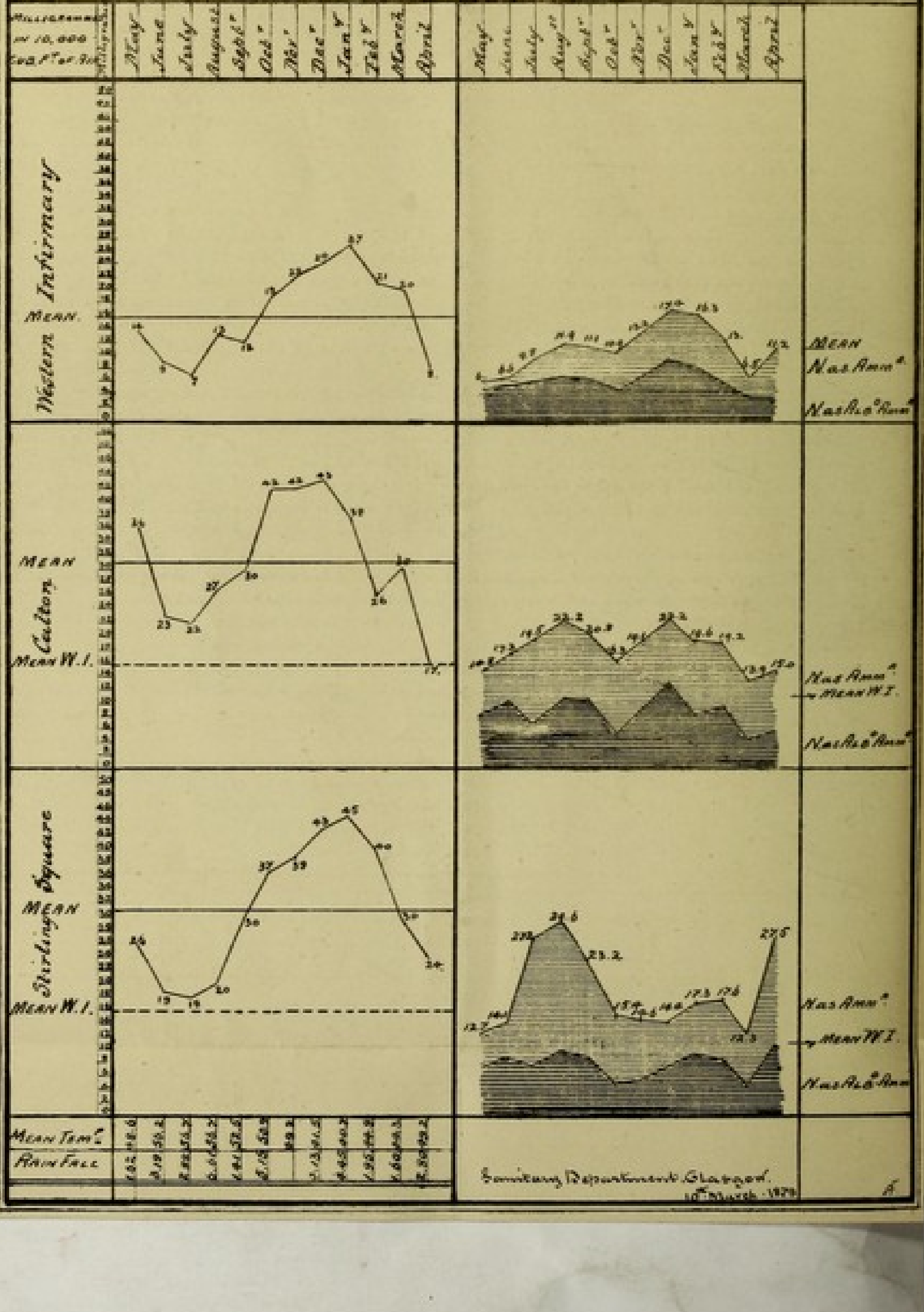

EXPLANATION OF PLATE, WITH REMARKS.

Sulphur.—At each station the mean for the whole year is shown by a continuous line across the diagram.

The Western Infirmary being the most excentric of the three stations, and having therefore the purest air, its mean is taken as a standard, and shown as a dotted line across the centric Calton and Stirling Square diagrams.

It will be observed that not only is the average amount of Sulphur present in the air of the centric stations *above* the average of the Western Infirmary, but at no period of the year is it less than the mean of the Western Infirmary, *i.e.*, the air is never so free of Sulphur at those stations.

The lowest point of the Sulphur line at all the stations is in the month of July. This is coincident with the circumstance that "Glasgow Fair" falls in this month. It began in 1877 on 12th July, and practically leads to a cessation of work as well as to a partial exodus of the people during the latter half of the month.

The Sulphur reaches its highest point in the winter months at all the stations. The absolute highest being in January at the Western Infirmary and in Stirling Square, and in December in Calton.

Nitrogen.—The curves show the variations in Nitrogen in two forms, as actual and potential ammonia, the proportion of each being indicated by shading.

As in the Sulphur diagrams the mean line for the two Nitrogens combined, as observed at the Western Station, is marked on the diagrams of the other stations, but by a marginal arrowhead in place of a line, to avoid confusion. Like the Sulphur, the Nitrogen present in the air of the centric stations is *always* above the mean of the excentric station.

Whether we follow the range of the sum of those Nitrogens, or of each singly, it appears that at each station there are two periods of excess, one in the summer and one in the winter.

But there are differences in the degree of these two periods of excess at the different stations. In the excentric station (Western Infirmary) the summer rise is but slight, and the winter rise is much the greatest. In the Calton district both elevations culminate at the same point, *i.e.*, exactly the same proportion of Nitrogen marks the acme both in summer and in winter. On the other hand, in the Stirling Square district the summer acme is much higher than the winter, which is but slightly marked, though quite distinct. It is also remarkable that the greater portion of this summer excess of Nitrogen in the Stirling Square district is in the form of actual ammonia.

Comparing the Sulphur with the Nitrogen acmes, it appears that the summer excess of Nitrogen coincides with the summer minimum of Sulphur, and the winter excess of Nitrogen with the winter maximum of Sulphur.

It is also remarkable that the July depression in the Sulphur acme is in the two centric stations contemporary with a decided depression in the acme of potential Nitrogen. In the excentric station there is no such depression, and in all the stations the actual Nitrogen or the ammonia increases continuously throughout the Sulphur depression.

The only other analyses which represent or aspire to represent the average condition of the air of one locality continuously, night as well as day, for a succession of months, are those made at the Observatory of Montsouris, in the neighbourhood of Paris. These have been carried on without interruption since November, 1876, by aspiration with an arrangement on the principle of Sprengel's pump, through "roses" and solutions similar to those employed in the Glasgow observations. Those two sets of observations present the first opportunity of making seasonal comparisons on a sufficient scale. The defects pointed out by Mr. Dunnachie do not deprive Mr. Dixon's observations of value for such a comparison. They differ from the Parisian (so far as yet published, though we may shortly expect results from the various quarters of Paris), in that they afford a gauge of urban air. Still it is interesting to find them in accord in their most startling features. Although in the *Montsouris Annual* for 1878 it is stated that the amount of ammonia is greatest during the hot season (1876-77), still the reporter points out (p. 508) as remarkable, that in the first ten days of July there was a minimum amount. In fact, it was the same as in the first ten days of February, the mean temperature of the former month being 65°F., of the latter 44°·6 F. But in the *Annual* for 1879 (for the year 1877-78), which is the first set of observations for the whole round of a year, the reporter points out (p. 425), that it is during the hot season that the ammonia is least, the mean being $2^{\text{mg.}}3$ per 100 cubic metres of air, against $3^{\text{mg.}}2$ for the winter season. The maximum observation was in the third decade of October. There are no records of the potential ammonia to compare with the Glasgow results, but the carbonic acid was much higher in the hot six months than in the cold ($34^{\text{lit.}}3$ to $31^{\text{lit.}}2$).

The Glasgow results, confirmed by the Parisian, are startling and irreconcilable with the general canons of interpretation as to chemical source and hygienic importance hitherto laid down. We have been taught to accept the two forms of ammonia as absolute indices of the salubrity of the air, inasmuch as they were supposed to originate chiefly in the slow combustion of putrefaction, whereas they are proved by Mr. Dunnachie's experiments to be also largely derivatives of the rapid combustion of fire applied to coal or wood. This circumstance as a theoretical fact has been thoroughly recognized by chemists, but its practical importance in the etiology of the ammonias in air has not been recognized, as the following quotations amply prove:—

"This ammonia will measure the amount of sewage matter thrown into the atmosphere, and ought to be greater where there is a greater exposure of manures to air, and especially to air and water."—*Angus Smith*, p. 432.

"It has already been explained that this is the ammonia [Albuminoid or Potential], which comes from organic substances, either alive, as animals and vegetables, or dead and in decay."—*Angus Smith*, p. 435.

"The ammonia is one measure of the sewage of the air: it is the result of decomposition."—*Angus Smith*, p. 277.

"This Table [*i.e.*, of Albuminoid Ammonia] is a measure of sewage of air not purified, and includes the most dangerous substances, germs of living things vegetable and animal."—*Angus Smith*, p. 270.

Such are Dr. Smith's rules of interpretation, although at p. 443 of his classic book on Air and Rain we find the following clear enunciation of the fact regarding "Tarry matters in the Air":—

"Now, I have ascertained by experiment that some of these products are capable of decomposing manganates, and *when judging of the wholesomeness of a district by the amount of organic matter, care must be taken not to be misled by this.* The error cannot be high, because if there be one half of tarry matter, capable of decomposing a manganate, to 100 of coals, then the 99 of coals taken as carbon, which is near enough for the case, will give 363 of carbonic acid, or there will be only 1 of tarry matter to 726 of carbonic acid. The acid must therefore increase immensely before its accompaniment the tar can produce any effect. Besides, only a part of this tarry or distilled matter is decomposable during the time of an ordinary experiment. It must not, however, be forgotten."

In this depreciation of the probable importance of tarry distillates, Dr. Smith forgets the physical condition in which they may exist in the air, *e.g.*, that which is described by Dr. Frankland in a paper "On Dry Fog," recently laid before the Royal Society, in which he says:—

"From our manufactories and domestic fires vast aggregate quantities of coal-tar and paraffin oil are daily distilled into the atmosphere, and condensing upon, or attaching themselves to the watery spherules of fog or cloud, must of necessity coat these latter with an oily film, which would in all probability retard the evaporation of the water, and the consequent saturation of the interstitial air." (January 9th, 1879).

Mr. Dunnachie's observation as to the obstruction of his "roses" with these tarry products, shows that the same mechanical difficulties which interfere with the aspiration of minute particles as contrasted with gases, attend the estimation of those condensed products of rapid combustion. They exist as molecules, and are therefore not dispersed by diffusion.

The following quotations are from a recent work by Dr. C. B. Fox :—

"Ammonia, which is in itself harmless, is a product of animal organic matter, and is present in air in exceedingly variable quantity, out of which it is washed by the great air cleanser, rain." (p. 66).

"Ammonia generally occurs in the air as a salt, such as the carbonate, chloride, nitrate or nitrite, derived from decomposing animal matters, such as manure, sewage, effete matters from the lungs and skins of men and other animals." (p. 191).

Taking those statements as the canons of interpretation of the diagrams of Glasgow air, it is obvious that they are irreconcilable with their accuracy, but having regard to the Sulphur curves and to the two sources of the Ammonias in urban air, they become chemically comprehensible, but at the same time hygienically puzzling. The question is, in each result how much of this nitrogen is derived from decomposition, and how much from combustion? And in the present position of chemical analysis, without information as to the season of the year, whether the time is day or night, the locality, the sulphur compounds, &c., to guide us to the probabilities in each case, the question cannot be satisfactorily answered. Even with all these side-lights the answer must remain one of likelihood in most cases. In short, for Sanitary purposes the guidance of the chemistry of air is like that of the chemistry of water, not absolute, but to be controlled by concurrent information as to the natural history of each sample.

There are two ways of circumventing and making up for these deficiencies of chemistry until they are supplied by a more refined analysis—(1) by creating special experimental circumstances or choosing simple cases, where one or other source of impurity is excluded, and so getting chemical support to sanitary conclusions as to the noxious effects of various conditions, *e.g.* the structure of buildings, the presence of sources of nuisance, and (2) by appealing to the microscope, and to botanical and physiological or pathological experiment. The potential ammonia is of sanitary importance in so far as it indicates the presence of microbiods—elementary forms of organized life or fragments in transition from structure to their chemical elements. We could never be satisfied with such a roundabout way of determining the origin and nature of visible seeds as would be afforded by analyzing the products of their destructive distillation, when we have it in our power to plant or sow them in congenial soil and *see* what they produce. So with those seeds or solid bodies which are sometimes not even visible through the microscope, though their growth or development soon brings them within the sphere of observation and study as distinct forms, or by their effects on the media which sustain them. The methods of Pasteur and Pouchet, Cohn and Lister, are necessary to give precise meaning to the work of Angus Smith and other chemists in the region of air, and of Wanklyn and Frankland in the region of water. Such investigations demand the labour and accumulated knowledge of a lifetime, but much has been done, and much is being done, especially in Germany, and at Montsouris, in France, in direct connection with the systematic chemical analysis of the air.

JAS. B. RUSSELL, M.D.

1 Montrose Street,
May, 1879.

REPORT ON AIR ANALYSIS.

Since issuing our last Report (for the six months ending April, 1878) it has been found necessary to alter very materially the method of air washing adopted by Mr. Dixon.

In his (Mr. Dixon's) explanatory remarks, accompanying all past Reports, he says :—"The 'marks "'of interrogation' in the Tables indicate results departing so far from the normal character as to be clearly "erroneous, while it is impossible to state with certainty the cause of error."

Whilst engaged in the preparation of the last Report, I was somewhat struck by the excessive divergence which many of the results showed from the "normal character;" but, having been solely engaged in the chemical department of the investigation, and being satisfied that the solution of the difficulty did not lie there, I was, at that time, able to do little more than theorise as to the cause or causes of such divergence. In this I was assisted by the fact that, with very few exceptions, when the result was above the "normal character" the volume of air washed was small, and *vice versa*. This was not merely a characteristic of those results departing from the "normal character," but held good even in the case of those which were in strict accordance with it. (See Table I. in the Appendix.)

From this fact I concluded that, in all probability, when a small volume of air produced a high result, it had flowed continuously, so that the washing of that air had occupied the entire period during which the samples had been taken, and hence would be more thoroughly deprived of its impurity than would a larger volume of air which had been washed in a corresponding period. I have stated that there were exceptions to this rule. In some cases I found that a small volume of air gave a correspondingly small result. This I attributed to a reduction of the water pressure (a thing by no means uncommon) to such a degree as to cause, for a portion of the period, an entire stoppage in the flow of air through the solutions.

To illustrate these points I have, in Table I. in the Appendix, reproduced from last Report the figures given for January in Tables I., II., IV., and V., for the following Stations:—Stirling Square; Hospital, Kennedy Street; and Calton, to which I have added the volume of air in cubic feet from the washing of which each result was obtained; as also those results which departed so far from the "normal character" assumed by Mr. Dixon as to seem to warrant deletion.

To place the subject beyond the region of doubt I had two samples of the air of the Laboratory washed simultaneously. For this purpose I prepared two sets of absorbers, charging them with a solution of caustic potash for the absorption of carbonic acid. To ensure uniformity in the composition of the air supplied, I united the initial "rose" of each set to one common service pipe. Through one set I caused the air to pass at double the rate of the other. The results of these and two other confirmatory experiments done on a different date were as follows:—

Volume of Air in Cubic Feet.	Rate per Hour.	Volumes of CO_2 in 10,000 vols. of Air.
50	$2\frac{19}{28}$	4·956
25	$1\frac{19}{56}$	7·555
50	$2\frac{6}{19}$	4·854
25	$1\frac{12}{19}$	8·312

These figures clearly prove that complete absorption of the carbonic acid had not taken place in those cases where the air had been passing at the rate of $2\frac{19}{28}$ and $2\frac{6}{19}$ cubic feet per hour, and that hence, in the absence of perfect washing, which would yield absolutely comparable results, no results were of any comparative value unless such as had been obtained from a uniform rate in the flow of air.

In my explanatory remarks in last report, I stated that each case of absorbers, previous to being taken from the Laboratory to the "Stations," was carefully adjusted so as to allow of the passage through each series of, as nearly as possible, the same volume of air per hour, and hence, when variations were found to the extent of, in many cases, over 100 cubic feet in the forty-eight hours, notwithstanding the nicety of adjustment, it was clear that mere variation in the water pressure was not sufficient to account for the entire phenomena as, in such a case, each series of absorbers would have been equally affected. Close observation revealed the fact that, even supposing uniformity of draught, other causes were at work on the volume of air washed. (1) Not the least of these was the use of beads for the further subdivision of the air issuing from the perforations in the ends of the "roses." I found that the air, on escaping from the "roses," instead of dispersing amongst the beads, took the direction of least resistance, gradually displacing the beads and ultimately forming for itself an unobstructed channel through which it passed in an unbroken column, the surface alone of which was subjected to the action of the solutions. The nature of this displacement varied in almost every absorber, producing a variable and very material difference with regard to absorption and volume of air passed. (2) Meters which had been in use for several months gave incorrect registration, whilst the pressure necessary for the movement of the internal mechanism differed with almost every meter, the consequence being that under any pressure different volumes would be passed. (3) Again, other causes, such as irregularity in the number and size of the perforations of the "roses," unequal height in the columns of the solutions in the absorbers, might tend to produce variations in the absorption of the impurities; but, with due care and strict uniformity in the mode of charging the absorbers, these causes are not sufficient to materially influence the result, provided only uniformity of flow is secured. To this the following experiments bear testimony:—

Volume of Air in Cubic Feet.	Rate per Hour.	Volumes of CO_2 in 10,000 vols. of Air.	
50	3	4·196	From the same air.
50	3	4·196	
50	3	4·545	From the same air.
50	3	4·556	

It was considered inexpedient to continue the observations at the six "Stations" erected by Mr. Dixon; accordingly they were dismantled, and at the request of Dr. Russell I made preparations for the simultaneous examination of the air of confined places such as "hollow squares" (the spaces enclosed by blocks of building) and the air of the surrounding streets. The first of this series of observations was conducted at a "hollow square" off Claremont Street. The south-west corner of this enclosure is bounded by a Church, the Managers of which kindly permitted me to erect two Stations—one at the front and one at the back of their property—for the simultaneous collection of samples of air from Claremont Street and the Court.

In commencing operations here I abandoned the use of beads, and increased the number of the absorbers in each series from three to four.

During the first month my endeavours were chiefly directed to the obtaining, automatically, a uniform rate in the flow of air through the various sets of absorbers, but I was ultimately forced to the conclusion that, to render the water pressure serviceable as a motive power, it would be necessary to secure self-regulating valves to be placed on the "inlets" of the various meters. Meanwhile I placed my assistant to watch the progress of the currents, giving him instructions to maintain a flow of not more than three feet per hour. By this arrangement night air was excluded, but, for the purposes of our investigation, this exclusion was unimportant.

The difference in the results obtained, even by this imperfect arrangement, as compared with those by the old, was most marked; from having no particular "character," they now began to assume a uniformity which was pleasing and hopeful. The contrast will be obvious from Table II. in the Appendix. The observations made at North Street, Pollok Street, and Argyle Street (the results of which are given in Tables III., A, B, and C), were conducted in the same manner as at Claremont Street, with this exception, that, from the difficulty of obtaining a water-supply, recourse was had to a double-acting air-pump. (See page 5 of last Report.)

While these results are comparable, the rate of flow being uniform, the perfect absorption of the impurities of the atmosphere and the consequent obtaining of absolute results were still to be accomplished. When our observations were interrupted by the late severe frost, I began a series of experiments bearing upon this point which have terminated most successfully.

At the outset I found it absolutely necessary to obtain a self-regulating valve or governor provided with the means of adjusting it to allow of the passage of any required volume of air per hour within certain limits. Of the various patents which have come under my notice, "Borradaile's Patent Dry Metallic Governor for Street Lamps"* has given the most satisfactory results, from the fact that it works equally well with suction as with direct pressure, and, by a very simple arrangement, can be adjusted so as to pass from four cubic feet to the smallest fraction of one cubic foot per hour.

Having determined to adopt this governor, I prepared three sets of absorbers, increasing the number in each set from four to six. The first series I charged with 100 cubic centimeters of caustic potash solution, $25^{c.c.}$ of which I divided between the last two absorbers. The second series was charged with dilute sulphuric acid, the last two absorbers receiving $15^{c.c.}$ each. The third series was charged with a dilute solution of permanganate of potash, the last two absorbers receiving $15^{c.c.}$ each. After several trials I found that, on

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* Manufactured by Messrs. Borradaile & Wright, 7 Union Court, Old Broad Street, London, E.C.

passing 25 cubic feet of air through each series at the rate of $1\frac{12}{19}$ cubic feet per hour, the last two absorbers of the first series yielded, on precipitation with chloride of barium, 0·5115 grammes of carbonate of baryta, whilst $25^{c.c.}$ of the original potash solution gave 0·5157 grammes carbonate of baryta. Both of these estimations were made by the specific gravity process, and I believe the slight excess in the latter case to be due to the separating out of a small quantity of barium chloride crystals during the time allowed for the subsidence of the precipitates, which was less protracted in the former case than the latter. I do not found this opinion upon anything observable in the latter precipitate, but from the fact that, if a sufficient length of time be given, a large quantity of barium chloride crystals will separate out, provided the amount of carbonic acid present be small.

The contents of the last two absorbers of the second set were distilled, and $100^{c.c.}$ of the distillate gave, with $1^{c.c.}$ Nessler reagent, a colouration equal to that given by $0·9^{c.c}$ of a solution of chloride of ammonium, the strength of which was $\frac{\text{Normal}}{1000}$. A blank experiment (see last Report, page 6), carried out under similar conditions, gave $0·9^{c.c.}$ as a reading, showing that the impurity in the first case was not due to the air passed.

The contents of the last two absorbers of the third series were tested for sulphur, and gave a colouration equal to that produced by $0·8^{c.c.}$ of a solution of bichromate of potash, the strength of which was $\frac{\text{Normal}}{200}$. A blank experiment gave the same result. (For a full account of this process see last Report, page 6.) Thus, the point has at length been reached when the results obtained by this method of air washing can be made available, not only for trustworthy comparison with each other, but also with those obtained by other methods. The cost of carrying out continuous observations has also been reduced to a minimum, as the washing and regulating of the air are both conducted automatically. Furthermore, by the use of Borradaile's Patent Regulator, the variations produced by the internal economy of the meters, to which I have already referred, have been overcome, as an excess of water pressure over that absolutely required to produce the flow of air through the various solutions can with perfect safety be maintained. To ensure accuracy in the records of the meters, I have arranged to have them tested once per month, and adjusted when necessary, and, lastly, though the washing is perfected by passing the air through four absorbers at the rate of $1\frac{12}{19}$ cubic feet per hour, six absorbers will, for the future, constitute a series, so as to preclude the possibility of error.

The only change in the analytical department of the investigation which I have found it necessary to make is the disuse of copper retorts for the distillation of the ammonias, and the substitution of glass ones. It was impossible to tell when the copper retorts were clean, and hence the liability to error from this source was great.

In note 4, at the end of the July, August, September, and October reports, Mr. Dixon says:—"An examination of the fluctuations presented in the foregoing Tables . . . . shows, amongst other things, that a rise in the nitrogenous matters contained in the air takes place during the summer months."

In view of this statement, Dr. Russell has prepared diagrams [see Plate] showing the monthly variations in the quantities of ammonia, albuminoid ammonia, and sulphur in combination, as presented by the Tables for the entire year ending April, 1878. These show that whilst there is an increase in the summer, there is another, and sometimes greater, increase in the winter months. The results, it is true, were obtained by a process which, as I have proved, was far from accurate, but yet, taking them *en masse* over the year, their general indications may be trusted, especially as these agree with the observations of others. Thus, I find the following in page 237 of Dr. Angus Smith's laborious work on air and rain:—

"M. Bineau has found as an average—

In Winter,............	16·3	milligrammes of	ammonia	per litre	(rain).
In Spring,............	12·1	,,	,,	,,	,,
In Summer,..........	3·1	,,	,,	,,	,,
In Autumn, ...	4·0	,,	,,	,,	,,

These observations were made at Lyons Observatory. Let us suppose for one moment that the great bulk of the ammoniacal salts found in the atmosphere of towns is the product of the spontaneous decomposition of organic matter; it would follow from Bineau's average and the diagram that the cold of winter is much more favourable to organic decomposition than the heat of summer.

If Bineau's averages and the diagrams show anything, it is that there is another and more prolific source of ammonia than the spontaneous oxidation of organic substances. What then is this more abundant source which would tend to increase the winter average to a greater degree than that of the summer? The Tables given in the Appendix show that, on the average, the quantities of ammonia and albuminoid ammonia found in the air of the courts are less than those from the air of the streets. To confirm the accuracy of these indications, I had two samples of air from the middle of Claremont Street washed, and two from the centre of the court referred to in Table II. The averages of the results are given in Table IV., and show a distinct excess of ammonia and albuminoid ammonia in the street air. I believe that the excess in the street as compared with the court and the excess in the winter as compared with the summer are due to one and the same cause, viz., smoke from the combustion of coal, wood, and other organic substances. I am aware that ammonia is decomposed by being subjected to a certain degree of heat, but only a portion of that produced during the combustion of the substances named is so affected under ordinary circumstances.

Dr. Angus Smith says, at page 238 of his Book on Air and Rain :—" Volcanoes in a state of activity throw out a notable quantity of ammonia salts. They are given off also in calcining organic matter and in the combustion of coal." Again, at page 246—" Ammoniacal salts increase in the rain as towns increase. They come partly from coal and partly from albuminoid substances or protein decomposed." The smoke, issuing as it does in a more or less heated condition, rises above the point of issue and is carried hither and thither by currents of air which ultimately find their way into our streets, but seldom penetrate such enclosures as " hollow squares." Hence the excess of smoke in the street as compared with the court, and the consequent excess of ammonia and albuminoid ammonia. Upon this hypothesis it is natural to expect that there would be an excess of ammonia and albuminoid or potential ammonia in the winter, as the smoke is produced in greater quantity and is held in suspension by watery vapour in the form of fogs, &c.

As I was unable to obtain actual analyses bearing upon this subject, carried out by other observers, Dr. Russell secured for me a room at the Small-pox Hospital, Kennedy Street, the air of which I tested for ammonia and albuminoid ammonia, and afterwards introduced a moderate volume of smoke from a slow fire of coals, and again tested. The results of these and other similar experiments will be found in Table IV. of the Appendix.

It is a well ascertained fact that the air contains less impurity after a shower of rain than before it, due to the washing to which it has been subjected. It follows then that the analysis of the rain will give a very reliable indication of the state of the atmosphere through which it has passed, and that the degree of purity will vary with the length of time elapsing between the commencement of the shower and the times of collecting the different samples.

" M. Boussingault found (Paris) :—

" Commencement of Shower,	4·0	milligrammes of ammonia	per	litre.
" End,	0·5	,,	,,	,,

" During another series of observations he found :—

" First part of Shower,	4·0	milligrammes ammonia	per	litre.
" Middle,	2·0	,,	,,	,,
" End,	0·5	,,	,,	,,

" Another series :—

" Beginning,	1·15	,,	,,	,,
" Further on,	·70	,,	,,	,,
,,	·20	,,	,,	,,
,,	·10	,,	,,	,,
" End,	·03	,,	,,	,,

" After a cessation of several hours in the rain, he found at the beginning 1·13 milligrammes," or nearly as much as he found at the beginning of the first shower.—(See " Air and Rain," page 235.)

It would appear from these observations that the source of this atmospheric pollution is indeed a prolific one, for, notwithstanding the degree of purity which had been attained at the end of the first shower, a few hours sufficed to render the air as impure as at first. When we view this in the light of the fact that, however prolonged the showers may be, the last drops contain traces of ammonia, we conclude that either the source of the ammonia remains active, notwithstanding the rain-fall, or that, by atmospheric commotion and diffusion, fresh portions of air are continually finding their way into the region of rain-fall. I am inclined to accept of the former theory, and, if it be the true one, I think it would be obviously erroneous to look upon decomposing organic matter as being, under the circumstances, capable of producing the effects above referred to, and I see no other source except smoke adequate to do so.

In judging of the healthfulness of any particular town or locality by the quantities of ammonia and albuminoid ammonia contained in the air, great care must be exercised and hasty conclusions avoided, as the physiological effects of these compounds, or rather of their accompaniments, depend entirely upon the origin of such compounds, and that locality or town which shows the smallest percentage of such atmospheric impurity, may nevertheless be the most dangerous to health. It does not therefore follow that because less ammonia was found in the square than the street, the latter would be less conducive to health than the former, as it is highly probable that the great proportion of that found in the courts is due to the decomposition of organic matters, chiefly of animal origin, and, in consequence, may be accompanied by the germs of disease.

Referring again to the Tables in the Appendix we find that the sulphur compounds predominate in street air. This fact confirms our opinions regarding the chief source of the ammoniacal salts and undecomposed organic matter found in street air.

Lastly, it will have been observed that the carbonic acid is in excess in the court compared with the street, due, I believe, to the fact that the apartments, the windows of which open into the court, consist almost entirely of bedrooms and kitchens, and constitute the principal living rooms of the inhabitants Add to this the quantity of carbonic acid produced by external decompositions, and view the whole in the light of the fact that the atmospheric renewal is much less than in the open street, and the result does not at all appear strange.

WILLIAM J. DUNNACHIE.

1 Montrose Street,
February, 1879.

DESCRIPTION OF THE "STATIONS" REFERRED TO IN THE TABLES.

The results given in Table II. were obtained at Claremont Street and an adjoining Court, which is bounded by properties in Kent Road on the north, Breadalbane Street on the east, Dover Street on the south, and Claremont Street on the west.

This is by no means a bad specimen of the "hollow square," as the occupants of the houses are almost entirely such as belong to the respectable working-class. The erections within this enclosure consist of four washing-houses, four dry ash-pits and a number of coal-cellars. The height of the stations above ground level was at the front about 20 feet, and at the back 30 feet, the court being sunk about 10 feet below the street level.

Table III. A contains the results obtained at North Street, and a "cul-de-sac" bounded by properties in Richard Street on the north, Cadzow Street on the east, West Bothwell Street on the south, and North Street on the west. The first two samples were obtained from the south-east corner of the square, and the remaining two from the north-west, which is partially occupied by coal-cellars, washing-houses, ash-pits, and privy. The occupants of the surrounding houses belong to the labouring class. The height of the stations was at the front about 10 feet, and at the back about 6 feet.

Table III. B contains a few results obtained at Pollok Street and a neighbouring court, or rather series of courts, bounded by properties in Paisley Road on the north, South Kinning Place on the east, Houston Street on the south, and Pollok Street on the west. It would be somewhat misleading to designate this enclosure a "hollow square," as within it have been erected three separate blocks of dwelling-houses, a bakery, and large stable, together with cellars, ash-pits, and privies. Admission to the west side of this enclosure is had by means of a wide "close," through which a strong current of air from Pollok Street prevailed during our observations. I placed one of the cases of absorbers in this current, and another about the middle of the space between the first row of the enclosed tenements and the properties fronting to Pollok Street. The second sample was taken from the same central position in the court, and is compared with Pollok Street air as obtained from the window of a dwelling-house about 15 feet above ground level. The last sample was taken from the middle of a narrow passage separating the first row of enclosed tenements from the second. It also is compared with Pollok Street air. The height of the stations in the court was about 6 feet.

Table III. C contains the results obtained in Argyle Street and Binnie's Court, which is bounded by properties in Argyle Street on the north, Oswald Street on the east, and on the south and west by enclosed tenements. The only erections within this square are a large ash-pit and privy. The height of the stations would be at both front and back 15 feet.

In all the foregoing observations the washing was conducted without the use of beads; four absorbers instead of three constituted a series, and, with the exception of those results given in Table II., from 5th July to 30th August, a uniform flow of 3 cubic feet per hour was maintained.

With the exception of the carbonic acid, the amounts of the substances estimated are expressed in units of weight per 100 cubic feet of air, the unit being the milligramme. The carbonic acid is expressed in the usual way—in volumes per 10,000 volumes of air.

W. J. D.

TABLE I.

Results Obtained at Stirling Square, Calton, and Hospital, Kennedy Street, under Mr. Dixon's System, showing relation of Volume of Air washed to Impurity obtained.

N.B.—The bracketed results are those which were deleted from last Report, their places being occupied by a "mark of interrogation."

Date.	CARBONIC ACID.						SULPHUR IN COMBINATION.						NITROGEN AS AMMONIA.						NITROGEN AS ALBUMINOID AMMONIA.					
	Stirling Square.		Hospital, Kennedy St.		Calton.		Stirling Square.		Hospital, Kennedy St.		Calton.		Stirling Square.		Hospital, Kennedy St.		Calton.		Stirling Square.		Hospital, Kennedy St.		Calton.	
	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.	Volume of Air.	Impurity.
1878.																								
Jan. 2......	137	3·296	123	3·555	79	3·787	112	0·33	116	0·30	102	0·21	203	·097	203	·061	259	·112	203	·112	203	·109	259	·069
,, 4......	16	(4·389)	97	3·605	94	3·900	53	0·44	134	0·34	92	0·28	72	(·435)	133	·092	22	·238	72	·146	133	·087	22	·032
,, 7......	99	3·418	109	3·337	116	3·183	54	0·35	200	0·24	99	0·46	105	·060	402	·019	131	·128	105	·070	402	·018	131	·059
,, 9......	121	3·624	40	3·958	71	3·835	73	0·61	50	0·69	31	(0·98)	118	·128	186	·023	24	·131	118	·033	186	·023	24	(·350)
,, 16......	136	3·957	151	3·781	79	4·420	72	0·51	114	0·68	105	0·52	263	·068	313	·045	183	·078	263	·053	313	·026	183	·057
,, 18......	30	(5·317)	139	3·843	57	4·211	66	0·71	152	0·66	107	0·52	234	·108	139	·045	191	·038	234	·036	139	·048	191	·076
,, 21......	105	3·330	152	3·342	115	3·814	51	0·37	159	0·14	235	0·27	265	·057	283	·041	161	·070	265	·045	283	·040	161	·071
,, 23......	73	3·291	95	3·477	91	3·071	122	0·32	62	0·48	130	0·21	91	·123	207	·101	149	·072	91	·096	207	·041	149	·143
,, 25......	141	3·143	128	3·389	101	3·582	100	0·20	52	(0·11)	96	0·24	83	·102	195	·093	68	·179	83	(·296)	195	·093	68	(·210)
,, 30......	155	2·731	139	3·275	78	3·960	19	0·57	24	0·67	103	0·69	130	·108	112	·153	116	·148	130	·108	112	·128	116	·115

TABLE

N.B.—From the 15th July to 14th August the Air Washing was conducted by the method in use during the year ending April, August to 30th August the Washing was only conducted during the day, and the flow was regulated

DATE.	WIND.			CARBONIC ACID.						SULPHUR IN COMBINATION.					
	General Direction.		Velocity.	Volume of Air.		Impurity.		Difference.		Volume of Air.		Impurity.		Difference.	
	A.M.	P.M.	Miles per hour.	Street.	Area.	Street.	Area.	Increase.	Decrease.	Street.	Area.	Street.	Area.	Increase.	Decrease.
1878. July 15,...	W.	W.	11·5	68	98	3·709	5·527	1·818	...	123	105	·120	·122	·002	...
,, 16,...	S.W.	W.S.W.	12·4	104	101	3·131	3·480	0·349	...	53	28	·276	.147	...	·129
,, 17,...	S.W.	W.S.W.	14·1	82	101	3·541	3·361	...	0·180	83	106	·311	·214	...	0·97
,, 18,...	W.S.W.	S.W.	14·1	94	84	3·495	3·533	0·038	...	77	109	·212	·268	·056	...
,, 19,...	S.W.	W.	11·0	86	102	3·395	3·287	...	0·108	73	101	·188	·167	...	·021
,, 20,...	S.W.	W.S.W.	9·9	39	82	4·746	3·646	...	1·100	8	40	...	·323	...	...
,, 22,...	E.N.E.	E.N.E.	6·6	106	121	6·211	5·464	...	0·747	84	176	·236	·123	...	·113
,, 23,...	N.E.	E.N.E.	10·0	59	5	3·968	...	...	...	35	120	·310	·256	...	·064
,, 24,...	N.E.	N.E.	14·0	77	36	3·561	5·120	1·559	...	8	61	...	·225	...	...
,, 25,.	E.N.E.	W.	13·5	58	3	4·765	...	...	...	19	45	·356	·219	...	·137
,, 26,..	S.W.	E.N.E.	7·7	63	38	3·771	3·798	0·027	...	64	11	·170	...	...	...
,, 27,...	E.	W.	7·0	55	23	4·378	...	...	...	10	46	...	...	...	...
,, 29,...	N.E.	N.N.E.	5·7	137	170	3·202	2·939	...	0·263	3	21	...	·188	...	...
,, 30,...	E.	N.E.	5·9	65	27	3·726	5·024	1·298	...	37	130	·161	·174	·013	...
Aug. 1,...	N.	N.E.	5·0	56	93	4·465	3·148	...	1·317	164	44	·314	·179	...	·135
,, 3,...	E.N.E.	E.N.E.	10·0	106	105	3·350	3·004	...	0·346	105	147	·150	·142	...	·008
,, 5,...	E.N.E.	E.N.E.	18·5	85	178	3·439	5·256	1·817	...	178	184	·111	·102	...	·009
,, 6,...	E.N.E.	E.N.E.	16·6	36	59	4·855	4·218	...	0·637	60	29	·165	·412	·247	...
,, 7,...	E.	S.	15·6	109	112	3·322	3·168	...	0·154	112	234	·159	·178	·019	...
,, 8,...	S.W.	W.	7·5	114	70	3·063	3·644	0·581	...	70	73	·169	·082	...	·087
,, 9,...	S.W.	S.W.	10·2	69	53	3·862	3·802	...	0·060	53	60	·056	·181	·025	...
,, 10,...	E.	W.	4·9	59	66	4·168	3·678	...	0·490	66	46	·271	·108	...	·163
,, 12,...	W.S.W.	S.W.	10·9	133	69	3·100	3·364	0·264	...	69	108	·071	·274	·203	...
,, 14,...	W.	W.	17·0	62	64	3·631	3·579	...	0·052	63	89	·108	·067	...	·041
,, 17,...	W.	W.S.W.	5·9	62	62	4·198	4·093	...	0·105	62	62	·159	·096	...	0·63
,, 21,...	N.E.	N.E.	9·5	90	90	3·670	3·620	...	0·050	90	90	·198	·165	...	·033
,, 30,...	N.E.	N.E.	8·3	90	90	3·437	2·950	...	0·487	90	90	·285	·263	...	·022
Sept. 4,...	W.	S.W.	11·2	90	90	3·529	3·559	0·030	...	90	90	·088	·055	...	·033
,, 7,...	W.	S.W.	6·2	90	90	3·464	3·636	0·172	...	90	90	·285	·395	·110	...
,, 11,...	S.W.	S.W.	9·0	90	90	3·286	3·620	0·334	...	90	90	·318	·274	...	·044
,, 14,...	S.W.	S.W.	14·5	90	90	3·464	3·437	...	0·027	90	90	·340	·362	·022	...
,, 18,...	S.W.	S.W.	25·5	90	90	3·293	3·448	0·155	...	90	90	·143	·132	...	·011
,, 21,...	W.	W.	11·6	90	90	3·364	3·554	0·190	...	90	90	·230	·340	·110	...
,, 25,...	S.E.	W.	8·3	90	90	3·509	3·672	0·163	...	90	90	·373	·132	...	·241

II.

1878, with this exception, that four absorbers, instead of three, constituted a series, and beads were not used. From the 14th twice per day. From the 4th to 25th September the Air Washing was under constant supervision.

NITROGEN AS AMMONIA.						NITROGEN AS ALBUMINOID AMMONIA.					
Volume of Air.		Impurity.		Difference.		Volume of Air.		Impurity.		Difference.	
Street.	Area.	Street.	Area.	Increase.	Decrease.	Street.	Area.	Street.	Area.	Increase.	Decrease.
175	108	...	...	...	...	175	108	·056	·062	·006	...
75	101	·174	·169	...	·005	75	101	·089	·076	...	·013
110	105	·201	·218	·017	...	110	105	·061	·052	...	·009
79	96	·400	·691	·291	...	79	96	·058	·055	...	·003
78	117	·203	·241	·038	...	78	117	·072	·179	·007	...
28	25	·250	·571	·321	...	28	25	·125	·100	...	·025
105	246	·197	·118	...	·079	105	266	·059	·021	...	·038
62	65	·164	·697	·533	...	62	65	·034	·032	...	·002
61	79	·295	·116	...	·179	61	79	·035	·049	·014	...
57	2	·092	...	...	...	57	(2)	·004	...	...	...
11	95	...	·177	...	...	(11)	95	...	·029	...	...
68	52	·077	·087	·010	...	68	52	·003	·007	·004	...
152	111	·085	·201	·116	...	152	111	·013	·031	·018	...
68	63	·109	·050	...	·059	68	63	·067	·008	...	·059
144	242	·092	·096	·004	...	144	242	·039	·019	...	·020
53	51	·066	·055	...	·011	53	51	·049	·109	·060	...
69	238	·312	·038	...	·274	69	238	·169	·016	...	·153
53	76	·106	·179	·073	...	53	76	·086	·037	...	·049
95	119	·161	·068	...	·093	95	119	·069	·024	...	·045
99	61	...	...	...	...	99	61	...	...	...	...
68	71	...	...	...	...	68	71	...	...	...	...
61	92	·166	·122	...	·044	61	92	·057	·015	...	·042
161	155	·122	·031	...	·091	161	126	·024	·031	·007	...
94	126	·266	·225	...	·041	94	126	·134	·047	...	·087
62	62	·491	·740	·249	...	62	62	·045	·102	·057	...
90	90	·183	·097	...	·086	90	90	·023	·039	·016	...
90	90	·229	·315	·086	...	90	90	·078	·023	...	·055
90	90	...	...	...	...	90	90	...	...	...	...
90	90	·113	·128	·015	...	90	90	·023	·031	·008	...
90	90	·082	·074	...	·008	90	90	·054	·012	...	·042
90	90	·241	·089	...	·152	90	90	·004	·012	·008	...
90	90	·086	·062	...	·024	90	90	·043	·016	...	·027
90	90	·191	·031	...	·160	90	90	·023	·016	...	·007
90	90	·109	·035	...	·074	90	90	·019	·027	·008	...

TABLE

OBSERVATIONS ON

N.B.—The Air, from the Washings of which all the results contained in this Table were obtained, was in each

DATE.	WIND.			CARBONIC ACID.						SULPHUR IN COMBINATION.					
	General Direction.		Velocity.	Volume of Air.		Impurity.		Difference.		Volume of Air.		Impurity.		Difference.	
	A.M.	P.M.	Miles per hour.	Street.	Area.	Street.	Area.	Increase.	Decrease.	Street.	Area.	Street.	Area.	Increase.	Decrease.
A.—NORTH STREET															
Oct., 1,...	N.E.	N.		...	50	...	4·545	Same Air.		...	50	...	·474	Same Air.	
,, ,, ...	N.E.	N.	5·4	...	50	...	4·556			...	50	...	·474		
,, 3,...	S.W.	S.W.	11·2	40	40	4·481	5·295	0·814	..	40	40	·815	·568	...	·247
,, 5,...	N.E.	S.E.	12·5	50	50	3·865	4·174	0·309	...	50	50	·711	·356	...	·355
B.—POLLOK STREET															
,, 9,...				Lost from leakages in Pipes.											
,, 11,...															
,, 15,...	S.E.	S.E.	12·5	50	50	3·254	4·284	1·030	...	50	50	·632	1·106	·474	...
,, 17,...	E.	S.	8·0	50	50	3·364	4·168	0·804	...	50	50	·514	·316	...	·198
,, 19,...	E.	E.	14·6	50	50	3·584	4·265	0·581	...	50	50	·751	751	...	...
C.—BINNIE'S COURT AND															
,, 25,...	W.	S.W.	8·4	50	50	4·196	4·237	0·041	...	50	50	·948	·751	...	·197
,, 28,...	W.	N.W.	11·5	50	50	4·196	4·296	0·100	...	50	50	·612	·652	·040	...

III.

ENCLOSED SPACES.

case passed through four absorbers at the rate of 3 cubic feet per hour, and in no instance were beads used.

NITROGEN AS AMMONIA.						NITROGEN AS ALBUMINOID AMMONIA.					
VOLUME OF AIR.		IMPURITY.		DIFFERENCE.		VOLUME OF AIR.		IMPURITY.		DIFFERENCE.	
Street.	Area.	Street.	Area.	Increase.	Decrease.	Street.	Area.	Street.	Area.	Increase.	Decrease.
AND CUL-DE-SAC.											
...	50	...	·133	Same Air.		...	50	...	·022	Same Air.	
...	50	...	·133			...	50	...	·022		
40	40	·070	·053	...	·017	40	40	·044	·026	...	·018
50	50	·196	·497	·301	...	50	50	·063	·007	...	·056
AND COURT.											
50	50	·189	·252	·063	...	50	50	·056	·154	·098	...
50	50	·133	·161	·028	...	50	50	·028	·035	·007	...
50	50	·133	·315	·182	...	50	50	·028	·056	·028	...
ARGYLE STREET.											
50	50	·329	·217	...	·112	50	50	·049	·056	·007	...
50	50	·168	·133	...	·035	50	50	·028	·042	·014	...

TABLE IV.

OBSERVATIONS ON AMMONIA PRODUCED BY COMBUSTION OF COAL.

VOLUME OF AIR.	IMPURITY.		REMARKS.
	Nitrogen as Ammonia.	Nitrogen as Albuminoid Ammonia.	
50	·217	·126	Average of two samples of Air taken from the middle of Claremont Street.
50	·133	·063	Average of two samples of Air taken from the Centre of Hollow Square, referred to in Table II.
50	·217	...	Sample of Air from Room previous to the introduction of Smoke.
50	·231	·077	Sample of Air from same Room previous to the introductiou of Smoke.
25	2·394	·686	Average of two samples of Air from the same Room after the introduction of a moderate volume of Smoke from slow fire.
50	·133	·098	Average of two samples of Air from another room previous to the introduction of Smoke.
17	5·234	1·316	Sample after introducing a dense volume of Smoke. The perforations of the "roses" were completely stopped by tarry matter.
50	·336	·077	Sample twenty-four hours after introduction of small quantity of Smoke. Room closed up meanwhile.
50	·567	·112	Sample after introduction of Smoke issuing from a sharp moderately clear fire.
50	·889	·273	Sample from Smoke and Air issuing from a chimney-top in connection with an ordinary house (fire burning in open grate).
10	1·260	·980	Sample from the Smoke of burning wood, chiefly white and yellow pine. The perforations of the initial "rose" were all but closed by solid matters. The rate here was one-and-a-half cubic feet per hour.

N.B.—The Air, from the washing of which all the results contained in this Table were obtained, was passed through six absorbers at the rate of three cubic feet per hour. Beads were not used. The only exception as to rate was as noted above in the last observation.