To be bound together.

HOUSE OF COMMONS (VENTILATION).

35

REPORT

AND

RECOMMENDATIONS

BY

Dr. M. H. GORDON.

Presented to both Houses of Parliament by Command of His Majesty.

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REPORT

OF AN

INVESTIGATION OF THE VENTILATION of the DEBATING CHAMBER OF THE HOUSE OF COMMONS, and RECOMMENDATIONS with view to the Improvement of the same, by M. H. GORDON, M.A., M.D., B.Sc.

TO THE RIGHT HONOURABLE THE LORD WINDSOR,

HIS MAJESTY'S FIRST COMMISSIONER OF WORKS.

MY LORD,

I HAVE the honour to submit to you the report of an investigation which I have made at your request of the ventilation of the Debating Chamber of the House of Commons.

The details of the scope of the investigation were decided upon after consultation with Sir Michael Foster, and throughout its course he has constantly increased the value of the enquiry by his experience and advice.

The investigation, which was carried out between May and August last, on occasions when the Debating Chamber was in use, has had for its principal object the determination of the quality of air supplied to the Debating Chamber by the method of ventilation adopted. Secondly, some observations have been made of the quantity of air being passed through the Chamber. Thirdly, so far as circumstances permitted, an attempt has been made to determine the area of inlet and outlet actually operative within the Chamber under present conditions. Scope.

The observations of the quality of the air which I undertook to make were primarily of a bacteriological description. As the investigation proceeded, however, it became plain that the value of the enquiry would be increased by subjecting the air to chemical observations in addition. I therefore obtained the co-operation of W. H. Hurtley, D.Sc., Demonstrator of public health chemistry at St. Bartholomew's Hospital, and have the honour to submit in appendix the report which he has made of the quality of the air from a chemical standpoint. Methods.

In addition to these bacteriological and chemical investigations, the temperature of the air, its relative humidity, and its evaporative power, have been under observation. A further quality of the air which it seemed of interest to ascertain was the proportion of dust particles contained in it. John Aitken, LL.D., F.R.S., who has made this subject particularly his own, when passing through London on a recent occasion, volunteered to visit the House of Commons with me and examine the air with an instrument he has devised for the purpose of estimating the number of dust particles in a measured volume of air. Dr. Aitken's account of his observations on that occasion, and some criticisms and suggestions which he has added concerning the ventilation of the Debating Chamber, are also appended. I may add that Dr. Aitken speaks with great authority on the subject of dust particles in air, he having been the first to demonstrate that fog is due to the condensation of moisture upon these particles, and likewise the first to invent a method of counting them.

Full particulars of all the several observations to which I am referring, and of the inferences to be drawn from them, are contained in the larger report which I have the honour to submit to your Lordship in the form of an appendix to this one. Here it will be my task to deal only with the chief facts which have been made out, and especially to offer such recommendations for the improvement of the ventilation as in view of these facts appear to be desirable, and in the circumstances possible.

The purpose of ventilation. The object of artificially changing the air of an occupied room being to preserve the vigour, comfort, and health of the inmates of such room, the efficiency of a particular process in use in a given case for attaining this end must be thought of according as it prevents fatigue, discomfort, or disease of these persons that may reasonably be attributed to the air of that room. As the vital activity and tone of every portion of the human body is intimately and continuously dependent upon the supply of oxygen and on the removal of carbon dioxide, that is to say upon that body's ventilation, and as these subsidiary processes are in turn all dependent upon the exchange of gases between the blood and the air effected by the act of breathing, it follows that the application of a given process of artificial ventilation to an inhabited room is in reality an exceedingly delicate physiological experiment.

The Debating Chamber of the House of Commons. There can be little doubt that the Debating Chamber of the House of Commons is one of the most difficult of all public buildings to ventilate, chiefly because of the long hours during which it is continually in use when the House is sitting, but also because of the varied extent to which during a sitting the Chamber is occupied. It is therefore, *à priori*, probable that if a weakness existed in the ventilation of the House as a whole, in the Debating Chamber if anywhere such weakness would most readily become manifest. The history of the attempts to ventilate the Debating Chamber of the House of Commons shows that this probability has been realised. It has been said that the history of ventilation begins with the attempts at ventilating the Houses of Parliament in 1660 by the Architect, Sir Christopher Wren, and that as almost every device has been tried in these halls at one time or other, the history of the attempts would be almost equivalent to a history of the art of ventilation. At the present time a visit to the air courses of the Debating Chamber shows evidence on many sides of continual and sometimes costly attempts in the past to improve the ventilation of the building. With regard to intake alone no less than three different sources for the air have been tried. It is clear, therefore, that the conditions of efficient ventilation have not in the past been satisfactorily fulfilled with regard to the Debating Chamber, and that the system at present in use represents no more than a stage in the evolution of its ventilation.

Results of the present enquiry. The results of the present investigation of the ventilation of the Debating Chamber will be dealt with according as they refer to (1) the quality of the air supplied and of that withdrawn; (2) its quantity in each instance; and (3) its distribution within the Chamber.

(1)—The Quality of the Air.

The technique of the ordinary chemical and physical methods used in examining air is so well known that there is no need for special description of them. On the other hand, the bacteriological tests applied in the present enquiry have been only recently devised, and it is therefore needful to briefly refer to the basis upon which these tests rest.

The principal object of a bacteriological examination of air supplied to an inhabited room is to determine the degree of the liability of that air to be charged with micro-organisms capable of producing disease in man, and especially the degree of its liability to be charged with micro-organisms capable of producing such result when inhaled. But while of the greatest significance when found, the detection of specific pathogenic micro-organisms in air is so difficult and uncertain that failure to detect them even after a careful search does not necessarily imply their absence. Now an attack of infectious disease commonly arises by transmission more or less direct of infection from person to person, and it has been proved that the *materies morbi* is especially apt to be conveyed in particulate matters derived from mouth or intestine respectively. By reason of the fact that in the mouth (inclusive of the air passages) and intestine certain micro-organisms possessed in each case of well defined differential characters, are normally present in large numbers, the presence of such micro-organisms in air may be applied to serve as indices by means of which particulate matter derived from either source can be identified.

Principle of the bacteriological tests used.

Generally speaking, particulate matter expelled from the mouth or discharged from the intestine of animals is less liable to convey disease to human beings than similar materials derived from man. But as there are several diseases of animals communicable to man, the risk to man from matters emanating from lower animals may be by no means unreal. The micro-organisms significant of particulate matter derived from the intestine of man are also found in similar material derived from the horse and some other animals. As regards the micro-organisms significant of the presence of particulate matter emanating from the mouth of man, no sufficiently exact data are yet available with regard to corresponding micro-organisms from the mouths or air-passages of lower animals.

In the present investigation of the bacteriological quality of the air of the House of Commons, therefore, the air has been specially examined for micro-organisms significant of the presence of particulate matter derived from mouth or intestine respectively, the importance of such micro-organisms consisting in the evidence they afford of the liability of the air to be charged also, on occasion, with particulate matter containing micro-organisms of disease.

In the course of the present enquiry there was occasionally recovered from the air a micro-organism that became of considerable importance owing to the fact that it was found to be frequently brought in from the outside upon Members' boots. The micro-organism in question, B. mycoides, is characteristic not of animal material, but of soil, and accordingly it serves as a means by which the presence in air of even minute particles of soil may be identified. Although not comparable to the micro-organisms of animal origin, therefore, as an index of the access of specific pathogenic micro-organisms, B. mycoides has nevertheless proved of use as affording evidence of the presence of material from without brought within the House upon Members' boots.

In the bacteriological examination of the air in the present instance, the method adopted has been to expose in the process of sedimentation of air sterile culture media for a stated time, and subsequently to incubate these media at a temperature favourable to the growth of bacteria that may have become deposited upon them. Under such conditions the micro-organisms deposited from the air upon the surface of the medium develop into colonies visible to the eye, and the number of these colonies is proportionate to the number of micro-organisms deposited from the air during the exposure. The medium used to determine the general bacterial incidence, viz., agar, afterwards incubated at 20° C., was favourable to the development of B. mycoides should that micro-organism be deposited from the air during exposure of the plate.

After preliminary determination of the general bacterial deposit at a given point as compared with like deposit at other parts of the airway, the question of the presence in the air of bacteria significant of particulate contamination derived from mouth or intestine respectively, has been investigated by exposing to the air various kind of culture media, viz., neutral red broth, Drigalski's medium, and agar afterwards incubated at 37° C., media that is which are favourable to the growth of bacteria of the class in question if they are present in the air, and are being deposited therefrom during exposure of the plates designed to collect them.

In addition to means adopted for the detection of bacteria from mouth and bowel, a detailed search for pathogenic micro-organisms has been made in course of the present enquiry, and the results in this connection are fully described in sub-section 5 of the bacteriological report.

The quality of the air.

The chief results of the examination of the quality of the air will now be described.

(A).—*Air entering the inlet.*

The first matter necessary to be considered in reference to the existing system of ventilation of the Debating Chamber is the quality of the air at the inlet. There can, I think, be no doubt that the air of the terrace is remarkably fresh to the subjective senses, and that therefore it is as well suited for the supply of the Debating Chamber as any in the neighbourhood of the building.

Bacteriologically.

A series of bacteriological observations of air entering the inlet showed that rainfall had a distinct influence on the abundance, or otherwise, of bacteria of all sorts to be obtained from it; the number of bacteria deposited by the incoming air being diminished in wet weather. No evidence was obtained of the presence of particulate contamination derived from the mouth in air entering the inlet. It was found, however, that air entering at the north inlet was liable to be polluted by material of intestinal origin—probably horse-manure—derived from the boots of persons walking over the grating on the terrace fixed above the inlet in question. With this exception, the air at the inlet showed exceedingly little evidence of being charged with particulate impurity of a kind we at present recognise as liable to be associated with matter that can convey disease.

Chemically.

Dr. Hurtley made a very thorough chemical examination of the air entering the inlet and has fully dealt with the results obtained by him. He found the air to be normal for town air as regards oxygen and carbon dioxide. Ozone was absent, and tests led him to conclude that even were small quantities of ozone present in the air at the inlet they would not reach the Debating Chamber. For the rest, he found traces of substances that in appreciable amount would certainly be injurious, though they were present in such small quantities as to be probably harmless to a normal human being. The single exception he makes to this statement is with regard to organic matter, and he does so on the ground that it may contain pathogenic micro-organisms. The bacteriological results which I record supply the requisite information upon this matter. An important observation was made by Dr. Hurtley with regard to the purifying action upon the air exercised by the fine rainlike spray in occasional use at the inlet for moistening the air.

Physically.

Dr. Aitken's observation with regard to the number of dust particles in the air at the inlet led him to infer that its quality in this respect was good, for the air of a town.

(B).—*Air entering the Debating Chamber.*

Bacteriologically.

During debates, the number of bacteria deposited from the air of the Equalising Chamber showed a marked increase at certain points corresponding to gratings in the roof thereof which constitutes the floor of the Debating Chamber. The excess of bacteria at these points was due to showers of debris falling through the gratings from Members' boots. The increase in the bacterial deposit from this cause was most marked below the portion of the centre gangway between the Bar and the Lobby door at that end of the Debating Chamber, and, to a less extent, behind the Speaker's Chair and below the side gangways. No evidence was forthcoming that the air of the Equalising Chamber below the

Debating Chamber was contaminated by particulate material derived from the mouth*. On the other hand, the chief pollution found to be brought in on Members' boots and imparted to the air below the floor of the Debating Chamber was particulate material of intestinal origin—derived in all probability from horse-manure.

Air supplied to inhabited rooms in this country should have a temperature of between 60° and 65° F. The average temperature of the air of the Equalising Chamber was 63° F., and therefore, in this respect, the air was found to be entirely satisfactory. The same, however, cannot be said with regard to another physical quality of the air supplied to the Debating Chamber, namely, its relative humidity. Air supplied to inhabited rooms in this country should contain moisture to the extent of between 70 and 80 per cent. of saturation (de Chaumont); preferably between 73 and 75 per cent. of saturation (Wilson). Under the present system the humidity of the air of the Equalising Chamber was found to average 63 per cent. of saturation. The air supplied to the Debating Chamber, therefore, was altogether too dry. There is reason to believe that this relative dryness of the air supplied to the Debating Chamber has had much to do with the complaints of Members in the past with regard to the enervating effects of sustained attendance on debates. Complaint has also been made as to the "want of freshness" of the air of the Debating Chamber; and consequently it is of interest to note that a striking difference was found when air entering the Debating Chamber was compared with fresh air entering the inlet from the Terrace both as regards humidity, and also as regards capacity for absorbing moisture. The mean of a number of hygrometrical observations at both parts of the airway showed that the percentage of humidity of fresh air at the inlet was 71 per cent. of saturation as compared with 63 per cent. shown by the air in the Equalising Chamber. As regards capacity for absorbing moisture, however, the difference was found to be still more marked. The vapour required to saturate a cubic foot of fresh air at the inlet was 1·6 grains, whereas the amount required to saturate a cubic foot of air entering the Debating Chamber was 2·4 grains. This difference is due to difference of temperature between the incoming air and the air delivered to the Debating Chamber. It follows that under the present system, in which it is omitted to moisten the air after raising its temperature, the average capacity for absorbing moisture possessed by air entering the Debating Chamber has been found to be 50 per cent. above that of fresh air entering the inlet from the Terrace. **Physically.**

(C.)—*Air passing out of the Debating Chamber.*

It has been found that when the Debating Chamber is in use, the number of bacteria deposited from air leaving the Debating Chamber was increased as compared with the number obtained from corresponding air when the Chamber was empty. The chief bacterial contamination detected in air leaving the Debating Chamber during debates was due to the presence therein of micro-organisms disseminated from the mouth and upper respiratory passages of persons speaking, coughing, sneezing, etc., within the Debating Chamber.

In the course of the examination of air leaving the Debating Chamber bacteriological evidence was also occasionally obtained of the presence therein of particulate material of the same class as that brought in from the outside upon Members' boots. The evidence, in fact, served to emphasise the advisability of excluding to a greater extent than at present pollution of the air of the Debating Chamber from material brought in upon Members' boots.

* It is possible, nay probable, that further investigation might reveal a certain amount of pollution from sputa brought in from the pavements. When the enquiry was in progress, however, I noticed two things. First, sputa are not so common on the pavement in the immediate vicinity of the Debating Chamber as they are in some other parts of the Metropolis. Secondly, Members frequenting the Debating Chamber, as a class keep their boots remarkably clean. I have no hesitation in saying that with an ordinary assembly of similar numbers much more dirt would be brought in. But as it is, the pollution undergone by the air from this cause was quite serious enough.

Chemically.

The chemical evidence showed that, as regards carbon dioxide, air passing out of the Debating Chamber during debates was remarkably pure for air coming from an inhabited room. The diminution of the oxygen was also small. As regards these two gases therefore the air of the Debating Chamber was entirely satisfactory.

Regarding as a whole the evidence of the quality of the air, it may be said that faults have been proved to obtain in four respects, one physical and three bacteriological. In the first place, the air supplied to the Debating Chamber under the present system is altogether too dry. Secondly, air entering at the north inlet is liable to be polluted by dirt aspirated off the boots of persons walking over the grating fixed above this inlet. Thirdly, the air below the floor of the Debating Chamber is polluted by bacteria derived from members' boots, and, fourthly, the air of the Debating Chamber itself is contaminated by material derived from the mouths and upper respiratory passages of persons speaking, coughing, or sneezing within it.

Index-experiments with the harmless but readily recognised micro-organism B. prodigiosus were carried out in order to determine the extent to which the air of the Debating Chamber is liable to be polluted by material brought in from the outside on boots, and secondly contaminated by material sprayed from the mouth in performance of the act of loud speaking. Earth infected with B. prodigiosus and deposited outside the Debating Chamber at a point 576 feet from the Bar was found to have been brought in upon Members' boots ; it was recovered from air below the Bar. In the speaking experiments which were made with the ventilation off and on respectively, it was found that so far from removing the particulate contaminating matter sprayed from the mouth in performance of the act of loud speaking, the effect of the ventilation at the time the experiments were made was merely to permit distribution of such material over a larger area in the Chamber than had been the case in a previous experiment when the ventilation was off. The importance of this form of contamination, of the presence of which evidence was also constantly obtained when examining the air leaving the Debating Chamber during debates, lies in the fact that certain infectious diseases are liable to be transmitted as a result of dissemination of their infection in air, notable instances being influenza and infectious colds.

(2.) The Quantity of Air supplied to and of that removed from the Debating Chamber.

The quantity of air, supplied,

The quantity of air indrawn by the fan at the time that the investigation was made was insufficient to meet the requirements of the Debating Chamber when crowded during a fully attended debate. But I am informed that the more powerful fan now in use will be capable of supplying an amount of air ample for this purpose.*

withdrawn.

The quantity of air extracted at the level of the ceiling at the end of the Debating Chamber over the Ladies' Gallery was found to be insufficient.

(3.) Distribution of the Air supplied by the Ventilation.

Distribution of the air.

Observations of the air passing upwards through various parts of the Equalising Chamber below the floor of the Debating Chamber gave strong ground for suspecting that, under the present conditions, the air delivered into the Debating Chamber is by no means satisfactorily distributed to the benches and seats on the floor of the House.

In the preceding paragraphs I have indicated the chief faults which have been found in the ventilation of the Debating Chamber. The remedies which I venture to suggest in view of these faults are described in the following recommendations.

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* Dr. Boswell Reid found by experience that 50,000 cubic feet of air per minute was hardly sufficient to meet the requirements of the Debating Chamber of the temporary House of Commons when crowded. The maximum quantity of air supplied by the fan in August, 1904 (110 revolutions) was considerably below this amount.

RECOMMENDATIONS.

A.—With Regard to the Inlet at the Terrace.

There can be no doubt that the present air intake would be improved by raising the inlet a few feet and at the same time widening it. The difficulty, however,, is to do this without interfering with the appearance of the building. A systematic survey of the structure of the building at this point might, perhaps, lead to the discovery of some way in which these ends could be attained without unduly interfering with the façade. If it could be done, a good plan would be to draw the air in through some opening already existing above the level of the terrace. In any case, traffic over the north inlet should be abolished. 1.—The inlet.

In view of Dr. Hurtley's observations, I would recommend that the fine spray at present in occasional use for moistening the air at the inlet should always be employed in the future for the purpose of purifying the air passing through the airway. 2.—The spray.

B.—With Regard to the Airway between the Terrace and the Equalising Chamber.

Owing to the fact that the fan which draws in the air from the terrace is separated from the inlet by a distance of about 100 feet of airway, and also owing to the resistance to the inflow of air offered by the comparatively small size of the present inlet, there is a great tendency for air in the basement and engine rooms which abut on the airway in this interval to be drawn into the air-stream passing to the Debating Chamber. The air in the engine rooms and basement contiguous to the airway in question is, in my experience, somewhat "stuffy"; at any rate it is undesirable that any of this engine room air should be drawn into the airway and passed to the Debating Chamber. There are three wooden doors into the airway between the fan and the inlet. One of these doors gives access to the airway from the basement under the Central Hall, the others are situated on either side of the airway near the inlet. The door giving access from the basement under the Central Hall is a double one contrived on the principle of a river lock. No special means are in use to make these two doors airtight. The other two doors, one on each side of the airway near the inlet, are also not airtight. Moreover, when the House is sitting, and a stream of fresh air is being drawn by the fan along the airway towards the Debating Chamber, occasionally one of these doors near the inlet is opened for the purpose of passing a policeman, or perhaps a workman, across the airway. Though traffic in this sense is infrequent, every time the doors open air from the basement and engine rooms must needs be drawn into the air stream and forwarded to the Debating Chamber. 3.—The question of leaks.

I am of the opinion that all three of these doors should be abolished or at least should be made absolutely airtight. In any case no one, policeman or other, should be allowed to pass across the airway when the House is sitting.

If it be determined that the doors that are in question be made as airtight as possible, their imperviousness to air should, when this is believed to have been accomplished, be *proved* when the House is not sitting by generating hydrogen sulphide gas on that side of them in each instance without the airway for the purpose of testing by the sense of smell whether or not the gas thus generated can find entrance within the airway. The smoke test could be used as well, but hydrogen sulphide is far the more delicate test, and therefore the more trustworthy.

The need for imperviousness of the airway between fan and inlet is increased now that the fan power is greater. On the other hand, the outward leaks located between the fan and the Equalizing Chamber are of less importance than when the fan power was less. I have indicated the places where these outward leaks were localised, in Section VII. of the Appendix.

C.—With Regard to the Debating Chamber.

4.—Mode suggested for moistening the air after it has been warmed.

I would recommend that shallow pans of water should be suspended in the Battery Chamber over the heating apparatus in order that the increased avidity for moisture that air obtains through its temperature being raised should be satisfied. Further details of the process suggested for the purpose of moistening the air after it is warmed are given in Section VI. of the Appendix. The pans and water should be kept *absolutely clean*, and should be examined as a matter of routine every day before the Ventilation is started.

Possibly, wet mats suspended in the Battery Chamber may be found useful for moistening the air. It would also be an advantage to use warm water for moistening the air. The question of these and other details, however, can only be decided by experiment upon the spot.

After the air has been warmed and moistened, means should be taken for ensuring the uniformity in these respects of all the air passed upwards into the various parts of the Debating Chamber.

5.—Insulation of steam pipes.

That all steam pipes passing through the airway between the inlet and the floor of the Debating Chamber be covered with asbestos or suitable composition, so that these *irregular* sources of increased temperature should be isolated from the air as much as possible. There is a steam pipe in the cotton wool filter under the Speaker's chair, another in the Equalising Chamber going to the Treasury Bench, and in the Battery Chamber under the Government side of the Debating Chamber and over the Commons' pipe vault are a number of steam pipes. All of these steam pipes should be screened from the air as much as possible.

6.—Routine hygrometrical observations.

That by means of numerous hygrometers the humidity of the air and its capacity for absorbing moisture* should be observed and controlled throughout the Equalising Chamber, Debating Chamber, and Division Lobbies as regularly and systematically as the temperature now is. It is of great importance to have a large number of hygrometers in use, and to observe them frequently. Further, it is as important to prevent the air of the Debating Chamber becoming too damp as it is to prevent its being too dry.

7.—Particulate pollution from boots.

That, with view to diminishing the liability of the air of the Debating Chamber to be polluted by material continually being brought in upon Members' boots, a tray be, as a make-shift arrangement, placed beneath the grating of the centre gangway between the Bar and the Lobby door under the clock. This tray should be in close apposition to the grating so as to prevent particles of dirt being carried up by the air currents. An alternative plan, also make-shift, would be to place a movable metal plate over the top of the grating and under the present matting. The exact spot should be determined on by observing where the traffic at this point is most active during use of the Chamber. Whatever remedy is temporarily adopted here might also be applied behind the Speaker's Chair and perhaps under the side gangways.

It may be added that a considerable amount of dirt falls through the floor of the Division Lobby between the entrance to the Debating Chamber, from the Common's Lobby, and the folding door under the clock of the Debating Chamber.

It is necessary to insist that any arrangement such as is above indicated should be regarded as temporary only: it would necessarily operate to diminish the area of air entry. As, however, there is reason to think that in order to remedy the faults in the present distribution of the incoming air through the floor it will be necessary to increase the resistance to the up-flow of air through the gangways, it is possible that the prevention of pollution of the air from material brought in upon Members' boots, and also the prevention of air-waste,

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* These two qualities of the air should not be confused. A cubic foot of air containing 75 to 76 per cent. of humidity absorbs, at 40° F., ·7 grain of water, but at 80° F. 2·7 grains.

may be combined in the same remedial measure. But before the exact form of that remedy can be arrived at, it is first necessary to carry out an investigation of the present distribution of the air over the floor area.

While there cannot be any doubt that so far as the gaseous products of respiration are concerned, the upward system of ventilation as in use in the Debating Chamber at the present time is not open to objection, it is equally clear from the results of this investigation that so far as particulate contamination by material given off in the breath is concerned, the existing upward system cannot do away with it. **8.—Particulate pollution from breath.**

Several new buildings are now being supplied with downward ventilation. Unbiassed and detailed evidence of the value or otherwise of this system is not available, but an investigation on lines such as I have adopted could be made, and useful, perhaps valuable, information obtained. I venture to submit that, in view of the unsatisfactory results of the present conditions at the Debating Chamber, some better means of dealing with the particulate contamination to which the air is continually subjected during debates is desirable, and that such better means should be sought diligently.

That the distribution of the incoming air through the floor of the Debating Chamber be determined in detail and that measures be taken for ensuring that the air is directed equably to the parts where it is required. In Section IX of the Appendix I have pointed out how this can be done. **9.—Distribution.**

I may here add that from Dr. Boswell Reid's book on ventilation, a copy of which I have only recently been able to obtain as it has long been out of print, it is quite plain that he designed the present Equalising Chamber of the House of Commons "*that local currents, otherwise apt to form unequal eddies, might be broken, and terminate in a uniform supply to every part of the floor.*" **Object of the Equalising Chamber.**

Dr. Reid used hair matting on the floor of the Debating Chamber in order to increase the diffusion of the air passing up through perforations in the floor. The hair matting he caused to be changed daily. It is worthy of serious consideration whether this hair matting used by the designer, and evidently in his mind when he designed the present system, should not replace the present string matting. Besides increasing diffusion of the upgoing air, another advantage the hair matting has is that it permits of being sterilised by steam. The present string matting is liable to injury by steam, and therefore it is only formalinised—a disinfection process that kills some, but by no means all, micro-organisms. Steam, on the other hand, as applied in a modern steriliser, kills all micro-organism at a single exposure. An instance of the relative value of the two processes is seen in the fact that anthrax spores escape when subjected to the action of formalin vapour*, but are killed by steam. **10.—The matting.** **Steam steriliser.**

I would recommend that a more effectual withdrawal of air be obtained at the end of the ceiling over the Speaker's Chair and Ladies' Gallery, and that whatever the means adopted for securing uniformity of withdrawal from the Chamber, anemometer tests be made to prove its efficacy. **11.—Exhaust.**

I would suggest that the ventilating men when on duty between the inlet and the floor of the Debating Chamber wear clean white linen or drill, etc., clothes or overalls, and that before coming on duty they change their boots or wear felt slippers. The latter would have the advantage of making their tread noiseless. The white clothes should, of course, be washed frequently on a routine system, and at the same time the felt slippers might be sterilised by steam. **12.—(General)— (a) Clothing of ventilating men when on duty.**

These precautions are taken to prevent particulate pollution of the air of operation rooms. There is no reason, therefore, why they should not be employed with the same object elsewhere.

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* Report to the London County Council on Disinfection by Drs. Klein, Houston, and Gordon, 1902.

(b) Charted record.

For maintaining the uniform efficiency of the ventilation it is desirable to have a continuous record of its most important features. This is at present carried out up to a certain point, but the record is not complete enough. I would strongly recommend that blank forms of *Charts* be printed, and that on these Charts should be recorded in continuous curves the temperature, the relative humidity, and the evaporative power of the air in the Equalising Chamber, Debating Chamber, and Division Lobbies, respectively. The quantity of air passing into different parts of the Debating Chamber and out at different parts of the ceiling should also be constantly observed and recorded, and for this purpose some graduated form of static anemometer that could be fixed, for instance, on the gratings in the Equalising Chamber, and some form of self-recording anemometer in other parts of the air courses are needed. It is only by controlling all these features scrupulously and continuously that the desired end can be secured.

Force is added to the above suggestion from the fact that, since it was written, I have obtained the copy of Dr. Reid's book to which reference has been already made, and on page 328 he gives the elaborate printed form which was used at the House of Commons when he had charge of the ventilation. It is interesting to note that the velocity of the air was observed, as well as the temperature and other points. The scrutiny of all features of the ventilation was so elaborate that in some cases, where debates had been continued for a long period, he made, with advantage, from 50 to 100 variations in the quantity or quality of the air supplied in a single night. Dr. Reid's success in ventilating the House of Commons is beyond doubt, as the following statement of his contemporary Arnott shows, "until the late* House of Commons existed as ventilated by Dr. Reid, there was never in the world a room in which 500 persons or more could sit for ten hours in the day, and day after day, for long periods, not only with perfect security to health, but with singular comfort."

Finally, I venture to ask your Lordship to regard these recommendations and suggestions as the outcome of an investigation which, though as detailed as I could make it in the time at my disposal, has not covered the whole ground. Although the ventilation of the Debating Chamber of the House of Commons has taken 250 years to reach its present stage, it could, in my opinion, be much improved even in the present building with systematic and continual study. I have merely indicated what constitute, I believe, the chief lines along which this improvement may be attained, and the vigour, comfort, and health of Members enhanced so far as the air of the Debating Chamber is concerned.

In bringing my report to a close, I desire to acknowledge the uniform courtesy and good-will with which Mr. Rivers, Chief Engineer, Mr. Patey, and the staff generally, have throughout assisted the progress of the enquiry.

I have the honour to be,

My Lord,

Your obedient Servant,

(Signed) M. H. GORDON.

December, 1904.

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* This refers to the temporary House. Dr. Reid's book was published in 1844, its title being "Illustrations of the Theory and Practice of Ventilation." A special part of the book is devoted to the ventilation of the House of Commons. Arnott's statement is quoted from Dr. Billings' book on ventilation, p. 35.

[*In continuation of Parliamentary Paper. Cd. 2404—1905.*]

HOUSE OF COMMONS (VENTILATION).

REPORT AND RECOMMENDATIONS

OF THE

COMMITTEE APPOINTED TO INVESTIGATE

AND

ADVISE THE FIRST COMMISSIONER OF WORKS

ON THE QUESTION OF IMPROVING THE

VENTILATION OF THE HOUSE OF COMMONS.

Presented to both Houses of Parliament by Command of His Majesty.
July, 1906.

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1906.

[Cd. 3035] *Price 1d.*

REPORT.

To the Right Honourable LEWIS VERNON HARCOURT, M.P., His Majesty's First Commissioner of Works.

SIR,

THE Committee appointed by your predecessor, the Earl of Plymouth, in April, 1905, consisting of Sir Michael Foster, Chairman, Dr. J. S. Haldane, and Dr. M. H. Gordon, to which, at the Committee's request, Mr. Arthur P. Patey, the Resident Engineer of the Houses of Parliament, was subsequently added, to carry out further systematic observation of the working of the present system of ventilation of the House of Commons with view to ascertaining what improvements in it are desirable, beg leave to report to you as follows:—

Throughout the enquiry the Committee has had the advantage of the co-operation of Dr. W. N. Shaw, Secretary of the Meteorological Council, whose valuable consulting services were secured to the Committee on its inception by your predecessor.

As a considerable number of observations of the quality of the air from both the chemical and bacteriological points of view had been carried out previously, the Committee has been satisfied in the present instance with continuous examination of the temperature and humidity of the air by means of recording instruments, and also with examination of the purifying value of the washing screen in operation during last Session at the Terrace inlet. The observations of the temperature and humidity of the air were carried out by Mr. Lempfert, of the Meteorological Office, and the examination of the purifying value of the washing screen and cotton-wool filter was made partly by Dr. John Aitken, who kindly volunteered his valuable help and advice, and partly by Dr. Gordon.

Acting for the Committee, Dr. Gordon and Mr. Patey, assisted in part by Mr. Lempfert, have carried out a prolonged, careful and often minute investigation of the quantity and distribution of the air passing through the Debating Chamber, Division Lobbies and other parts of the system under varying circumstances.

Shortly before the appointment of the present Committee the old propeller fan used for driving air through the intake airway had been replaced by a much more powerful centrifugal fan, and another centrifugal fan was at the same time substituted for the furnaces previously used for extracting air through the ceiling of the Debating Chamber. It was found that in consequence of these changes the quantity of air supplied was approximately doubled, and that in addition a much more efficient control was obtained over the general ventilation. A marked improvement was also observable in the quality of the air in most parts of the Debating Chamber. Further investigation, however, disclosed the fact that the distribution of fresh air to various parts of the Debating Chamber and Division Lobbies is still very imperfect. Other serious defects were also found.

The details of the experimental investigations will be found in the accompanying Appendix.

Dr. Gordon and Mr. Patey have, as a result of the investigations in question, formulated a number of recommendations which meet with the general approval of the Committee. Many of them the Committee are of opinion should be put in hand without delay, especially those which refer to the treatment of the air on its passage from the battery chamber upwards. But in respect to these they consider that the Recommendation (No. 8 (*a*)) suggesting changes with view to diverting a larger portion of the air from the central floor of the Debating Chamber and the gangways to the area beneath the benches must needs be carried out tentatively

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so as to be accompanied by careful observations, with the object of learning by experience how large a portion of the air may thus be diverted without unduly depriving the front benches of air, and without any risk whatever of subjecting occupants of back benches to the sensation of "draught." The Committee advise that the observations made and records taken of the temperature and humidity of the air should be in future still more numerous and systematic than they are at present.

The recommendations which the Committee have the honour to present are fully specified on the pages immediately following.

In conclusion, the Committee desire to remark that the investigations so far made, though extensive, do not cover the whole subject. No systematic series of observations, for instance, has yet been made of the warming of the ingoing air; and several other matters need to be investigated.

We have the honour to be,
Sir,
Your obedient Servants,
M. FOSTER.
J. S. HALDANE.
M. H. GORDON.
A. P. PATEY.

June, 1906.

Recommendations.

1. *Abolition of North inlet.*

That the present north inlet should be abolished because it is covered by a grating on which Members walk; and that in its place the next Chamber further north should be used for intake. The suggested mode of connecting this new north inlet to the airway is shown on the accompanying plan.

2. *Enlargement of sectional area of the Terrace inlet.*

That the three windows by which air is indrawn from the Terrace should be enlarged as much as possible.

3. *Air course between inlet and input fan.*

(*a*) That the narrower parts of the air course between the inlet and the input fan should be widened as much as possible.

(*b*) That the channel in question should be simplified by filling in recesses with brickwork, by splaying off angles, and by forming slopes in the floor.

(*c*) That the faulty old paving should be taken up and replaced by new flooring, and that the angles between the sides of the airway and the floor should be rounded.

(*d*) That the side walls of the East Passage, which are at present dewed with moisture carried forward from the inlet water screen, should be covered with glazed tiles.

(*e*) That the steam-condense main and steam pipes which at present are contained in this part of the air-way should be removed.

(*f*) That the old propeller fan should be removed, and that a wall should be constructed across the vault in which this fan is contained, and an opening cut in the side wall at this point in the manner shown in the plan. In this way the air-course will be enlarged at what is at present its narrowest point between the inlet and input fan.

(g) That, for the prevention of inleakage of undesirable air, "air-locks" be provided at all points of entry to the air-course on the suction side of the input fan.

4. *Air-course on discharge side of input fan.*

That, on the discharge side of the input fan, steps be taken to prevent side leakage, and that new flooring be put down over the existing stone flagging at this part.

5. *The Cotton-wool Filter.*

(a) *Alteration of position.*—The Committee find that in its present position the cotton-wool filter is continually contaminated by dust deposited from the air passing over it, and also by material falling down on to its inner surface from the centre gangway above. They recommend, therefore, that this filter be transferred from its present site to an adjoining vault, and that arrangements be made by which the air can be bye-passed through it in time of fog.

(b) *Adjustable panels on outside of filter.*—That when the cotton-wool filter is transferred steps be also taken to provide movable wire-work panels in such a manner as to permit of the external layers of wool being removed and replaced by fresh layers as need arises.

6. *The Battery Chamber.*

It is further recommended that the wooden framework and partition walls in the battery chamber be removed, and that the whole of this chamber beneath the equalising chamber be thrown open for better diffusion of the air.

7. *Equalising Chamber.*

(a) That the inlet to the equalising chamber be increased to its fullest possible extent by throwing open three gratings at present closed.

(b) That the wooden partition at the centre be removed.

8. *Debating Chamber floor.*

(a) That steps be taken with a view to remedying the present excessive entry of air by the centre gangway, especially at those parts of it where pollution from material brought in on Members' boots has been chiefly found to obtain.

(b) That the area of inlet to the seats at either end of the Debating Chamber under the Gallery be increased.

9. *Members' Gallery.*

That the air input to the Members' Gallery should be increased by rendering the shafts thereto from the equalising chamber more efficient than at present.

That an air-space be formed and floored off under the benches of these Galleries so as to provide a cleanable channel and distributing chamber.

10. (a) *Ladies', and* (b) *Press Galleries.*

(a) *Ladies' Gallery.*—That the downcast shafts situated at the back of the Ladies' Gallery, and at present disused, be converted into upcast shafts for the purpose of conveying air to the Ladies' Gallery; that the fresh air thus provided should be introduced along the wall rising at the back of this Gallery; and that the extraction be effected, as far as possible, through the grille.

(b) *Press Gallery.*—That the rising shafts to the Press Rooms be connected to the Press Gallery, and that the air thus provided should be led in by an equalising and distributing air-space as recommended in case of the Members' Gallery.

11. *Strangers' Gallery.*

That the shafts in the wall at the Bar end of the Debating Chamber be connected to the battery chamber, and that the space under the Strangers' Gallery, to which these shafts can be made to deliver air, be made as simple and efficient as possible as a distributing chamber.

12. *Division Lobbies.*

(*a*) *Input.*—That the air-input to the Division Lobbies be increased, especially at the continuation of these Lobbies at either end of the Debating Chamber.

(*b*) *Extract.*—That the vitiated air-chamber over the Division Lobbies be connected to the House of Commons' extract fan, so that extraction from the Lobbies can be increased during Divisions.

13. *Lavatories.*

That steps be taken to promote ventilation of the Lavatories, and also heating.

14. *Retiring Rooms.*

That the position of the inlets to the Retiring Rooms be altered, for at present the fresh air is delivered at the ceiling.

HOUSE OF COMMONS (VENTILATION).

APPENDIX

TO PARLIAMENTARY PAPER (Cd. 3035–1906).

REPORT

BY DR. M. H. GORDON,

ON AN

INVESTIGATION OF THE VENTILATION

OF THE

DEBATING CHAMBER

OF THE

HOUSE OF COMMONS.

Presented to both Houses of Parliament by Command of His Majesty.

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1906.

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PREFACE.

To Sir Michael Foster, K.C.B., F.R.S., &c., Chairman of the Committee appointed to investigate and advise the First Commissioner of Works on the question of improving the ventilation of the House of Commons.

Sir,

The report which I have the honour to submit herewith to the Committee records particulars of an investigation which has been carried out during the past two years with the object of defining the conditions of the ventilation at the Debating Chamber of the House of Commons.

The report is divided into two parts, which deal with successive stages of the enquiry effected during 1904 and 1905 respectively. Part I is the appendix to a brief report* submitted by me to the First Commissioner of Works prior to the appointment of the Committee; while Part II deals with the observations made on behalf of the Committee subsequent to their appointment in April, 1905.

In carrying out this investigation I have had the great advantage of the co-operation of Dr. W. H. Hurtley, Lecturer on Chemistry at St. Bartholomew's Hospital, of Mr. R. G. K. Lempfert, of the Meteorological Office, and of Dr. John Aitken, F.R.S. Reports by these gentlemen dealing with the ventilation from the chemical and physical points of view will be found incorporated with the present report. In addition to the services of the above gentlemen, I have to add that the investigation of the quantity and distribution of the air was carried out conjointly with Mr. Arthur P. Patey, the Resident Engineer of the Houses of Parliament, to whose valuable co-operation and experience of the working of the system this portion of the enquiry owes much of whatever value it may possess.

As a result of the investigation a number of recommendations for the improvement of the ventilation have been drawn up by Mr. Patey and myself. These recommendations are submitted to the Committee under separate cover.

I am, Sir,

Yours faithfully,

M. H. GORDON.

June, 1906.

* Command Paper 2404, 1905 (House of Commons (Ventilation) Report and Recommendations by Dr. M. H. Gordon).

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CONTENTS.

PART I.

General Purpose of the Inquiry, and the Result of Observations made during 1904.

PART II.

The Result of Observations made during 1905, *and General Conclusions.*

PART I.

SECTION I.

CIRCUMSTANCES PRECEDING THE INQUIRY.

The Problems to be solved with regard to the Ventilation of the Debating Chamber.

From certain questions put to witnesses by Members of the Select Committee that recently reported on the ventilation of the House of Commons, it would appear that the immediate cause of the inception of the Committee was an epidemic of influenza* amongst Members. The Committee caused both a chemical and a bacteriological examination to be made of the air of the Debating Chamber. The result of the chemical examination, which was made by Mr. Butterfield, showed that the air of the Debating Chamber compared favourably with that of some other public buildings in respect of carbonic acid, and was therefore regarded by the Committee with satisfaction. The quantitative bacteriological tests made by Dr. Graham Smith on the same occasions as the chemical tests, showed a mean of 5·8 micro-organisms per litre of air in the Debating Chamber—a quantity that also compared favourably with that found in the air of other public buildings. Accordingly the Committee observed that "though less exact and less satisfactory than the chemical "results, the bacteriological results could not be regarded as distinctly "unsatisfactory."

The Committee concluded that, so far as these objective tests went, the quality of the air was sufficiently satisfactory. They went on to say, however, that this conclusion, obtained by means of objective tests, was not confirmed by the subjective test of Members' own feelings: "It is "the common experience of many Members that the air of the Chamber "'lacks freshness,' that there are some qualities possessed by it which "lead to a stay for a length of time in the Chamber causing in Members "a lassitude and feeling of heaviness which tends to interfere with the "due performance of their duties."

The Committee also pointed out that the air of the Chamber was liable to pollution from dust and various impurities continually being brought in on Members' boots. "Particles of dirt, and with these various "organisms, must be borne upwards by the ascending currents, and other "particles must be falling through the interstices of the matting and "grating and mixing there with the incoming air."

With view to general improvement of the ventilation, the Committee recommended a number of important changes which have since been effected. Their final recommendation was as follows:—

> "The institution of inquiry into problems of ventilation still unsolved, with view of introducing further improvements into the present system."

It is in accordance with this final recommendation of the Select Committee that the further investigation to be recorded in the present report has been carried out on behalf of His Majesty's Office of Works.

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* First Report of the Ventilation Committee, dated June 25, 1903: Page 28, Q. 563; page 36, Q. 678; page 47, Q. 906. Second Report, July 28, 1903: Page 9, Q. 130.

The investigation in question was begun in 1904 and continued during 1905; the great majority of the observations being made on occasions when the House was in session, and the ventilation, therefore, in full working order.

The principal problems calling for investigation at the beginning of the inquiry may be summarised as follows :—

(1) The relationship, if any, between the ventilation of the Debating Chamber and the spread, or possible spread, of influenza.

(2) The extent to which the air of the Debating Chamber is liable to pollution from material continually being brought in upon the boots of Members; the exact nature of such material, and its capacity, actual and potential, of producing disease amongst Members.

(3) The reason of the want of freshness in the air of the Debating Chamber, and especially the nature of the fault in the ventilation causing in Members the undesirable physiological effects drawn attention to in the report of the Select Committee.

It has been possible to investigate problems (1) and (2) to a certain extent separately; the third problem, however, has necessitated a detailed examination of the whole of the present aircourse of the Debating Chamber system.

SECTION II.

DEFINITION OF VENTILATION.

TESTS OF ITS EFFICIENCY, AND THEIR RELATIVE VALUE.

Before proceeding to describe the plan and *modus operandi* of the present investigation, it is desirable to refer as briefly as possible to the purpose of ventilation, and to the relative value of the principal practical tests by means of which, at the present time, its efficiency may be gauged.

Ventilation has been defined by Dr. Billings* as "the continuous and "more or less systematic changing or renewal of the air in a room or "other closed space. It involves," he continues, "the introduction of the "comparatively pure external air in continuous currents, the diffusion of "this air throughout the room, and the constant removal of a corresponding "volume of the air which has become contaminated by vapours, gases, "particulate matters, or odours, or which has had its temperature raised "within the apartment."

Referring to the effects of bad ventilation, Dr. Billings states that "comparison of the results has shown that when in any room occupied "by human beings there is a definite unpleasant animal or musty odour "perceived by a person whose sense of smell is of the usual acuteness and "who enters the room from the fresh outer air, then continuous breathing "of the air producing such odour will be injurious to health." *The subjective test.*

The unpleasant smell that the air of an occupied room acquires when ventilation is insufficient has been generally attributed to its contamination by organic matter contained in the exhalations of those present. Some experiments recently made by Dr. Aitken† imply that this exhaled organic matter is not present in the air as particulate matter in the usual sense of that phrase, but that it exists there in the form of gas or vapour. Whatever its exact nature may be, objective tests directed to the estimation of the quantity of this odoriferous material in air have not hitherto met with much success, and a simple and convenient method by which this may be determined in practice to the requisite degree of accuracy is still wanting. *The organic matter.*

When examining the efficiency of ventilation, therefore, recourse has generally been had to measuring the proportion of exhaled carbonic acid contained by the air of the room.

The importance of the carbonic acid test is not because of the injurious attributes of the gas itself; these are not obvious until the proportion of carbonic acid is far higher than that observed in the air of some of the worst ventilated inhabited rooms. The value of the test lies in the fact that the carbonic acid added to the air of a room by the exhalations of its inhabitants has been found to form, as a rule, *a relative index* of the evil-smelling injurious quality of such air. *The carbonic acid test.*

The interrelation of the quality of the air of inhabited rooms that gives rise to a disagreeable smell and the carbonic acid also present was first definitely established by the late Dr. de Chaumont, of Netley, whose results, according to Dr. Billings, "are now generally accepted as "authoritative, having been confirmed by subsequent observers." Dr. de Chaumont's observations were made on the air of barracks and hospitals, and his description of the manner in which he carried them out is as follows:‡ "The plan followed in all was to take the observations chiefly "at night, when rooms or wards were occupied, and when fires and lights *Dr. de Chaumont's investigations of the air of inhabited rooms.*

* Ventilation and Heating, J. S. Billings, M.D., D.C.L., LL.D., &c., 1893.
† Proceedings of the Royal Society of Edinburgh, 1905.
‡ Proceedings of the Royal Society, Vol. 23; *Ibid*, Vol. 25.

"(except the lamp or candle used for the observation) were out. On first "entering the room from the outer air the sensation was noted and recorded "just as it occurred to the observer, such terms as 'fresh,' 'fair,' 'not close,' "'close,' 'very close,' 'extremely close,' &c., being employed. The air was "then collected (generally in two jars or bottles, for controlling experi-"ments) and set aside with lime water for subsequent analysis, and the "temperatures of the dry and wet bulb thermometers noted. About the "same time samples of the external air were also taken, and the ther-"mometer read. In this way any unintentional bias in the record of "sensations was avoided, and this source of fallacy fairly well eliminated."

The number of observations of the air of barracks and hospitals made in this way was between four and five hundred. As a result, Dr. de Chaumont found that five orders, classes, or qualities of air could be differentiated by the senses. These five classes of air and the amounts of carbonic acid found to be contained by them respectively were as follows:—

No. 1. Quality air. Air described as feeling "fresh," "fair," "not close," "no unpleasant smell," &c., indicating a condition giving no appreciably different sensation from the outer air.

Temperature about 63° F.

Carbonic acid not exceeding the amount in outer air by more than 2·0 per 10,000 vols.

No. 2. Air described as "rather close," "a little close," "not very foul," "a little smell," &c., indicating the point at which organic matter begins to be appreciated by the sense of smell.

Carbonic acid excess over outer air reaches over 4·0 per 10,000 vols.

No. 3. Air described as "close," indicating the point at which organic matter begins to be decidedly disagreeable to the sense of smell.

Carbonic acid in excess over outer air to the amount of 6·0 per 10,000 vols.

No. 4. Air described as "very close," "bad," &c., indicating the point at which organic matter begins to be offensive and oppressive to the senses.

Carbonic acid in excess over outer air reaches 8 per 10,000.

No. 5. Air described as "extremely close," "very bad," &c., indicating the point at which the maximum point of differentiation by the senses is reached.

The figures in this series differ but little from those of 4, so that the probable limit of differentiation by the senses is reached in 4.

Summary of de Chaumont's Observations.

Quality of Air.	Subjective Test.	Objective Test.
		Excess of CO_2 over that present in outside air per 10,000 vols.:—
1	"Fresh"	2·0
2	"Rather close"	Up to 4·0
3	"Close"	6·0
4	"Very close"	8·0
5	"Extremely close" ...	Practically same as No. 4, but CO_2 may be increased.

After analysing his results in considerable detail, de Chaumont laid down the following standard of good ventilation:—

Carbonic acid respiratory impurity, that is to say, the excess of this gas over the quantity present in outside air, ought not to exceed 2·0 per 10,000 volumes of air.

De Chaumont inferred that the amount of fresh air necessary in barracks to keep the impurity due to respiration down to the desired limit would be 3,000 cubic feet per head per hour. In hospitals, on the other hand, although this amount would, of course, keep the air below the limit as regards carbonic acid, it was not sufficient to keep the air fresh and sweet to the subjective senses. Either from the greater quantity of organic matter given off in disease, or from its more offensive quality to the subjective senses, his observations led him to infer that in hospitals about 4,000 cubic feet per head per hour would be required to keep the air fresh and sweet. That this figure for hospitals is not an exaggeration is proved by an observation of Dr. Wilson that when as much as 3,500-3,700 cubic feet of air have been delivered per patient per hour, hospital wards have not been free from offensive smell. De Chaumont's standard.

The standard of carbonic acid proposed by de Chaumont as a limit of good ventilation is more stringent than that of some other observers. Pettenkofer, for instance, had previously proposed as a limit not to be exceeded 10 volumes of carbonic acid per 10,000 volumes of air, or 6 volumes in excess of the amount usually present in the open air of towns. Carnelly, Haldane, and Anderson concluded that for the very crowded elementary schools of this country a lower limit than 13 volumes (or 9 volumes in excess of that usually present in the outer air) could not, for practical and financial reasons, be fixed in 1887, although Dr. Haldane admits that with the present improved facilities for mechanical ventilation a much lower limit could now doubtless be assigned.* The limit fixed by law in regard to the artificially humidified air of cotton-weaving sheds is 9 volumes per 10,000 (or 5 volumes in excess of the outer air). This regulation, however, is only enforced during daylight. The Departmental Committee on the Ventilation of Factories and Workshops, from whose recently issued first report (1903) these latter data are cited, go on to say from their own observations, chiefly of the air in factories and workshops when in use at the present time, "it is reasonable to expect that under ordinary circum- " stances 10 volumes (*i.e.*, 6 volumes in excess of the outer air) should not be " exceeded in factories and workshops unless gas is burning." The limit the Committee eventually propose to be prescribed by the Home Secretary for all factories and workshops during daylight, under the Factory Act of 1901, as a limit beyond which a penalty should be imposed, is 12 volumes of carbonic acid per 10,000 of air, or 8 volumes in excess of that usually present in the open air of towns, the only exception to this rule to be in cases where the extra carbonic acid is produced in other ways than by respiration or combustion. Standards proposed by other observers.

The difference between the carbonic acid limit proposed by de Chaumont and that recommended by the Departmental Committee of the Home Office is, therefore, very considerable, since the former proposed to allow only 2 volumes per 10,000 in excess of the outer air, and the latter up to 8. This difference, however, is, I venture to think, explained by an examination of the original papers of both authorities. The object of de Chaumont was to define good ventilation, that of the Departmental Committee was to define for factories and workshops in their present state a practical boundary line beyond which a penalty should attach. The difference between these two purposes is so great that it explains to a considerable extent the difference between their respective standards.

But if this explanation is correct, it will, no doubt, be granted that of the two carbonic acid limits mentioned, the one within which the air of the Debating Chamber of the House of Commons should be kept is not the horizon suggested by the Home Office Committee, but the limit of first-class air suggested by de Chaumont. It must be remembered, also, that de Chaumont's standard is only representative of the best air actually observed in barrack dormitories while in occupation during the night.

* The Council Schools in London at present have an excess over outer air of over 6 volumes CO_2 per 10,000 in the majority of cases. Report of Medical Officer to the late School Board, March 25, 1904, page 35.

The question now arises: How does the air of the Debating Chamber compare with de Chaumont's standard as regards carbonic acid?

De Chaumont's limit was an excess of carbonic acid over outside air not exceeding 2·0 per 10,000 volumes.

In the case of Mr. Butterfield's figures, by taking the amounts found by him in each of his four tests of the air of the Equalising Chamber as the amount of carbonic acid present in unbreathed air when his observations were made, and by subtracting this amount from his figures for carbonic acid in the air of the Debating Chamber at various points, we find the respiratory impurity expressed as carbonic acid, per 10,000 volumes, is found to be as follows:—

Mr. Butterfield's First Test.

Date, 7th July, 1902.

Time	6.30–7.10 p.m.	10.35–11.5 p.m.
Centre of Equalising Chamber	0	0
Ministerial Benches, middle	1·43	1·58
Opposition Benches, middle	1·49	1·83
Ministerial Benches, wall under Gallery	1·48	1·00
6 inches below ceiling	1·86	1·61

Mr. Butterfield's Second Test.

Date, 21st July, 1902.

Time	6.48–7.30 p.m.	10.32–11.18 p.m.
Centre of Equalising Chamber	0	0
Ministerial Benches, wall	1·58	1·32
Ministerial Benches, near Gangway	0·21	—
Ministerial Benches	—	0·73
Opposition Benches, near Gangway	1·82	—
Opposition Benches	—	0·19
6 inches below ceiling	2·15	2·0

These results show that on both the occasions when the test was applied the air of the Debating Chamber over the benches on the floor was, as regards carbonic acid impurity due to respiration, within the limit of good ventilation defined by de Chaumont. On the first occasion also (July 7th) the respiratory impurity in the air expressed by carbonic acid was within this limit at the ceiling. On the second occasion, however (July 21st), the respiratory impurity expressed by carbonic acid at the ceiling, between 6.48 and 7.30 p.m., was in excess of de Chaumont's limit by 0·15 per 10,000 volumes, and between 10.32 and 11.18 p.m. it was exactly up to the limit, viz., 2·00 per 10,000.

It would appear, therefore, that in one of the four tests the air at the ceiling was found to be slightly outside de Chaumont's standard of good ventilation. Moreover, the part of the ceiling at which the air was examined in all four tests was at the end near the Strangers' Galley. The air is probably purer at this end than at the opposite end of the ceiling, near the Ladies Gallery, where the outflow is less.

The subjective observation of the Ventilation Committee, therefore, that the air of the Debating Chamber lacks freshness, is to some extent confirmed by the result of this objective observation, in which the respiratory impurity expressed by carbonic acid exceeded de Chaumont's limit for first-class air before the air reached the ceiling. It must be admitted, however, that on the three other occasions no such excess was found, and that even on this occasion the air from the carbonic acid standpoint was still removed by a considerable interval from de Chaumont's second-class air, in which the respiratory impurity due to carbonic acid reached 4 parts per 10,000, and the air felt "rather close."

Limited value of the carbonic acid test.

It has been mentioned that the first test applied to air is the subjective test of the feelings, and that the carbonic acid is only a *relative* index to that quality of the air of an ill-ventilated inhabited air-space that makes it disagreeable, and if breathed continuously, harmful. Moreover, while the relation between the carbonic acid and the smell of organic matter in the air of an inhabited room holds as a rule, in exceptional instances the smell may not be perceptible when the carbonic acid impurity due to respiration is as high as 5 parts in 10,000, and it may be very decided when the carbonic acid impurity does not exceed 3 per 10,000. It depends in part on the temperature, in part on the amount of moisture present, and in part on the amount of diffusion going on—for organic matter does not diffuse so readily as carbonic acid gas (Billings). The most trustworthy objective test of ventilation available, therefore, valuable though it undoubtedly is as a rule, is at the best only of relative worth, and sometimes it is actually misleading. In brief, the value of the carbonic acid test is aptly expressed by a well-known phrase of the late Sir George Buchanan, who, referring to the value of chemical analysis for detecting pollution of drinking water dangerous to health, observed that in this matter "chemistry could inform "us of impurity and hazard, but not of purity and safety."

Measurement of the delicacy of the sense of smell.

It is exceedingly doubtful if any objective test of the offensive odour of air polluted by the exhalations of human beings in a closed room will ever be quite equal in delicacy to the test of the subjective feelings. It is of interest in this connexion to refer to a valuable point cited by Dr. Hurtley in his chemical report, namely, that the delicacy of the human sense of smell has recently been the subject of quantitative investigation by one of the most distinguished chemists of the day—Professor Berthelot, of France. Professor Berthelot selected two substances possessed of powerful odour, musk and iodoform, and he carefully ascertained the smallest amounts of each of them perceptible by the sense of smell. The results which he obtained are stated in the following table, in which the range of some of the most delicate objective tests is also given, and, for comparison, the range of the carbonic acid test as usually applied to air.

Delicacy of the Sense of Smell compared with that of some of the most delicate Objective Tests.

Substance.	Smallest Part of a Gramme Detected.	Re-agent.	Authority.
Musk... ...	0·000,000,000,000,000,01	Human sense of smell...	Berthelot.
Iodoform ...	0·000,000,000,000,01	Do. ...	Do.
Sodium ...	0·000,000,000,03	Spectroscope	Bunsen and Kirchoff.
Lithium ...	0·000,000,001	Do.	Bunsen.
Nitrite ...	0·000,000,001	Ilosvay's re-agent ...	Warington.
Saliva ...	0·000,000,1—1	Culture-test (Streptococci)	Gordon.
Carbonic acid	0·000,1—1	Usual range	Pettenkofer.

According to these figures, therefore, the human sense of smell is about a million times as delicate an index of the presence of musk as is the spectroscope of sodium; and the latter test exceeds in delicacy the ordinary chemical test for exhaled carbonic acid by about the same extent. As the sense of smell is a frequent means by which the efficiency of ventilation is judged by the public, it is well to bear in mind the enormous delicacy of this test as compared with objective tests at present available.

Temperature and humidity.

A combined factor which recent observations have convicted of playing a chief part in causing the unpleasant subjective sensation that is evoked by the atmosphere of a crowded room, is the coexistence in the air of an excess of temperature with an excess of humidity. This relationship between the physical condition of the atmosphere and the subjective feelings aroused by it, is of fundamental importance not only as regards ventilation, but as regards the subjective effect of climate and season; and the interaction may be briefly stated as follows. In health the body temperature is kept at a constant level by the operation of a delicate balance between the internal production and the external loss of heat. As the whole of the energy expended in the internal work of the body eventually becomes heat, the supply as a rule exceeds the demand, and hence one of the chief uses to which the air environment is put under ordinary conditions is the continual cooling of the body.* For this reason, an undue increase in the temperature and humidity of the air environment induces discomfort by interfering with the elimination of heat from the body; and, on the other hand, an undue deficiency in these respects by causing a too rapid loss of heat induces the feeling of "chill."

Now, it has been known for long that the temperature alone of the air environment may be raised considerably without necessarily inducing harmful or even unpleasant effects, but that if at the same time the humidity is raised unduly, a point arrives at which the continuous elimination of heat from the body is impeded, with the result that persons exposed to such air suffer from the effects of heat retention. Extreme instances of evil effects consequent on the massing of a large number of persons in a small unventilated apartment have been attributed to this coexistence in the air of a high temperature with an excess of humidity. But what has, to a great extent, escaped suspicion † until the observations recently published by Flügge, Paul, Heymann, and Ercklentz‡ is that the unpleasant subjective symptoms that first warn the occupants of an ill-ventilated apartment of the oppressive condition of its atmosphere are to be attributed not (as hitherto generally believed) to the gases or effluvia exhaled by those present, but chiefly to the fact that the temperature and humidity of the air have become increased to beyond the combined limit compatible with human comfort.

In a series of experiments made in a specially constructed glass chamber Paul found that the point at which the temperature and humidity of the air exceeded the limit compatible with the comfort of a normal person varied somewhat within certain limits; the temperature of the air at the onset of unpleasant feeling varying from about 70° F. to 86° F., and the humidity from 45 per cent. to 86 per cent; the unpleasant effect becoming manifest at a lower relative humidity at the higher temperatures. The lowest temperature at which Paul records unpleasant subjective symptoms as having been induced was on an occasion when the temperature of the air was 69·8° F., and the coexistent humidity 56 per cent. On some other occasions, however, this degree of temperature and humidity appears to have been exceeded without unpleasant symptoms having been provoked.

Taking the wet bulb index and the last instance cited as the lowest limit at which subjective feelings of unpleasant character may be evoked by reason of excess of temperature and humidity of the air, it would appear that such effects are avoided if the wet bulb temperature of the air is kept below 60° F. According to this figure, with a percentage humidity of 63 the limit of comfort would be liable to be exceeded when the temperature

* According to Rubner, the quantity of heat excreted by an adult man in 24 hours amounts to 2,700 calories given off as follows :—lungs 35 calories, work 51, warming food and drink 42, evaporation 558, conduction 833, radiation 1181 calories.

† It is but just to Dr. Reid, the designer of the Debating Chamber system, to state that his published works prove that he was fully alive to the importance of both temperature and humidity. By extensive and arduous employment of the experimental method he had acquired an insight into the art of ventilation that has probably never been equalled.

‡ Zeitschrift fur Hygiene. Band 49, 1905.

of the air passed 67° F., and with a percentage humidity of 73-75 the same limit would be passed after 65° F. As the temperature at which the air of an inhabited room should be kept in this country is generally considered to be from 60-65° F., and the humidity of the air has been stated on good authority to be most pleasant when 73-75 per cent. of saturation,* the importance of these recent statements is obvious, as also is the need for further and more extensive investigation before the inferences to which they have given rise can be considered to be fully justified.

The subjective symptoms found by Flügge and his associates to be induced by air that had exceeded the limit as regards temperature and humidity were described as "feelings of inconvenience, oppression, lassitude, giddiness, nausea, &c."—symptoms that were found to be relieved at once by reducing the temperature and humidity of the air. On the other hand, so long as this combined factor was kept below the limit mentioned there was no evidence of any injurious effect even though the proportion of exhaled carbonic acid exceeded the maximum ever recorded as having been found in the air of a crowded room. Provided the temperature and humidity of the air did not exceed the limit, the absence of any disturbance was so complete that the power of co-ordination remained intact, as was proved by the ease and normal manner in which certain arithmetical calculations given by way of test were carried out, and further by examination as to the presence of mental fatigue by means of the usual instruments. In conformity with the above results was the observation that children kept in a crowded schoolroom showed no symptoms of disturbance provided that the temperature of the air was kept low.

The observations in question refer to the capacity of the air for producing unpleasant subjective sensations and deal with air from the point of view of comfort. This matter is of necessity a difficult one to gauge accurately owing to the varying susceptibility of individuals to different qualities of air, and also owing to the different degree to which the imagination influences the verdict. It is of interest, therefore, to take note of an investigation recently made by Dr. J. S. Haldane,† in which he determined the point at which a rise in the temperature and humidity of the air environment begins to produce objective evidence of harmful effect as expressed by a definite rise in the body temperature. He found that when the subject of experiment was at rest, and the air environment still, the point at which the temperature regulation of the body began to fail (as proved by careful observation on himself and others with the thermometer) was when the wet bulb temperature of the air rose above 88° F. In moving air, however, a wet bulb temperature up to about 93° F. could be borne without abnormal rise of body temperature, provided that the body was at rest. During muscular work, on the other hand, in still air, the maximum temperature that could be endured without abnormal rise of body temperature was very much lower, viz., for a person stripped to the waist about 78° F.

It would seem, therefore, that as regards the vigour, comfort, and health of the occupants of a given room, the temperature, humidity, and movement of the air are of great importance. Applying his results to the service of ventilation, Flügge has concluded that the temperature in public buildings should not be allowed to exceed 70° F., and that as far as possible it should be kept between 62° and 67° F. These figures are, of course, nothing new, as the practice in this country for many years past has been to keep the temperature between 60° and 65° F. The chief practical lesson

* In those occupied rooms in which the quality of the air was found by de Chaumont to be first-rate, the mean temperature was 63°F., and the mean humidity 73 per cent. of saturation. This degree of humidity, therefore, was suggested by him as a ventilation standard for this country (Parkes' Hygiene, 7th edit., p. 181). After extensive examination of the air of prisons Dr. Wilson has independently advocated a similar standard, viz. 73–75 per cent. of humidity (Wilson's Hygiene, 8th edit., p. 152). It may be added that at the time when he suggested the standard of humidity referred to, de Chaumont remarked that in Germany 50 per cent. is looked upon as an average humidity, whilst in England this would indicate an exceptionally dry atmosphere (loc. cit.).

† Journal of Hygiene, October, 1905.

to be learnt from these more recent observations then is the great importance of not allowing the temperature of the air to exceed the limit defined, and especially the necessity of continually observing and controlling the combined quality of temperature and humidity.

Small value of the quantitative bacteriological test.

As regards the second test applied at the instance of the Committee, the value of a quantitative bacteriological examination of air is limited, chiefly because the result is discounted by the fact that the significance of the great majority of the micro-organisms found is unknown. Little stress can be laid on failure to detect pathogenic micro-organisms by this method. Even if present in the air, the majority of such micro-organisms will not be detected by the quantitative method of Frankland, in which the micro-organisms are cultivated in gelatine at 20° C. Further, absence of pathogenic bacteria in 5 or even 35 litres of air does not, of course, imply their absence in a larger quantity. As an adult man inhales roughly 10,000 litres of air in the course of 24 hours, it is necessary to examine a large quantity before much stress can be laid on the absence of pathogenic bacteria in a bacteriological examination of air.

Bacteriological test for detecting organic matter derived from mouth and throat.

Although an objective test by which the evil-smelling organic matter in air can be readily estimated is still a desideratum, a method has recently been suggested by the writer of this report for estimating the degree to which the air of an inhabited room is polluted by particulate matter given off from the human mouth and upper respiratory passages. The principle of this test consists of utilising the natural flora of the mouth for the purpose of identifying minute particles of saliva expelled in the acts of sneezing, coughing, and loud articulation. Particles of saliva emitted from the mouth into the surrounding air in the acts mentioned have been shown to remain suspended in the air for a considerable time before settling, and have been proved to be liable to be wafted to distances up to 40 feet away by air currents such as exist in ordinary rooms with the windows closed and no artificial ventilation. A certain micro-organism, Streptococcus brevis, was found to be constantly present in normal human saliva, generally to the extent of over 10,000,000 per c.c. The micro-organism in question being in possession of definite physiological characters by which it can be identified, serves as an index by means of which so small a particle as one ten-millionth part of a c.c. of saliva can be detected, if present. It should be added that besides S. brevis, other streptococci occur abundantly in saliva, and serve on occasion as additional tests by which particles of it can be detected. The method by which these salivary micro-organisms are recovered from air is to expose a suitable sterile culture medium for a given time to the air, and to then incubate it at blood-heat (37° C.). Under these circumstances, particles of saliva in suspension in the air gravitate on to the surface of the medium, and when the latter is subjected to the temperature of the body, the micro-organisms deposited with the particles multiply. Streptococci recovered in this way from air are isolated in pure culture, and afterwards submitted to certain cultural tests previously found to be of value for differentiating streptococci characteristic of saliva from streptococci of other origin.

Although the inhalation of air charged with particulate matter derived from the mouth and respiratory passages of perfectly normal individuals has not yet been shown to be followed by actual disease, the process cannot be regarded as wholesome. It is, moreover, now known that persons recently exposed to air-borne specific infection may acquire and retain in their upper respiratory passages the virus of the infectious disease to which they have been exposed, and that though themselves perhaps unaffected thereby, they may, by expelling the materies morbi into the air in the acts referred to, be the means of infecting others. Conditions being equal in other respects, the larger the number of persons present in a given room, and the greater the length of their exposure to the air therein, the greater will be the chance of the successful transfer of infection in this way.

Its value.

The value of the streptococcus test lies in the fact that it is a direct index of potential access to the air of a given room of morbific virus liable

* Report of the Medical Officer of the Local Government Board, 1902–03, pp. 421–471.

to be contained in the saliva, and therefore liable to be expelled in the breath in the acts of sneezing, coughing, and loud articulation. Amongst diseases the virus of which is especially apt to be communicated to the air in this way are diseases of the respiratory passages, such as colds, influenza, diphtheria, tuberculosis, &c. From the abundance in the sputum of influenza patients of the specific micro-organism associated with the production of that disease, and from the frequency of sneezing and coughing in perhaps the commonest type of the malady, influenza would appear to be especially prone to be spread in this manner.

Summary of Section II.

Regarding as a whole the tests by means of which the efficacy of a ventilation process for *cleansing the air of a given air-space* can be judged, it would appear that no objective test at present available can in any way compare with the subjective sense of smell for delicacy in detecting the odoriferous portion of such organic pollution as may have been added to it in the exhalations of those present.

The objective test upon which up to the present time most reliance has been placed in practice is the measurement of the proportion of exhaled carbonic acid in the air, a method that has rendered good service in the past, and will, no doubt, continue to do so in future. It is important, however, to realise that the value of the carbonic acid test is partial only. Recent observations point to the temperature and humidity of the air as the qualities chiefly concerned in causing the symptoms that are evoked by the atmosphere of a crowded room when ventilation is bad—symptoms that it would seem are the result of heat retention in the body. The best method of preventing this unpleasant heat-conserving property of the air from obtaining, is to carry out systematic and continual scrutiny with both wet and dry bulb thermometers, and to keep the combined factor of temperature and humidity below the limit at which discomfort has been found to be induced.

The quantitative bacteriological test is a useful guide in judging general cleanliness of the air, but by itself has no further value.

While no sufficiently delicate objective test is at present available for directly estimating the exhaled organic matter in vitiated air, an objective bacteriological test has been introduced by means of which particulate matter expelled in the breath in certain acts may be estimated. The value of this test lies in the fact that it supplies a direct index of the possible access to the air of living particulate morbific virus given off in the breath. If affords, therefore, a means by which the efficacy of various systems of ventilation for removing such potentially dangerous particulate material can be examined.

SECTION III.

SCOPE OF THE INQUIRY.

1. Scope of Investigation Desirable.

The examination of the ventilation of the Debating Chamber desirable in view of the facts referred to in the preceding sections may be summarised under three heads:—

(1) Examination of the *quality* of the air of the Chamber by objective tests in addition to those already applied to it at the instance of the Ventilation Committee.

(2) Examination of the *quantity* of air sent into and removed from the Chamber by the ventilation.

(3) Examination of the *distribution* of this air inside the Chamber both at inlet on the floor, and at outlet on the ceiling.

Problems such as those concerning the spread of influenza in the Debating Chamber, and the pollution of the air by material brought in on Members' boots, are included in the general investigation of the quality of the air. The problem with regard to the cause or causes of the want of freshness in the air, and the undesirable physiological effect exercised upon Members, raised the question as to the quantity of air supplied to and removed from the Chamber, and also the question as to the actual area inside the Chamber over which the incoming air is distributed and from which the outgoing air is withdrawn.

2. Order in which this Investigation has been carried out.

The investigation consists of two parts carried out during 1904, and during 1905, respectively.

1904.

The main feature of the ventilation under investigation during 1904 was the quality of the air. This was examined both from the bacteriological and chemical point of view.

The object of the bacteriological examination was to determine the extent to which the air suffered from particulate pollution, and the order in which the bacteriological investigation was carried out between May and August was, as far as circumstances permitted, a systematic progress from inlet to outlet of the airway. When suspicion arose that the air was liable to receive contamination from any source, a sample of the material to which suspicion attached was, if possible, procured and examined to determine the nature and extent of such harmful properties as it might be possessed of. A special watch was then kept to determine if particles of the material could be detected bacteriologically in the air. In this way it has been possible to obtain evidence approximately justifying a verdict of conviction or acquittal in regard to certain materials conceivably implicated in imparting particulate pollution to the air.

As regards two special sources of pollution, it was desirable on account of their importance in reference to disease to ascertain further by special tests the degree to which the air was liable to derive infection by them. Accordingly in these two cases index-experiments were planned and carried out with due precautions. In these experiments an easily recognisable but harmless micro-organism was artificially introduced as index of infection, and the air then scrutinised for its presence.

A chemical investigation was also made at this time by Dr. Hurtley, principally in order to determine the extent to which the air suffered from gaseous pollution of various kinds. The question of carbonic acid having been previously investigated, it was thought unnecessary to repeat previous observations, and therefore, as regards this particular gas, Dr. Hurtley confined his attention to examining air passing out of the Debating Chamber during debates. During the inquiry an important question arose as to the extent to which the air passing from the inlet on the Terrace to the Debating Chamber is liable to be contaminated by air from the engine rooms, vaults, and vitiated air-passages contiguous to the airway. Some index-experiments, therefore, were made with the object of throwing light upon this matter. In these experiments an odoriferous substance, or a gas, was the index element introduced on the outside of the airway, and the subjective sense of smell was the re-agent relied upon for the detection of its passage to the interior of the airway.

Further than the above observations, the temperature and humidity of the air was also examined on occasions when the inquiry was in progress, the fresh air at the inlet being compared in these respects with the air passing into the Debating Chamber. Useful help was also afforded at this stage by Dr. Aitken, who visited the system and wrote a memorandum, which is appended.

A preliminary examination of the quantity of air passed through the system under the conditions obtaining in 1904 showed the need for further investigation both of this matter, and also of the distribution of the air within the Debating Chamber.

A report, briefly stating the results of the inquiry obtained up to this stage, and making a series of recommendations, was submitted by me to the First Commissioner of Works in December, 1904. A Committee was then appointed to supervise the continuation of the investigation; the Committee consisting of Sir Michael Foster, Chairman, Dr. Haldane, and myself, with Dr. W. N. Shaw as consultant. At the Committee's request Mr. Patey, the Resident Engineer, was subsequently added to their number.

1905.

The further investigation of the quality of the air made during 1905 consisted of a continuous examination of the temperature and humidity by means of recording instruments. These were in charge of Mr. Lempfert, whose report is appended. Other investigations relating to the quality of the air made during 1905 were examinations of the filtering value of the inlet washing screen, and also some observations bearing on the question of the inleakage of undesirable air into the airway.

The most important part of the enquiry during 1905, however, was the investigation of the quantity of air passed through the system as a whole and through its several parts separately, and especially the determination under differing conditions of the distribution of the fresh air within the Debating Chamber. Both the investigations in question were made for the Committee by Mr. Patey and myself acting in conjunction, and in the earlier parts we were assisted by Mr. Lempfert.

SECTION IV.

(A.) THE BACTERIOLOGICAL REPORT.*

SUBSECTIONS.

SUBSECTION 1.

PRINCIPLE OF THE BACTERIOLOGICAL TESTS EMPLOYED IN THE PRESENT INQUIRY.

The purest air found in Nature is comparatively free of bacteria. Thus in mid-ocean Miquel and Moreau† found in 10 cubic metres of air only 4-5 bacteria, a number corresponding to that found by de Freudenreich in air at an altitude of 2,000-3,000 metres. M. Binot‡ found that air on the summit of Mont Blanc contained 4-11 micro-organisms per cubic metre (1,000 litres), and that at successive stages of the descent the number in a like quantity of air was 8, 14, and 49, respectively, as the altitude diminished. Similarly M. Cristini,§ of Geneva, who ascended in a balloon and made some bacteriological observations of air at a height from the ground, found that air in the higher layers of the atmosphere—above 1,000 metres—even directly over a town, is extremely pure from the bacteriological point of view; and he thought it very probable that this absence or rarity of germs begins much lower down. This conclusion is confirmed by some observations of Dr. Miquel, who for 20 years past has made continuous and systematic observations of the quantity of bacteria present in the air of Paris. Miquel found that air in the Park at Montsouris was 28 times less charged with bacteria than air at the centre of Paris, while, on the other hand, air on the top of the Panthéon (82 metres from the ground) was purer bacteriologically in the quantitative sense than air in the Park of Montsouris‖ at the lower level. As regards the height at which the air is quite free of bacteria, Dr. de Freudenreich inferred from observations that at 4,000 metres§ the atmosphere is absolutely free of micro-organisms.

As pure air is almost, if not quite, free of bacteria, therefore, the bacteriological examination of air has, of necessity, for its sole object the

* The laboratory portion of this investigation was carried out in the Research Laboratory of St. Bartholomew's Hospital.

† Traité de Bacteriologie Miquel et Cambier (Paris, 1902), pp. 915-916.

‡ Comptes Rendus, March 1902.

§ Annales de l'Institut Pasteur, vol. 7, p. 665.

‖ Miquel. *Loc. cit.*

detection, not of diminished purity, but of added particulate impurity. The question as to the quantity of bacteria present in the air at various points along the airway from the Terrace, and in the Debating Chamber itself, having been previously investigated by Dr. Graham Smith by Frankland's method, evidently with much care, it was thought unnecessary to repeat these observations, and attention has been chiefly confined to the kinds of bacteria present. On occasions in the present investigation when it was desirable to ascertain the general abundance of bacteria in the air, this was effected by simultaneously exposing plates of culture-media at various points, and comparing the bacterial incidence upon them.

The aim of the present bacteriological investigation, then, has been chiefly *qualitative*. Moreover, as the majority of bacteria found in air are harmless, and their individual significance, even if a name can be attached to them, conjectural, or at the most botanical, the kinds of bacteria for which the air has been examined have been those of definite and well-ascertained significance.

The kinds of bacteria of most significance in air are primarily those capable of causing disease in man, and especially those capable of producing this effect when inhaled. Such micro-organisms, however, even when present in air, are difficult to detect. Although of the greatest significance when found, therefore, the detection of specific pathogenic micro-organisms in air is so uncertain in the present stage of bacteriology that failure to find them by the methods at present available, even after careful search, does not necessarily imply their absence.

Now, infection can only be derived from a previous case, and a person suffering from an infectious disease can communicate the materies morbi to others in only a limited number of ways. The ways in which infection may be given off are by contact, by the excreta, by material shed from the surface of the skin, and by particulate matter derived from the mouth and upper respiratory passages. Of all particulate matters given off by an infected person, those which have in the past been proved to be especially liable to convey infection to others are particulate matters derived from mouth or intestine. In either case the chief channel by which the virus gains entrance to the person of a susceptible individual is by the mouth; being either ingested with the water or food, or, in many cases, inhaled in the air. In order to prevent the spread of infection, therefore, it is especially necessary to prevent pollution of a food or air-supply by particulate matter derived from the mouth or intestine. Experience has shown that pollution of this kind may be unperceived by the unaided senses, and may even escape detection by chemical analysis, and yet be dangerous to health. Objective tests, therefore, by which traces of particulate matter from either of these two sources can be detected if present, are capable of much practical service in Preventive Medicine. Such tests are supplied by bacteriology. By reason of the constant and great abundance of certain bacteria of well-defined character and attributes in particulate matter recently derived from either mouth or intestine, the presence of exceedingly minute quantities of material from either source can be bacteriologically identified if present. Moreover, by observing the abundance or frequency of the index-bacteria referred to, the degree to which food or air is subject to pollution by particulate matter derived from mouth or intestine can be gauged.

Micro-organisms, therefore, on the detection of which we have chiefly to rely in applying bacteriology for the purpose of preventing the access to an air-supply of morbific virus, are not the specific pathogenic micro-organisms themselves, but those bacteria which, from their constant abundance in saliva and fæcal matter, respectively, afford evidence of the presence of particulate matter recently derived from either mouth or intestine, and by the very fact of their own presence demonstrate the liability of the air to be charged on occasion with specific micro-organisms of disease, and by their abundance enable the degree of this liability to be estimated.

The *streptococcus* test by which as small a particle as one ten-millionth to one hundred-millionth of a cubic centimetre of saliva can be detected, if present, has been previously referred to. The bacteriological test for fæcal matter is even more delicate. Dr. Houston has recently shown that by the presence of *B. coli* from one hundred-millionth to one thousand-millionth of a gramme of fæcal matter can be detected. Another micro-organism also constantly present in fæcal matter—*B. enteritidis sporogenes*—is a means by which from one millionth to one ten-millionth of a gramme of it can be detected. The latter micro-organism, by reason of the fact that it forms spores, is able to resist desiccation, and thus is a test by which not only recent, but also non-recent fæcal matter is revealed.

A further micro-organism, the presence of which has been of considerable importance in parts of the present inquiry is *B. mycoides*. Dr. Houston,* who has made an extensive examination of soils, has pointed out that this micro-organism is so abundant in many soils that it forms a trustworthy test by which, on occasion, one hundred-thousandth gramme of soil can be detected. B. mycoides, like B. ent. sporogenes, forms spores, and therefore serves an an index of the presence of old as well as of recent particles of soil.

Summary.

The main object in making a bacteriological investigation of an air supply is to determine the extent to which the air is liable to be charged with morbific virus. Hence the present investigation consists not so much of making a search for specific micro-organisms of disease, as of endeavouring to detect the presence and abundance of certain definite micro-organisms, which betray the presence of polluting material liable to be charged with specific micro-organisms of disease. In short, in the present instance, attention is directed to channels of infection, that is to say, to pollution, rather than to infection itself.

SECTION IV. SUBSECTION 2.

CHARACTERS OF THE SPECIAL MICRO-ORGANISMS SEARCHED FOR, AND METHODS USED FOR DETECTING THEM.

(*a*) *Characters by which the Special Micro-organisms searched for have been identified.*

For reasons given above, the micro-organisms for which both air and material suspected of imparting pollution to it have been examined, have been :—

Streptococci (indices of saliva).

B. coli (index of recent fæcal matter).

B. enteritidis sporogenes (index of both recent and non-recent fæcal matter).

B. mycoides (index of both recent and non-recent particles of soil).

The characters chiefly relied on in identifying micro-organisms with B. enteritidis sporogenes and B. mycoides respectively were, in the case of the former, the characteristic change produced in milk; and in the case of the latter, the characteristic appearance of the colonies on agar or gelatine. Streptococci, however, and bacilli of the B. coli type, were isolated in pure culture, and their characters examined in detail. This was necessary, because micro-organisms exist in nature that resemble one or other of these two micro-organisms, but differ from streptococci of saliva or from B. coli of the intestine both in character and significance.

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* Dr. A. C. Houston, Reports of the Medical Officer of the Local Government Board, 1897–98, 1898–99, 1899–1900.

In order to avoid the possibility of confusing such streptococci with salivary streptococci, and such coli-like bacilli with fæcal coli, the examination of micro-organisms of each of these two classes, isolated in the course of the present inquiry, has not been confined to ascertaining a few initial characters, but a series of differential tests have been applied to each.

Differential Tests for Streptococci.

The differential tests to which all streptococci have been submitted are nine in number.* The character of these tests and the nature of the response given to them by the five types of streptococci most frequently met with in human saliva, are shown in the following table :—

Re-actions of Five Streptococci found to be most frequently present in the Normal Human mouth.†

No.	Remarks.	Acid and Clot produced in Milk tinted with Litmus.	Change of Colour produced (anærobically) in Broth tinted with Neutral Red.	An Acid Re-action produced in Broth containing						
				Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.
1	The commonest streptococcus met with in 22 samples of saliva examined.	+	+	+	+	—	—	—	—	—
2	Practically as common as No. 1.	+	+	+	+	+	—	—	—	—
3	A good deal less frequent than the preceding two.	+	—	+	+	—	—	—	—	—
4	Much less frequent than 3.	—	—	+	+	—	—	—	—	—
5	About as frequent as 4	+	+	+	+	+	—	+	—	—

Differential Tests for Coli-like Bacilli.

The differential tests to which all bacilli bearing an initial resemblance to B. coli have been submitted are eight in number. The character of these tests, and the nature of the response given to them by the type of B. coli most frequently present in fæcal matter are both shown in the following table :—

Re-actions‡ of the Type of B. Coli found to be most frequently present in the Normal Human Intestine.

Acid and Clot produced in Milk tinted with Litmus.	Change of Colour produced in Broth tinted with Neutral Red.	Acid *and Gas* produced in			Indol produced in Broth.	Nitrate reduced to Nitrate.	Liquefaction of Gelatine within 30 days.
		Glucose.	Lactose.	Saccharose.			
+	+	+	+	—	+	+	—

* These differential tests for streptococci were described in a report by the writer in the Report of the Medical Officer of the Local Government Board (1902–03, p. 440).

† These data are taken from a report of the writer's which was published in the last issue of the Report of the Medical Officer of the Board (1903–04, p. 388).

‡ Dr. A. C. Houston, in Report of the Medical Officer of the Local Government Board 1902–03, pp. 511–566.

(b) Methods used for ascertaining the Presence of these Micro-organisms.

Materials (Dust, Dirt, &c.) suspected of polluting the Air.

A gramme of the material was weighed out and diluted through a series of flasks containing sterilised water. Cultures were then made from dilutions containing successive tenths of the material (·1, ·01, ·001, ·0001, ·00001, ·000001 of a gramme).

In order to isolate any streptococci that might be present in the material, primary cultures from measured dilutions of it were made on Drigalski and Conradi medium, or else in broth. Mackonkey's medium was employed for coli in the same way, and anærobic milk (heated to 80° C. for ten minutes after inoculation) for spores of B. enteritidis sporogenes.

Air.

(1) Sterile aluminium dishes 4 to 6 inches in diameter were filled with neutral-red broth and exposed to the air for a definite time. The broth was then poured back into its original tube, and subsequently incubated for 48 hours anærobically at blood heat. At the end of this time the broth was microscopically examined, and any streptococci present were, in the majority of cases, isolated and examined.

In all cases where the broth was found to have undergone a change of colour and gas bubbles were also present on the surface, subcultures were made in Mackonkey's medium, and in milk anærobically, in order to determine the presence or absence either of B. coli or of B. enteritidis sporogenes.

Streptococci were also isolated from the air by exposing to it plates of solid media, such as agar, raffinose-litmus-agar, and the medium devised by Drigalski and Conradi. Better results in obtaining streptococci characteristic of saliva from air leaving the Debating Chamber during debates were effected with plates containing solid media than with plates containing neutral-red broth. For this purpose, in short exposures, agar afterwards incubated at 37° C. was especially useful, but in longer exposures the Drigalski medium was found preferable. Besides the above media, plates of blood-agar and also blood-serum plates were used on special occasions.

SECTION IV. SUBSECTION 3.

THE RESULT OF THE SEARCH FOR POLLUTION.

(1.) The Result of the Examination of Materials liable to pollute the Air.

The materials examined have been—

i. Mud of the River Thames alongside the Terrace opposite the inlet.

ii. Material scraped from the inlet windows.

iii. Dust collected from the air-stream to the Chamber by the scrim cloth.

iv. The outer layer of wool on the cotton-wool filter.

v. Dust deposited on the floor of the Equalising Chamber during a debate. Samples of dirt falling into the Equalising Chamber from Members' boots.

vi. Dust from Debating Chamber, Division Lobbies, and New Palace Yard.

i. Mud of the River Thames.

The first material calling for examination was the mud deposited by the river alongside the Terrace, and exposed to the air at low tide. Complaints have been made in the past of unpleasant smells arising from this mud. Although at low tide the area of bare mud is considerable, the highest level of the mud appears to be some feet below the high-water mark. Opposite the inlet the top of the parapet is 22 feet above the surface of the mud, and the distance across the Terrace from the centre inlet window to the parapet is about 37 feet. It would appear, therefore, that though about 18 feet below the level of the inlet windows, and separated therefrom by the width of the Terrace and the height of the parapet wall (3 feet 1 inch), the mud is sufficiently near the intake to call for special bacteriological examination in an inquiry of the present kind.

Bad smells arising from the mud would be difficult to detect by objective tests, for reasons before given. Were their detection by objective tests possible, the gases productive of the odours in question would come within the field of the chemist rather than that of the bacteriologist. It is exceedingly unlikely, however, that *per se* bad smells of the kind referred to, however unpleasant and undesirable, do more than lessen the ability of the body to resist disease. The terms "miasma" and "effluvium," once so often used to account for infection, have passed into disuse since the advent of bacteriology. Infective virus that has been isolated up to the present time has been found, without exception, to be, not gaseous, but particulate.

It is unlikely that the mud, when wet and cool, would impart appreciable particulate impurity to the air. The case, however, would appear to be different when the mud is warmed by the rays of the sun during the summer months. Bubbles rising to the surface of the mud and bursting are a conceivable means by which particulate impurity might be sprayed into the air, and the fermentation, of which the bubbles are the expression, would be more active when the temperature of the mud was raised. It seemed also to be quite possible that the hot suns of July and August might dry up the surface of the exposed mud, and that particles of dust detached therefrom might be wafted by air currents upwards into the air around the inlet, and being drawn in by the air stream to the Debating Chamber, thus be liable to become inhaled by Members.

For these reasons a bacteriological investigation has been made to determine the following three points:—

(*a*) The extent to which the mud deposited by the river alongside the Terrace wall opposite the inlet to the Debating Chamber airway is polluted by material liable to contain morbific virus.

(*b*) The bacterial composition of the fresh wet mud, in order to observe if any particular micro-organisms, by the abundance and constancy of their presence therein, serve as a means whereby small detached particles of the mud may be detected.

(*c*) The effect upon the bacterial contents of the mud of the action of the summer sun, and also the nature of the micro-organisms which, by surviving the resulting process of desiccation, may be used to identify detached particles of the mud when dry.

Finally, the air at the inlet was carefully examined on two special occasions of low tide towards the end of July, in order to ascertain if any micro-organisms previously ascertained to be present in the mud, wet or dry, could be detected in such air. Besides the two special occasions referred to, however, it should be mentioned that on all the numerous occasions when the inlet air was examined, evidence of particulate contamination of the air from the river mud was being looked for.

(*a*) *The Extent to which the Mud alongside the Terrace is contaminated by Material liable to be charged with Morbific Virus.*

The chief pollution which the mud appeared likely to contain was fæcal matter derived from cattle on the banks of the higher reaches of the Thames, from surface washings, drains, and from sewage-farms discharging effluent into the river; and the objective evidence obtained by making a bacteriological examination of three samples of the Terrace mud has resulted in this suspicion being confirmed.

In order to obtain evidence as to the degree of pollution shown by mud deposited at Westminster as compared with mud higher up the river, samples have been obtained from points nearer the source of the Thames and examined in the same way as the Terrace samples. For this comparison samples have been obtained from the River Thames at Staines (above the intake of the water companies), about 36 miles from Westminster; from Tilehurst, about 75 miles from Westminster, and from three places near the source of the river, viz., from Inglesham, 143 miles from Westminster; Castle Eaton, 149 miles from Westminster; and from Ashton-Keynes, about 158 miles from Westminster and six miles from the Thames Head spring.*

Full details of the results of the bacteriological analysis of these samples are seen in the following table. (For table and diagram *see* next page.)

The characters of the coli-like bacteria and streptococci isolated from these samples of Thames mud were examined, and full particulars of them will be found in the appended tables. A specimen of B. coli, giving the reactions of typical B. coli of the intestine, was found present in the first sample of Terrace mud to the extent of 100,000 per gramme, and in a second sample the same micro-organism was present to the extent of 10,000 per gramme. The same micro-organism was also found in the sample of mud from Inglesham, in which it was present to the extent of 10, but under 100, per gramme.

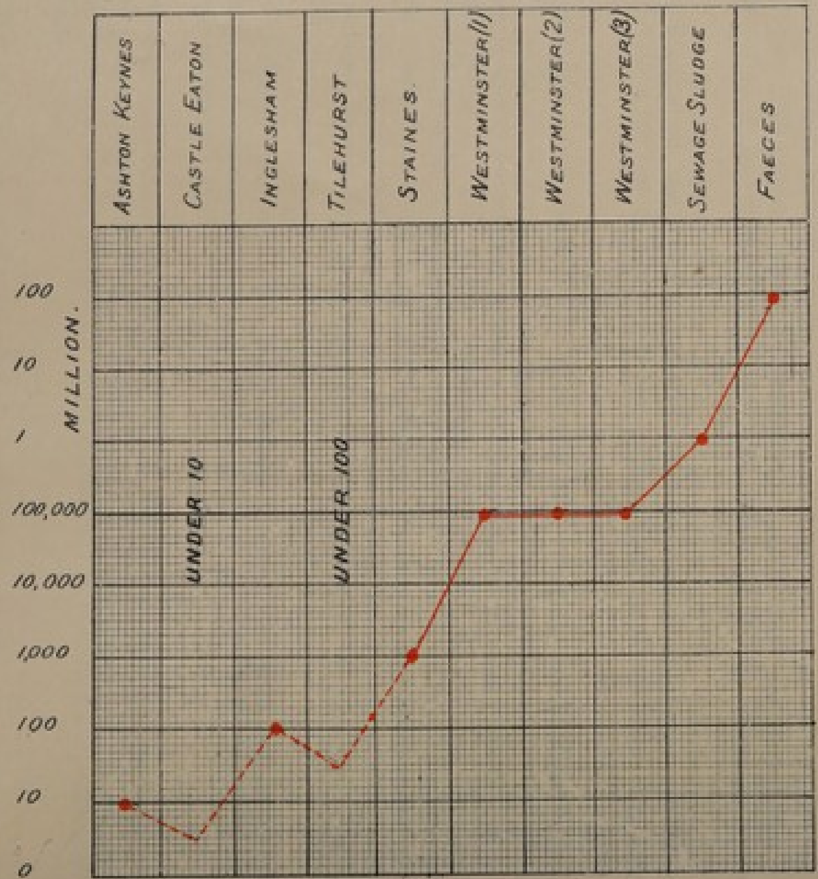
None of the streptococci that were isolated from one of the samples of Terrace mud and examined could be identified from their characters with streptococci characteristic of saliva.

Conclusion.—The inference drawn from these data is that the mud of the river deposited alongside the Terrace and left exposed to the air at low tide contains much fæcal pollution, and therefore is liable to be charged with morbific virus.

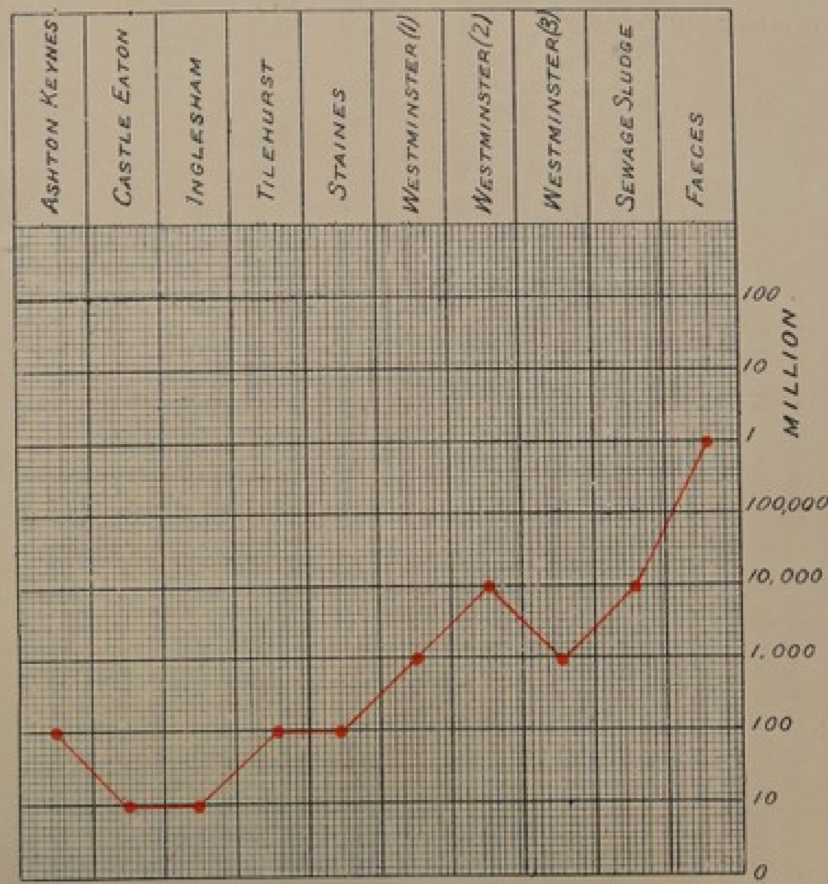
* The Thames Head Spring was dry when I examined it, and the river began about half a mile below this spot.

CURVES SHOWING THE RELATIVE ABUNDANCE OF COLILIKE BACTERIA AND SPORES OF B. ENTERITIDIS SPOROGENES IN THAMES MUD, SEWAGE SLUDGE, AND FAECAL MATTER, RESPECTIVELY. :—

COLILIKE BACTERIA.



B. ENTERITIDIS SPOROGENES.



To face p. 23.

The figures in the last two columns in each case were taken from reports by Dr A. C. Houston in the Fourth Report of the Royal Commission on Sewage Disposal (1904) P. 19. and in the Report of the Medical Officer of the Local Government Board 1902-3, P.538, The figures for Sewage Sludge are from samples of Barking sewage sludge and refer to 1 cubic centimetre of it, an amount that may be considered for

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Bacteriological Analyses of Samples of Thames Mud between the Source of the River and Westminster Bridge. The Figures represent the Numbers per gramme of the mud.

Locality.	Miles from Source of River Thames (approximately).	Miles from Terrace at Westminster (approximately).	Date of Collection.	Total Number of Bacteria (37° C.).	B. Coli-like Bacteria.	Spores of B. Enteritidis Sporogenes.	Streptococci.	Remarks.
Terrace, Westminster ...	164	0	1904. May 4th	1 million not 10 million.	100,000 not 1 million.	1,000 not 10,000.	10,000 not 100,000.	A red worm, *Tubifex Rivulorum, numerous.
" " ...	164	0	May 26th	"	"	10,000 not 100,000.	100,000 not 1 million.	"
" " ...	164	0	July 12th	Not estimated	"	1,000 not 19,000.	Not estimated	"
Staines (above water company's intake).	128	36	July 17th	"	1,000 not 10,000.	100 not 1,000.	"	—
Tilehurst	89	75	August 2nd	10,000 not 100,000.	Under 100	"	Under 10	—
Inglesham (above junction with canal and Colne)	21	143	August 7th	100,000 not 1 million.	100 not 1,000.	10 not 100.	"	—
Castle Eaton	15	149	August 7th	"	Under 10	"	"	—
Ashton Keynes... ...	6	158	August 6th	10,000 not 100,000.	10 not 100.	100 not 1,000.	"	Tubifex Rivulorum present.

* Professor Minchin, of University College, kindly identified this worm.

(*b*) *Micro-organisms Characteristic of the Mud.*

From the above results it appeared unnecessary to devote time to investigating the mud for other micro-organisms by which to detect the presence of particles of it in the air. If ·00001 gramme of the fresh mud were contained by the air, then the B. coli test would serve to detect this amount, and if ·001 gramme of it were present, spores of B. enteritidis would be present as well as B. coli. It will appear later, when dealing with the results of the examination of the air at the inlet, that of the other micro-organisms present in the mud, those that would possibly best repay investigation are the streptococci; but in view of other more important parts of the inquiry, I had to forego further investigation of them at this point.

(*c*) *The effect of Exposing a Sample of Terrace Mud to the Action of the Weather during a Fortnight in June is seen from the following figures*:—

—	Coli-like Bacteria.	Spores of B. Enteritidis Sporogenes.
	Per gramme.	Per gramme.
Mud fresh from the river by the Terrace.	100,000, under 1 million	10,000, under 100,000.
The same after exposure for two weeks to the weather (June).	10, under 100	1,000, under 10,000.

The number of B. coli, therefore, was diminished 10,000 times, and the spores of B. enteritidis 10 times.

But by the latter test ·001 gramme of the dry mud can be detected.

Conclusion.—It would seem from this observation that the mud, when dry, is much less liable to contain micro-organisms of intestinal origin than when it is fresh and wet. It may be taken that the majority of the micro-organisms known to be associated with the production of specific diseases in man would show no more vitality than B. coli here did.

ii. Particulate Matter scraped from the Windows at the Inlet.

The material in question was obtained by scraping the bars and edges of these windows with a sterilised knife. I was unable to get any material from the edges of the centre inlet window, so it is only scrapings from the North and South windows that have been examined.

The results were as follows (per gramme):—

Date.	Source.	Total Number of Bacteria (37° C.).	B. Coli.	Spores of B. Ent.	Strepto-cocci.
July 19, 1904 ...	Right window of inlet.	1,000, not 10,000 (spores of B. mesentericus only).	Under 10	Under 10	Under 10
" " ...	Left window of inlet.	Under 10 ...	Under 10	Under 10	Under 10

No evidence of pollution was therefore found.

A striking point about the material in both cases was that when the preliminary dilution of it was made, a large quantity of soot and coal-dust was seen to be contained by it. The particles of carbon referred to floated on the top of the water.

iii. Dust from the Scrim-Cloth.

The scrim-cloth screen through the interstices of which the air passes after getting past the fan is thoroughly washed in hot soda solution every Saturday morning during the Session. This procedure is an excellent one, as hot soda has a marked germicidal action.

It appeared to be of some interest to obtain a sample of the dust held up by the screen and to submit it to bacteriological examination. This has accordingly been done on two occasions, Saturday, July 23rd, and Saturday, August 6th, 1904. In each case the cloth had been in use during a week of sittings, viz., from the Monday to Friday inclusive. The maximum and minimum temperatures of the air of Westminster during these five days, the hours of bright sunshine, and the rainfall, were respectively as follows:—

—	Maximum Thermometer.	Minimum Thermometer.	Bright Sunshine.	Rainfall.
	Mean.	Mean.	Hours.	Inches.
Monday, July 18th, to Friday, July 22nd.	76·4	57·4	50·7	·01 Fell on Tuesday, July 19th.
Monday, August 1st, to Friday, August 5th.	82·0	61·0	52·8	·11 Fell on Thursday Aug. 4th, during a thunder storm.

Results of Analysis of the Dust arrested by the Scrim Cloth in two different Weeks.

Scrim-Cloth Dust.	Total Number (37° C.).	B. Coli-like Bacteria.	Spores of B. Enteritidis.	Streptococci.
July 23rd ...	10,000, not 100,000	100, not 1,000	1,000, not 10,000	Under 100
August 6th ...	Over 1 million	10, not 100	100, not 1,000	10, not 100 (not sub-cultured).

Taking the coli and enteritidis indices, therefore, as the most important points determined, we have in both cases a decrease in August to one-tenth of the number found in the July observation.

This decrease I believe to be due to the difference in the rainfall for the two periods during which the air was being passed through the scrim cloth. A reference to the meteorological data shows that ten times more rain fell in the August period than had been the case in the July one. In both periods all the rain fell on one day, but in the July period it fell on the Tuesday and in the August period on the Thursday. Now, it has been shown by Miquel, by a long series of observations, that the number of bacteria in the open air is diminished by rain, and is increased during dry weather, provided that the dryness is not too prolonged. The increased rainfall, therefore, doubtless freed the air of more bacteria in the August period; and as it took place later in the week its effect would be more clearly seen, because the constant draught through the interstices of the scrim cloth would have tended to gradually drag through particles deposited by the air on its outside surface earlier in the week.

Characters of the Coli-like Bacteria found in the Scrim-Cloth Dust.

Of the three coli isolated from the scrim-cloth dust on the two occasions, only one, namely, that present to 10 per gramme of the dust in July, had characters identical with those of typical B. coli of the intestine. It is curious that the coli obtained from the dust in August had characters identical with those of a coli isolated from a sample of river mud alongside the Terrace on July 12th, and present therein to 10 per gramme after the mud had been exposed to the weather for a fortnight.

Conclusion.—On both occasions when it was examined, the dust removed by the scrim cloth from the air contained distinct evidence of pollution with bacteria possibly derived from the intestine.

I am not prepared to say that this dirt is derived from the mud of the Thames by the inlet. In order to decide this, further investigation would have to be made. The resemblance between the characters of the coli No. 3 and the coli isolated previously from the mud when dry is suggestive, but nothing can be safely inferred from this single point.

iv. Wool of the Cotton-Wool Filter.

A piece (about 3 inches in diameter) of the wool of the outside layer of the cotton wool filter was removed on April 27th, 1904, and bacteriologically examined. The wool was dark from deposit upon it, and when the preliminary dilution was made, the water became quite black from soot contained in the wool. Neither B. coli nor enteritidis spores, nor streptococci were present in the piece of wool. The only micro-organism present was a stunted bacillus of no importance.

v. Dirt and Dust falling into the Equalising Chamber from Members' Boots.

Two Samples of Dirt deposited on the Floor of the Equalising Chamber.

This material was collected during a debate on April 27th, 1904, by rubbing a piece of sterile cotton-wool lightly over the surface of the floor of the Equalising Chamber at portions of it beneath the Centre Gangway above and below the Bar respectively. Cultures were subsequently made from dilutions of these two pieces of wool, with the following results:—

Dust falling on the Floor of the Equalising Chamber.

—	B. Coli.	B. Enteritidis Spor.	Streptococci.
Above the Bar	—	+	+
Below the Bar	+	+	+

The B. coli found below the Bar had characters identical with those of typical B. coli of the animal intestine.

From this preliminary observation, therefore, it appeared that the floor above the Bar was less contaminated than that below the Bar. This view received ample confirmation later.

Material falling directly from Members' Boots on to Paper exposed under the Centre Gangway below the Bar.

Mr. Patey had two pieces of board fixed for me under this part of the Centre Gangway immediately below the floor of the Debating Chamber, and throughout the inquiry, whenever the House sat, glazed paper covering an area of 3·4 square feet was stretched over this support, and the material coming through thus collected.

The amount of dirt falling through on to the paper during debates may be gauged from the following four observations:—

On May 10th, 1904, 0·22 inches of rain fell. The amount of dirt deposited on the paper (area = 3·4 square feet) between 3·40 p.m. and 5.40 p.m. was 1·5 grammes. This sample was analysed in detail.

On May 11th, 1904, 0·02 inches of rain fell. The amount of dirt deposited on the paper between 2 p.m.. and 8 p.m. was 2·0 grammes. This sample was also examined in detail.

On May 31st, 1904, 0·41 inches of rain fell. The paper between 2 and 7.30 p.m. collected ·250 gramme only. This was the first day after the Whitsun recess, and few Members were present in the Debating Chamber. This sample was also analysed.

The total amount of material deposited on the paper on all occasions when the House sat between May 5th and July 18th—excepting only the three occasions mentioned—was collected in a sterilized bottle, and at the end of this time weighed, and found to be exactly 20 grammes. This sample was also analysed.

It would appear, therefore, that an appreciable quantity of material is brought in on Members' boots, and is constantly falling through the floor of the Debating Chamber during Debates and mixing with the upgoing air in the Equalising Chamber. The amount of deposit varies within wide limits, and depends on the number of Members present, rainfall, &c.

Microscopical examination of the material showed that it consisted of particles of wool, hair, string from the matting, pieces of paper, particles of surface soil, quartz, silica, &c., vegetable débris, bits of leaves, chopped hay (horse manure?), chips of matches, &c. Of the 20 grammes sample, 17 grammes sank in water, while 3 grammes of it (fluff, &c.) floated.

The results of the bacteriological analyses of the four samples mentioned is seen in the following table:—

Bacteriological Analysis of Samples of Material falling into the Equalising Chamber from Members' Boots.

(The figures refer to the number per gramme of the samples.)

No.	Date of Collection.	Total Nos. 37° C.	B. Coli-like Bacteria.	Spores of B. Ent. Spor.	Streptococci.
	1904.				
1	May 10	1,000,000 not 10,000,000.	Under 100	100 not 1,000.	10,000 not 100,000.
2	May 11	10,000,000 not 100,000,000.	100 not 1,000.	10,000 not 100,000	10,000 not 100,000.
3	May 31 ... ... (1st day after recess.)	1,000,000 not 10,000,000.	Under 100	100 not 1,000.	Under 100.
4	May 5 to July 18 ... (Except above three samples.)	100,000 not 1,000,000.	100 not 1,000.	10,000 not 100,000.	1,000 not 10,000.

All the examples of B. coli isolated from these samples were examined and found to possess the characters of typical B coli of the intestine.

None of the 10 kinds of streptococci isolated from the samples could be identified with streptococci characteristic of saliva.

Conclusion.—These results show that the material brought into the Debating Chamber on Members' boots, and shed therefrom into the incoming air, is richly charged fæcal pollution.* On the other hand, no evidence was obtained that sputum is brought in from the pavements and imparted to the air in this way.†

* Derived almost certainly from the horse.

† Dr. Annett found that in Liverpool 4·76 per cent. of sputa lying on the pavements of public thoroughfares contained B. tuberculosis. ("Thompson Yates' Laboratory Reports," Vol. IV., Part 2.)

vi. Samples of Dust from the Debating Chamber, Division Lobbies, and New Palace Yard.

Two samples of dust were obtained from the Debating Chamber, and one from the Division Lobbies. Mr. Patey furnished me with these samples obtained with the vacuum cleaner. The sample of New Palace Yard dust was collected near the pavement.

The results shown by these samples are seen in the following table:—

Analyses of Samples of Dust.

No.	Material.	Date of Collection.	Total Nos. (37° C.).	B. Coli.	Spores of B. Ent. Spor.	Streptococci.
1	Dust of Debating Chamber.	1904. June 7	1,000,000 not 10,000,000.	100 not 1,000.	100 not 1,000.	None isolated.
2	Dust of Debating Chamber.	August 15	100,000 not 1,000,000.	1,000 not 10,000.	1,000 not 10,000.	10 not 100.
3	Dust of Division Lobbies.	June 7	1,000,000 not 10,000,000.	1,000 not 10,000.	1,000 not 10,000.	1,000 not 10,000.
4	Dust of New Palace Yard by Members' Entrance.	October 29	100,000 not 1,000,000.	10,000 not 100,000.	100 not 1,000.	Under 1,000.

Character of the Coli-like Bacteria isolated.

All of the B. coli isolated from the dust of the Debating Chamber had the characters of typical B. coli of the intestine. The sample of Lobby dust showed the same micro-organism present to 100 per gramme. The coli isolated at a later date from New Palace Yard was atypical.

Characters of the Streptococci isolated.

No streptococci characteristic of saliva were obtained from these samples.

It is interesting to observe that the same peculiar streptococcus was found present, respectively—

In dirt from Members' boots to 100 per gramme;

In Debating Chamber dust to 10 per gramme; and

In Lobby dust to 1,000 per gramme.

This streptococcus in all three cases, besides giving identical reactions, rapidly liquefied gelatine and peptonised milk.

Conclusion.—Fæcal pollution is evident in dust from the Debating Chamber and Division Lobbies, but no salivary pollution was found.

Tables showing the Characters of B. Coli-like Bacteria, and of Streptococci isolated from the above Materials liable to pollute the Air of the Debating Chamber.

B. Coli-like Bacteria from Thames Mud and from Materials liable to pollute the Air of the Debating Chamber.

No.	Material.	Date.	Abundance per Gramme.	Clot.	Reduction of N. Red.	Acid and Gas. Glucose.	Acid and Gas. Lactose.	Acid and Gas. Saccharose.	Indol.	Nitrite.	Liquefaction.
1	Terrace mud	May 4	100,000	+	+	+	+	—	+	+	—
2	" "	" 26	100,000	—	+	+	—	—	—	+	—
3	" "	" 26	10,000	+	+	+	+	—	+	+	—
4	" "	July 12	100,000	+	+	+	—	+	—	+	+
5	" "	" 12	10,000	—	—	+	—	—	—	+	+
6	Dried terrace mud ...	—	10	—	—	+	—	—	—	+	—
7	Staines mud	July 17	1,000	+	+	+	+	+	—	+	+
8	Inglesham mud... ...	Aug. 7	100	—	—	+	—	—	+	+	—
9	" " ...	" 7	10	+	+	+	+	—	+	+	—
10	Ashton Keynes	" 6	10	+	+	+	+	+	+	+	—
11	Dust from scrim cloth ...	July 23	100	+	+	+	+	+	+	+	—
12	" " ...	" 23	10	+	+	+	+	—	+	+	—
13	" " ...	Aug. 6	10	—	—	+	—	—	—	+	—
14	Dust, floor of Equalising Chamber below Bar.	April 27	...	+	+	+	+	—	+	+	—
15	Dust of Debating Chamber	June 7	100	+	+	+	+	—	+	+	—
16	" " "	Aug. 9	1,000	+	+	+	+	—	+	+	—
17	" " "	" 9	100	+	+	+	+	—	+	+	—
18	" " "	" 9	10	+	+	+	+	—	+	+	—
19	Dust of Division Lobbies	June 7	1,000	+	+	+	+	+	+	+	—
20	" " "	" 7	100	+	+	+	+	—	+	+	—
21	Deposit of Members' boots	May 11	100	+	+	+	+	—	+	+	—
22	" " "	July 18	100	+	+	+	+	—	+	+	—
23	" " "	" 18	10	+	+	+	+	—	+	+	—
24	New Palace Yard dust ...	Oct. 28	10,000	+	—	—	+	+	—	+	—
25	" " ...	" 28	1,000	—	+	—	+	+	—	—	—

Streptococci isolated from Materials liable to pollute the Air of the Debating Chamber.

No.	Material.	Date of Collection.	Abundance per gramme.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicen.	Coniferin.	Mannite.	Glycerin	—
1	River mud by Terrace.	May 26	100,000	—	+	+	+	+	—	—	—	—		
2	" "	" 26	100,000	—	—	+	+	+	—	—	—	+		
3	" "	" 26	1,000	—	—	+	—	—	+	+	+	—		
1	Dust on floor Equalising Chamber.	April 27	—	—	—	—	—	—	—	+	+	—		
2	" "	" 27	—	—	—	+	—	—	—	+	+	—		
3	" "	" 27	—	—	+	+	+	—	+	+	+	—		
	Dust of Debating Chamber.	Aug. 15	10	+	+	+	+	—	—	+	+	+	+	Liquefies gelatine.
1	Dust of Division Lobbies.	June 7	1,000	+	+	+	+	—	—	+	+	+	+	Do.
2	" "	" 7	1,000	+	+	—	+	—	+	+	—	—		
3	" "	" 7	Pathogenic, obtained *viâ* mouse.	+	—	+	+	—	—	+	—	—		

Streptococci from three Samples of Material brought in on Members' Boots.

No.	Positive Characters.	Date of Collection.	Abundance per Gramme.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Glycerine.	Samples from which Isolated.
1	2	May 10 ...	1,000	–	–	–	–	–	–	+	+	–		1
2	3	„ 10 ...	1,000	–	–	+	–	–	–	+	+	–		2
		„ 11 ...	1,000	–	–	+	–	–	–	+	+	–	+	
3		„ 11 ...	10,000	–	–	+	–	+	–	+	–	–		1
4		„ 10 ...	10,000	–	–	–	–	+	–	+	+	–		1
5	5	„ 11 ...	100,000	–	–	+	+	–	–	+	+	+	–	1
6	6	„ 10 ...	1,000	+	–	+	+	–	+	+	+	–		1
7		„ 11 ...	10,000	+	–	+	+	+	–	+	+	–		1
8		Between May 5 and July 18.	1,000	+	+	–	+	–	–	+	+	+	+	1
9	7	„ „	1,000	+	+	+	+	–	–	+	+	+	–	Gel. Liq. 1
10		„ „	100	+	+	+	+	–	–	+	+	+	+	1

(2.) The Air.

(A.)—Air at the Inlet.

i. *The general Bacterial Incidence at the Inlet.*

Agar plates were exposed on tables at the inlet to the incoming air-stream for an hour, and after incubation, for 48 hours at 22° C., the colonies counted. The results are seen in the following table:—

Air at the Inlet.

Bacterial Incidence at the Inlet.

Date.	May 2nd.	May 3rd.	May 4th.	May 10th.	May 11th.	May 26th.	June 20th.
Hour (p.m.)	7.10 to 8.10.	6.25 to 7.25.	2.40 to 3.40.	3.40 to 4.40.	6.30 to 7.30.	3.30 to 4.30.	7.45 to 8.45.
No. of plates exposed ...	4	3	3	3	3	4	2
No. of colonies (mean) ...	173	293	302	79	394	387	593
Rainfall (inches) ...	0·19	—	—	·22	·02	—	—

These observations show that rainfall has a distinct influence on the number of micro-organisms deposited by the air entering the airway. The marked diminution seen on the two wettest days, May 2nd, and especially May 10th, confirms the deduction previously made from the results shown by two samples of the dust arrested from the air by the scrim-cloth screen. Reference was also then made to Miquel's observations on the influence of rain in diminishing the number of bacteria present in the open air.

ii. *The Incidence of B. Coli and B. Enteritidis Sporogenes at the Inlet.*

(*a*) *Inlet Chambers.*—On seven occasions neutral-red broth was exposed in each of the three chambers of which the inlet is composed. The aluminium dishes containing the broth were exposed on tables in the middle of the chambers.

On three of these occasions observations were made with the anemometer at the doorways of the three chambers to determine the relative amount of air passing through each. As was to be expected, in all cases most air was passing into the airway through the centre chamber. The amount passing through the side chambers appeared to vary with the wind.

The results obtained in these tests are instructive. On July 4th when the observations were made tea was in progress on the Terrace outside the inlet windows. Although less air was passing through the north chamber than through the other two chambers, B. enteritidis sporogenes was obtained from the air in the north chamber alone. The exposure on this occasion lasted for half an hour. On July 7th the test was repeated with a similar result. On July 19th a third test was made, and 150 minutes exposure given, with the result that both plates in the north chamber became infected as against one plate infected out of four exposed in the other two chambers. A final test during tea on the Terrace was made on July 28th, and an exposure of 180 minutes given. The result was that B. enteritidis and two kinds of coli were obtained from the incoming air in the north chamber, whereas the plates in the other two chambers developed neither of these fæcal micro-organisms.

The presence of fæcal matter in the air of the north chamber on these occasions is due to the fact that a horizontal grating crosses directly over the inlet window, and that during tea on the Terrace there is constant traffic over this grating. The fæcal matter is aspirated off the boots of those passing over this grating by air drawn down into the chamber below.

On two occasions, July 11th and 13th, tests were made in the inlet chambers at low tide. The fact that the mud of the river alongside the Terrace was bare was ascertained before exposing the plates. No definite evidence was obtained of the presence of particulate matter from the mud in the incoming air. It must be admitted, however, that on both occasions the test was made in the evening, and hence the effect of the sun on the mud was not tested.

(*b*) *Junction of three Inlet Chambers.*—On 18 occasions tests were made at this spot with neutral-red broth. The exposure varied from 1 to 3 hours. On 15 occasions a negative result was obtained. On each of the three last occasions, however, B. enteritidis was present, and on the last occasion of all B. coli was also found. The exposure was between 2 and 4 hours on these three occasions when positive results were obtained.

Characters of the Coli-like Bacteria obtained at the Inlet.

Only one of the five coli obtained from the air at the inlet gave reactions in the differential tests identical with those given by typical B. coli of the intestine.

The results obtained at the inlet by exposing neutral-red broth are summarised in the following tables:—

Tests with Neutral-red Broth in Inlet Chambers.

No.	Circumstance.	Day.	Hour (p.m.)	Exposure, in Minutes.	South Chamber.		Middle Chamber.		North Chamber.	
					Coli.	Enteritidis.	Coli.	Enteritidis.	Coli.	Enteritidis.
1	End of tea on Terrace.	July 4	6.40 to 7.20	30	—	—	—	—	—	+
2	Tea on Terrace	„ 7	4.15 to 4.45	30	—	—	—	—	—	+
3	Low tide ...	„ 11	7.18 to 7.28	10	—	—	+	—	—	—
		„ 11	7.35 to 7.55	20	—	—	—	—	—	—
		„ 11	8 to 8.40	40	—	—	—	+	—	—
4	Low tide ...	„ 13	8.30 to 8.35	5	—	—	—	—	—	—
		„ 13	8.40 to 8.55	15	—	—	—	—	—	—
5	Tea on Terrace	„ 19	3.30 to 6	150	—	—	—	+ one plate.	—	+ both plates.
6	... ...	„ 26	6 to 6.40	40	—	—	—	—	+	—
7	End of tea on Terrace.	„ 28	4.45 to 7.45	180	—	—	—	—	+ two kinds of coli.	+

Tests made with Neutral-red Broth at Junction of the three Inlet Chambers.

No.	Neutral. Red Broths exposed.	Day.		Hour (p.m.).	Exposure, in Minutes.	B. Coli.	B. Enteritidis.
1	4	May	2	7 to 8	60	—	—
2	3	"	3	6.25 to 8.25	120	—	—
3	3	"	4	2.40 to 3.40	60	—	—
4	3	"	10	3.40 to 4.40	60	—	—
5	2	"	11	6.30 to 7.30	60	—	—
6	2	"	17	4.50 to 6.50	120	—	—
7	4	"	18	9.35 to 11.15	100	—	—
8	3	"	26	3.30 to 4.30	60	—	—
9	2	"	31	2.30 to 3.30	60	—	—
10	2	June	1	9.12 to 11.12	120	—	—
11	2	"	6	6.45 to 10	195	—	—
12	2	"	13	8.15 to 11.15	180	—	—
13	2	"	14	9.40 to 11.10	100	—	—
14	1	"	20	7.45 to 8.45	60	—	—
15	2	"	27	9.30 to 11.30	120	—	—
16	2	"	28	7.30 to 11.30	240	—	+
17	2	"	29	9.22 to 11.22	120	—	+
18	2	July	18	9 to 11.45	165	+	+

iii. *Streptococci from the Air at the Inlet.*

On 16 occasions streptococci were isolated from air at the inlet and examined. The total number of streptococci from the air at this point investigated was 39, and by their characters they were differentiated into 17 different kinds. None of the streptococci could be identified with any of the five streptococci most abundantly present in the normal human mouth.

This, notwithstanding the fact that on two occasions tea was going on on the Terrace, and a special attempt was then made to isolate saliva streptococci from the air at the inlet, as many as 20 plates being exposed on each of the two occasions referred to, and carefully searched for streptococci after incubation.

Conclusion as regards Pollution of the Air at the Inlet.—Air entering the north inlet chamber is subject to pollution derived from the boots of persons passing over the horizontal grating through which air is drawn down into that chamber.

Characters of Coli-like Bacteria isolated from the Air at the Inlet.

No.	Locality.	Day.	Hour.	Exposure, in Minutes.	Clot.	N. Red (reduction).	Acid and Gas.			Indol	Nitrite.	Liquefaction.
							Glucose.	Lactose.	Saccharose.			
1	Middle Chamber	July 11	p.m. 7.18 to 7.28	10	+	+	+	+	+	+	+	—
2	North Chamber	July 26	6 to 6.40	40	+	—	+	+	+	—	+	—
3	North Chamber (enteritidis also present).	July 28	4.45 to 7.45	180	+	—	+	+	—	—	+	—
4	North Chamber	"	"	180	+	—	+	—	+	—	+	—
5	Junction of inlets.	July 18	9 to 11.45	165	+	+	+	+	—	+	+	—

Characters of Streptococci isolated from the Air at the Inlet.

Characters Positive.	No.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Occasions when found.	Specimens.
1	1	–	–	+	–	–	–	–	–	–	3	4
	2	–	–	–	–	–	–	+	–	–	3	3
2	3	–	–	–	–	–	–	+	+	–	7	8
	4	–	–	+	–	–	–	+	–	–	4	4
3	5	–	–	+	–	–	–	+	+	–	5	6
	6	–	–	–	–	–	+	+	+	–	1	1
	7	–	–	–	–	+	–	+	+	–	1	1
4	8	–	–	+	–	+	–	+	+	–	2	2
	9	+	–	–	+	–	–	+	+	–	2	2
	10	–	–	+	–	–	+	+	+	–	1	1
	11	–	–	+	–	–	–	+	+	+	1	1
5	12	+	–	+	+	–	–	+	+	–	1	1
	13	–	–	+	+	–	–	+	+	+	1	1
	14	–	–	+	–	+	+	+	+	–	1	1
	15	–	+	+	+	–	–	+	+	–	1	1
6	16	+	–	+	+	+	–	+	+	–	1	1
	17	–	+	+	–	–	+	+	+	+	1	1

(B.)—Air between the Inlet on the Terrace and the Floor of the Debating Chamber.

Air between inlet and Debating Chamber.

The portion of the airway under review is about 300 feet in length. After passing the fan, the air-stream goes through the scrim-cloth screen, and next reaching the interior of the cotton-wool filter fixed some 25 feet below centre gangway of the Debating Chamber, it turns at a right angle to its previous course, and now proceeds vertically upwards through the Battery and Equalising Chambers in succession till it penetrates the floor of the Debating Chamber, mainly in the middle line.

Numerous tests were made by exposing culture-media to the air at various points along the airway between the inlet on the Terrace and the floor of the Debating Chamber. The three things determined were, first, the general bacterial incidence; second, the presence or absence of bacteria indicative of fæcal pollution; and third, the presence or absence of streptococci characteristic of saliva.

i. *The general Bacterial Incidence.*

The accompanying table shows the result of six representative tests. In the test first in the list the scrim-cloth screen was not in use, but in all the remaining five the air was being passed through it.

The first two tests have been termed "Controls," because in the case of the first no one at all was in the Debating Chamber, and in the second only a few Members were present in the Chamber, and they departed in the middle of the test.

The results yielded by the plates show that by the time the air reaches the cotton-wool filter a diminution occurs in the number of bacteria deposited by it. The diminution is maintained in the Battery Chamber and also in the Equalising Chamber when the Debating Chamber is empty, or when only few Members are present.

I was inclined at first to consider this diminution in the bacterial incidence to be due to the filtering action of the scrim cloth, but the test made in the Whitsun recess (No. 1 in the list), when the scrim cloth had been removed, showed that the diminution was due to some other cause. It is probable that three factors contribute to produce the diminution referred to. First, by reason of the length of the air passage between inlet and cotton-wool filter, gravity is continuously acting on the particulate matter in suspension in the air for a distance exceeding 250 feet; secondly, the varying width and tortuosity of the passage obstructs the flow of particles in the air much after the fashion that the structure of the upper portion of the human respiratory passages (*e.g.*, the nasal cavity and the glottis) arrests a large proportion of the particles of soot and dust suspended in inspired air; thirdly, I attribute the decrease to a smaller volume of air passing into the cotton-wool filter than along the airway at the inlet owing to loss at the origin of the shaft to the Commons Lobby.

The bacterial incidence at the cotton-wool filter, therefore, is less than at the inlet. As regards the incidence inside the filter, it will be noticed that a larger number of bacteria were deposited at the end of it under the Bar than in the middle of the filter, or at the opposite end of it under the Chair. This is due to the fact that the air-stream enters the filter mostly through the door at the end of it below the Bar.

The most striking feature of the bacterial incidence between inlet and floor of the Chamber, however, still remains to be noticed. The figures of chief interest are those yielded by plates exposed in the middle line under three points below the centre gangway of the Debating Chamber, viz., beneath the Chair, the middle, and the Bar respectively. These plates were exposed in the Equalising Chamber, in the Battery Chamber, and in the inside of the cotton-wool filter, successively downwards.

The numbers shown by the plates exposed on these three floors below the Debating Chamber clearly prove that during Debates (Tests 3, 4, 5, and 6) the bacterial incidence is greatly increased in the Equalising Chamber below the Bar, and sometimes also behind the Speaker's Chair. The increased incidence below the Bar, moreover, penetrates downwards on some occasions to the Battery Chamber to a point there 17 feet below the floor of the Debating Chamber.

On the other hand, when few or no people are in the Debating Chamber, the increased incidence at the points mentioned is not seen (Tests 1 and 2).

The cause of the increase in the bacterial incidence is plain to one present in the Equalising Chamber during a Debate. The portions of the Centre Gangway of the Debating Chamber below the Bar and behind the Chair, under which the increased incidence occurs, are the places where "traffic" is most active. The friction of the soles of Members' boots on the openwork string matting produces a rasping noise distinctly audible in the Equalising Chamber when Members stop, alter their direction, shift their feet, or turn round. The increased bacterial incidence is, in fact, obviously due to the up-going air at the points mentioned being polluted by showers of bacteria falling from Members' boots.

The General Bacterial Incidence between the Inlet on the Terrace and the Floor of the Debating Chamber.

Condition.	Control Tests.		Debate in Progress (Rain).	Debate in Progress.	Debate in Progress.	Debate in Progress.
	Whitsun Recess, House Empty.	House Exceptionally Empty. Adjourned 7.30.				
No.	1.	2.	3.	4.	5.	6.
Day	May 26	May 16	May 10	May 11	May 17	May 18
Hour (p.m.)... ...	3.30 to 4.30.	7 to 8	3.40 to 4.40.	6.30 to 7.30.	4.50 to 6.50.	9.35 to 11.15.
Exposure in minutes	60	60	60	60	120	80
Inlet	387	—	79	394	—	—
Passage after fan ...	320	686	—	—	571	289
Cotton-wool filter—						
Under Chair ...	40	59	2	25	74	11
" middle ...	130	155	15	38	115	62
" Bar ...	164	227	15	63	154	89
Battery Chamber—						
Under Chair ...	42	54	11	18	71	18
" middle ...	42	73	25	29	126	19
" Bar ...	47	83	**161**	**195**	88	41
Equalising Chamber—						
Under Chair ...	60	55	**154**	**120**	78	17
" middle ...	74	70	15	45	92	22
" Bar ...	43	52	**917**	**367**	**388**	**137**

The figures in heavy type show an increase of incidence due to showers of bacteria from Members' boots.

Having ascertained that the air at these three points was being polluted by bacteria brought in on Members' boots, further tests were next made in order to determine the degree to which air under other parts of the floor of the Debating Chamber was polluted from the same cause.

Detailed tests of the general bacterial incidence were accordingly made, chiefly in the Equalising Chamber, but also in the Battery Chamber, and in the inside of the cotton-wool filter.

Detailed Tests of the general Bacterial Incidence in the Equalising Chamber.

The results obtained in four tests are shown in the accompanying diagrams, in which the numbers yielded by the various plates are recorded at spots corresponding to those at which the plates they refer to had been exposed.

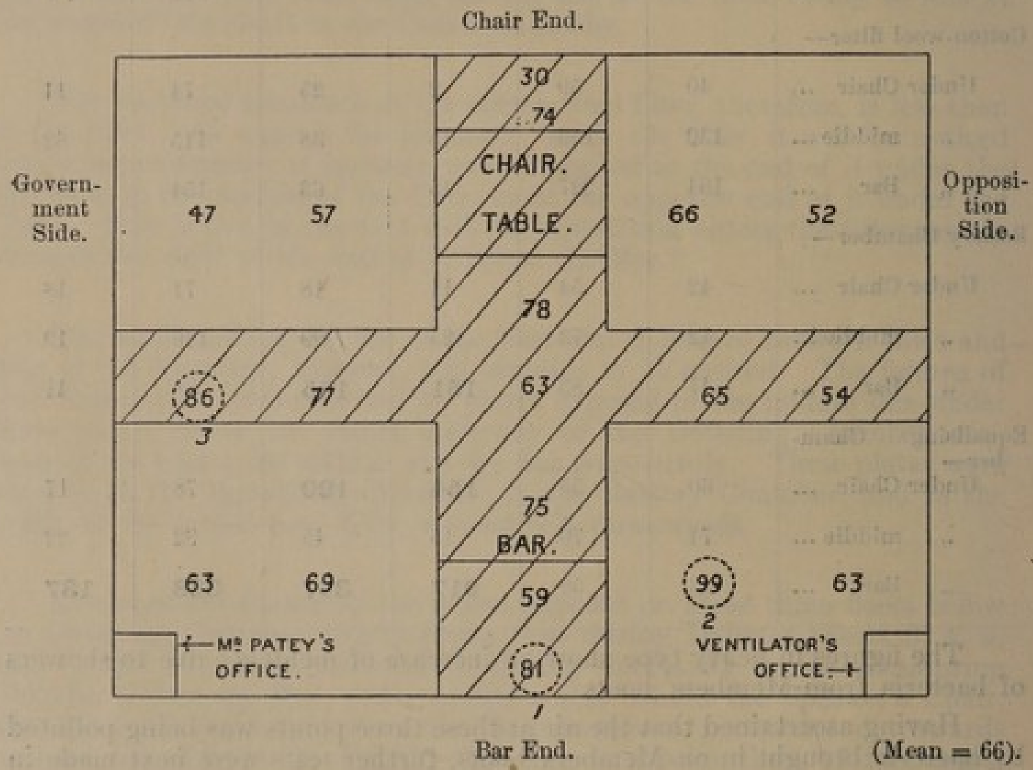
The figures show that the air of the Equalising Chamber is, as a rule, more polluted below the Centre Gangway, between the Bar and the Lobby door under the clock, than below other parts of the Debating Chamber. The excess of bacterial incidence beneath the locality mentioned is very marked in Tests 2, 3, and 4.

The second worst place was found to be below each of the two side Gangways.

On one occasion (Test 1) the numbers were greater below the Irish Benches than elsewhere. On another the incidence was excessive below the Centre Gangway behind the Chair.

Incidence of Micro-Organisms at Various Parts of the Equalising Chamber (I.).

The plates were exposed at these points on June 6th, 1904, from 8.15 p.m. to 9.15 p.m. The House adjourned at 7.30 p.m. and met again at 9 p.m.

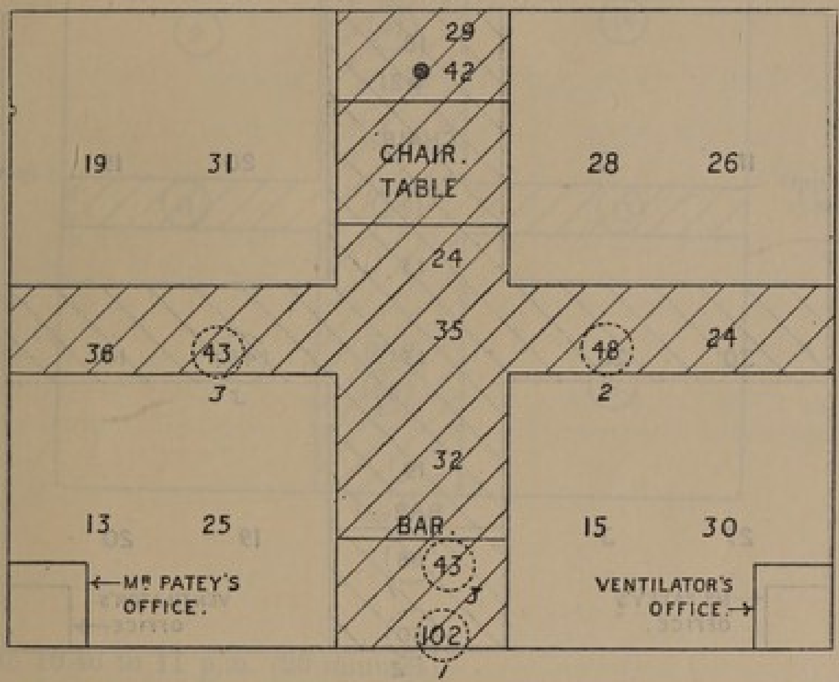


The part shaded is situated beneath the Centre and Side Gangways. The numbers refer to the number of Colonies appearing on agar plates exposed at these points, and incubated for two days at 22° C.

Result.—Highest incidence under Irish benches, 99; under Government Side Gangway, 86; and at extreme of Bar end of Centre Gangway, 81.

Incidence of Micro-Organisms at Various Parts of the Equalising Chamber—cont.—(*II.*).

The plates were exposed at these points on June 7th, 1904, from 9.30 to 10.30 p.m.

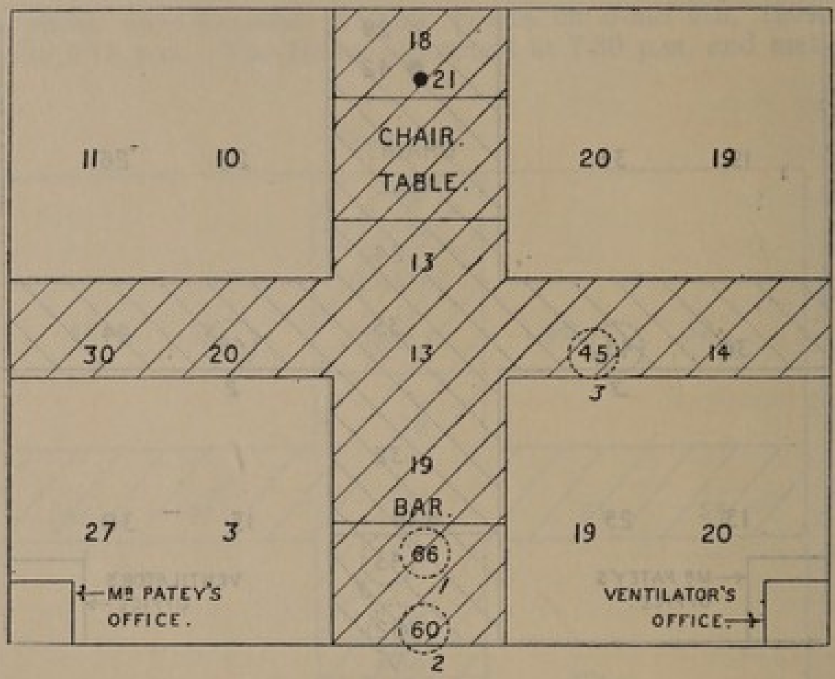


(Mean = 33.)

Result.—Highest incidence at extreme of Bar end of Centre Gangway, 102; there was a considerable drop between this plate and the next three, which yield 48, 43, and 43, and were situated under Government and Opposition side Gangways and under the Centre Gangway at the Bar.

Incidence of Micro-Organisms at Various Parts of the Equalising Chamber—(cont.)—(*III.*).

The plates were exposed at these points on June 8th, 1904, from 9.45 p.m. to 10.45 p.m.

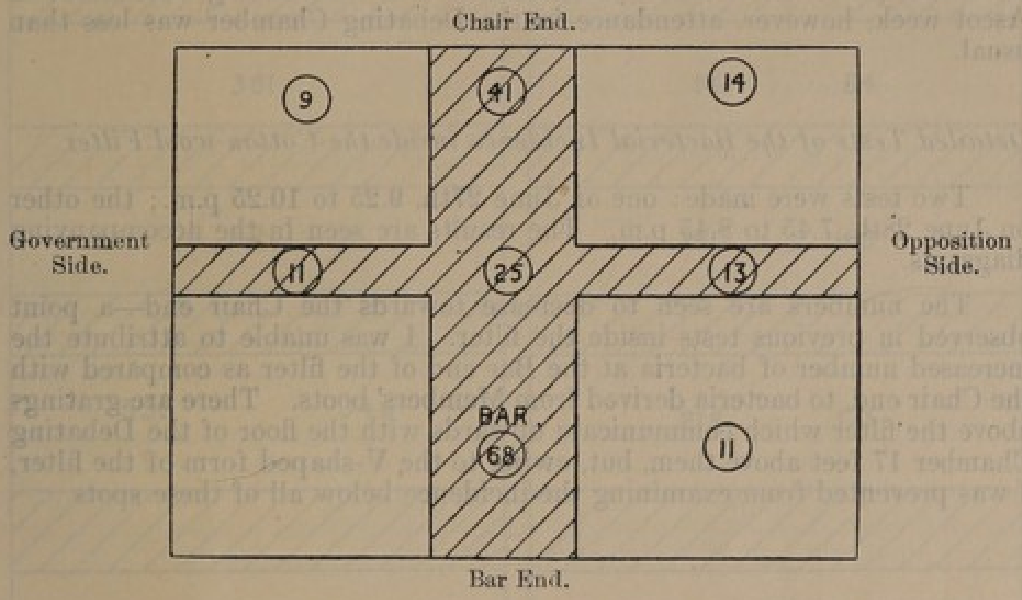


(Mean = 23).

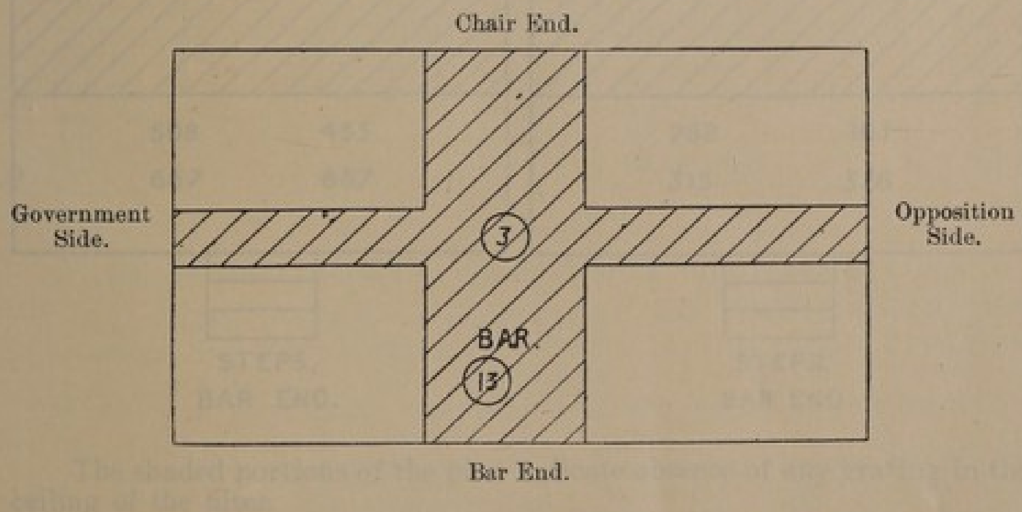
Result.—Highest incidence under Centre Gangway at Bar end, 60 and 66 respectively. The third plate in point of numbers had been exposed under the Opposition side Gangway, and showed 45 colonies.

Incidence of Micro-Organisms at Various Parts of the Equalising Chamber—cont.—(*IV.*).

The plates were exposed at these points on May 9th, 1904, from 9.20 p.m. to 10.20 p.m.



Ditto 10.40 to 11 p.m. (20 minutes).



Result.—Highest incidence beneath the Bar; after this behind the Chair.

Detailed Tests of the Bacterial Incidence in the Battery Chamber.

Tests were made on the following dates:—June 13th, 8 to 9 p.m.; June 14th, 9.40 to 11.10 p.m.; June 19th, 9.50 to 10.50 p.m.

In these tests three plates were exposed in each of the five compartments of the Battery Chamber, and one plate was exposed in the passage outside, below a grating in the floor of the Equalising Chamber under the Opposition side Gangway.

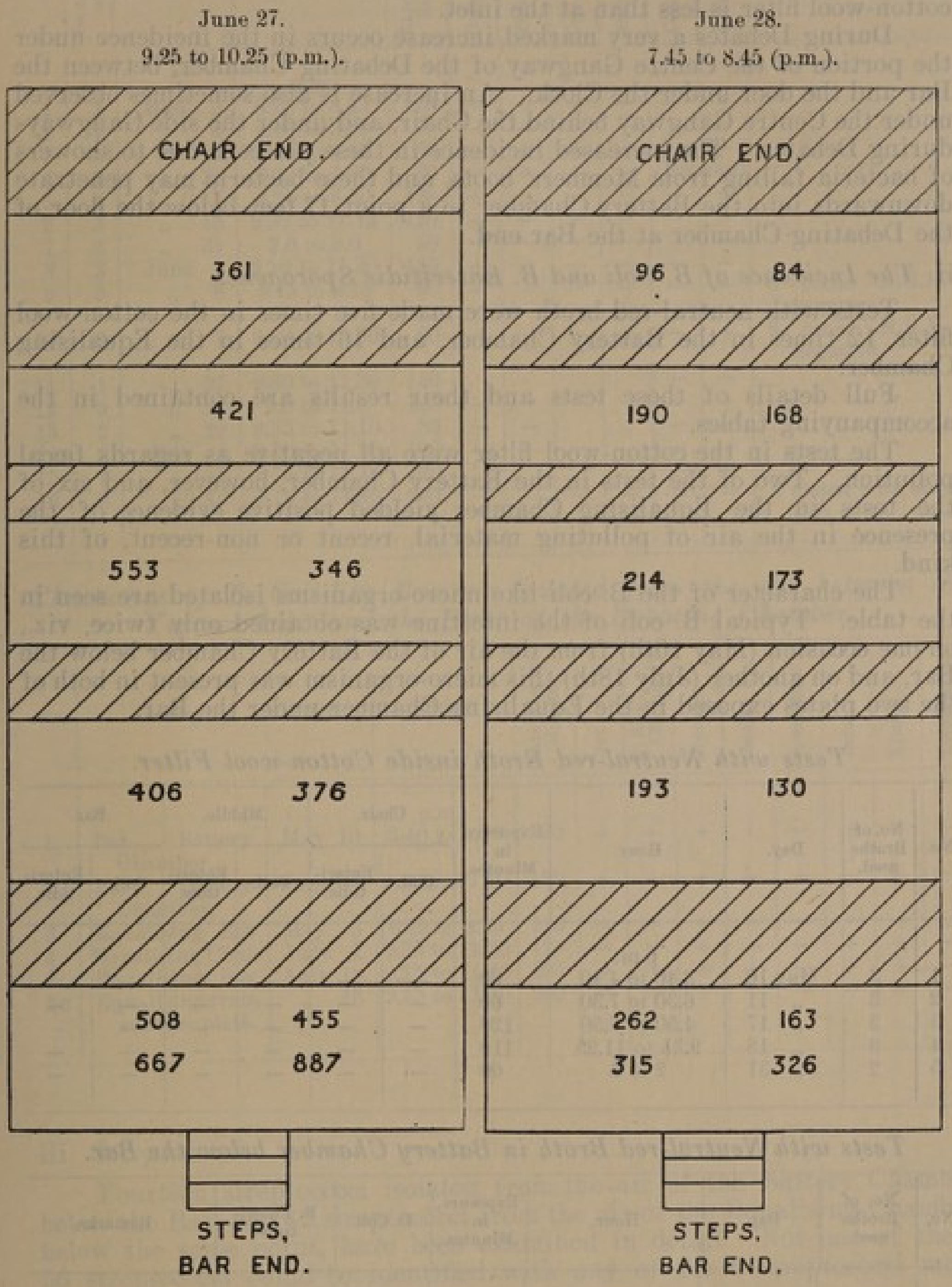
The results of the tests showed no marked difference in the incidence at various parts of the Battery Chamber. The tests having been made in Ascot week, however, attendance in the Debating Chamber was less than usual.

Detailed Tests of the Bacterial Incidence inside the Cotton-wool Filter.

Two tests were made: one on June 27th, 9.25 to 10.25 p.m.; the other on June 28th, 7.45 to 8.45 p.m. The results are seen in the accompanying diagrams.

The numbers are seen to decrease towards the Chair end—a point observed in previous tests inside the filter. I was unable to attribute the increased number of bacteria at the Bar end of the filter as compared with the Chair end, to bacteria derived from Members' boots. There are gratings above the filter which communicate upwards with the floor of the Debating Chamber 17 feet above them, but, owing to the V-shaped form of the filter, I was prevented from examining the incidence below all of these spots.

Bacterial Incidence inside Cotton-wool Filter, looking from above.



The shaded portions of the plan indicate absence of any grating in the ceiling of the filter.

The numbers refer to the number of colonies developing on plates exposed at the spots indicated.

Conclusions with regard to the General Bacterial Incidence along the Airway between the Terrace Inlet and the Floor of the Debating Chamber.

The general bacterial incidence from the air-stream at the site of the cotton-wool filter is less than at the inlet.

During Debates a very marked increase occurs in the incidence under the portion of the Centre Gangway of the Debating Chamber, between the Bar and the door under the Clock. An increase is also sometimes observed under the Centre Gangway behind the Chair, and under the side Gangways during Debates. The increased incidence in these places is due to showers of bacteria falling from Members' boots, and these bacteria may penetrate downwards into the Battery Chamber to a point 17 feet below the floor of the Debating Chamber at the Bar end.

ii. *The Incidence of B. Coli and B. Enteritidis Sporogenes.*

Tests with neutral-red broth were made five times in the cotton-wool filter, 12 times in the Battery Chamber, and 16 times in the Equalising Chamber.

Full details of those tests and their results are contained in the accompanying tables.

The tests in the cotton-wool filter were all negative as regards fæcal pollution. Two of the tests in the Battery Chamber, however, and six of the tests in the Equalising Chamber yielded positive evidence of the presence in the air of polluting material, recent or non-recent, of this kind.

The character of the B. coli-like micro-organisms isolated are seen in the table. Typical B. coli of the intestine was obtained only twice, viz., on one occasion (May 10th) from the air of the Battery Chamber below the Bar, and on another (July 18th) this micro-organism was present in both of the two plates exposed in the Equalising Chamber under the Bar.

Tests with Neutral-red Broth inside Cotton-wool Filter.

No.	No. of Broths used.	Day.	Hour.	Exposure, in Minutes.	Chair.		Middle.		Bar	
					Coli.	Enteritidis.	Coli.	Enteritidis.	Coli.	Enteritidis.
			p.m.							
1	3	May 10	3.40 to 4.40	60	—	—	—	—	—	—
2	3	„ 11	6.30 to 7.30	60	—	—	—	—	—	—
3	3	„ 17	4.50 to 6.50	120	—	—	—	—	—	—
4	3	„ 18	9.35 to 11.25	110	—	—	—	—	—	—
5	2	„ 31	2 to 3	60	—	—	—	—	—	—

Tests with Neutral-red Broth in Battery Chamber below the Bar.

No.	No. of Broths used.	Day.	Hour.	Exposure, in Minutes.	B. Coli.	B. Enteritidis.	Remarks.
			p.m.				
1	3	May 10	3.40 to 4.40	60	+	+	
2	3	„ 11	6.30 to 7.30	60	—	—	
3	4	„ 17	4.50 to 6.50	120	—	—	
4	4	„ 18	9.35 to 11.15	120	—	—	
5	3	„ 31	2 to 3	60	—	—	
6	2	June 1	9.12 to 11.12	120	—	—	
7	8	„ 13	8 to 9	60	—	—	Six broths elsewhere than unde. Bar negative.
8	8	„ 14	9.40 to 11.40	120	+	—	Ditto.
9	1	„ 27	9.30 to 11.30	120	—	—	
10	1	„ 28	9 to 11	120	—	—	
11	2	„ 29	9.28 to 11.28	120	—	—	
12	1	July 11	9.15 to 11.15	120	—	—	

Tests with Neutral-red Broth in Equalising Chamber.

No.	No. of Broths used.	Day.	Hour.	Exposure, in Minutes.	Chair. Coli.	Chair. Enteriditis.	Middle. Coli.	Middle. Enteriditis.	Bar. Coli.	Bar. Enteriditis.	Remarks.
			p.m.								
1	3	May 3	6.25 to 8.25	120	—	—	—	—	+	+	
2	4	„ 4	2.40 to 3.50	70	—	—	—	—	—	—	
3	3	„ 10	3.40 to 4.40	60	—	—	—	—	—	—	
4	3	„ 11	6.30 to 7.30	60	—	—	—	—	(Broken)		
5	3	„ 17	4.50 to 6.50	120	—	—	—	—	—	+	
6	3	„ 18	9.35 to 11.15	120	—	—	—	—	—	—	
7	3	„ 31	2.0 to 3.0	60	—	—	—	—	—	—	
8	3	June 1	9.30 to 11.30	120	+	+	—	—	—	—	
9	9	„ 6	8.15 to 9.15	60	—	—	—	—	—	—	6 other N.R.B.s negative.
10	9	„ 7	9.30 to 10.30	60	—	—	—	—	—	+	6 other N.R.B.s negative.
11	1	„ 27	9.30 to 11.30	120					—	—	
12	3	„ 28	9.0 to 11.0	120	—	—	+	—	—	+	
13	2	„ 29	9.35 to 11.10	85	—	—			—	—	
14	2	July 4	9.10 to 11.20	130	—	—			—	—	
15	1	„ 11	9.15 to 11.15	120					—	—	
16	2	„ 18	9.15 to 11.40	205	—	—	—	—	+	—	2 plates, both show coli.

Characters of B. Coli-like Bacteria isolated from the Air between the Terrace Inlet and the Floor of the Debating Chamber.

No.	Locality.	Day.	Hour.	Exposure, in Minutes.	Clot.	N. Red (Reduced).	Glucose.	Lactose.	Saccharose.	Indol.	Nitrite.	Liquefaction.
			p.m.									
1	Bar Battery Chamber.	May 10	3.40 to 4.40	60	+	+	+	+	—	+	+	—
2	Bar Battery Chamber.	June 14	9.40 to 11.10	120	+	+	+	—	+	—	+	-
3	Equalising Bar	May 3	6.25 to 8.25	120	—	—	+	—	—	—	+	—
4	Equalising Chair	June 1	9.30 to 11.30	120	—	+	+	—	—	+	+	—
5	Equalising Bar	July 18	9.15 to 11.40	205	+	+	+	+	—	+	+	—
5B	Equalising from another plate.	„ 18	9.15 to 11.40	205	+	+	+	+	—	+	+	—

iii. *Streptococci.*

Fourteen streptococci isolated from the air of the Battery Chamber below the Bar, and 42 streptococci from the air of the Equalising Chamber below the same point, have been examined in detail. Not one of these 56 streptococci could be identified with any of the 5 streptococci most frequently present in saliva.

This result is satisfactory. It confirms the inference from the result of the examination of the streptococci present in material shed directly from Members' boots on to the paper spread in the Equalising Chamber under the Bar. No evidence, therefore, was found that Members bring in particles of sputum from the pavements on their boots and impart them to the air-stream.

Origin of a large Proportion of the Streptococci obtained from the Air of the Equalising and Battery Chambers.

There is no doubt that a large proportion of these streptococci were brought in upon Members' boots.

Five of the 14 streptococci isolated from the air of the Battery Chamber, and 10 of the 42 obtained from the air of the Equalising Chamber, were never recovered from the air at the inlet by the Terrace. This circumstance alone is suggestive. Further evidence is seen in the fact that on two occasions the same rare streptococcus was isolated in the same test (*i.e.*, at the same time) from the air below the Bar both in Equalising and Battery Chambers. One of the two types of streptococcus referred to has not, up to the present, been again obtained elsewhere.

The number and variety of streptococci in material shed from Members' boots was very large. The only kind of streptococcus that occurred in more than one sample of this material was the common "air streptococcus," giving positive re-actions in saccharose, salicin, and coniferin. Eleven specimens of it were obtained in nine tests in the Equalising Chamber. A certain streptococcus found in the air of the Equalising Chamber, viz., No. 18, has only been found once again, namely, in one of the samples of material shed directly from Members' boots on to the paper in the Equalising Chamber.

The large number of positive re-actions exhibited by a considerable proportion of the streptococci obtained from air under the Debating Chamber is very striking, and especially the fact that six kinds from the Equalising Chamber air and three from the Battery Chamber air acted upon mannite. Although 300 streptococci isolated from 22 samples of saliva have been tested by me in this respect, not one of them acted upon mannite. On the other hand, certain streptococci of fæcal origin readily decompose mannite with an acid re-action.

Conclusion as regards Pollution of the Air between Inlet on the Terrace and Floor of the Debating Chamber.

The air in the Equalising and in the Battery Chambers below the Bar sometimes derives fæcal pollution from Members' boots.

Characters of Streptococci isolated from the Air below the Bar in the Battery Chamber.

Characters Positive.	No.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Occasions when found.	Specimens.
2	1	—	—	+	—	—	—	+	—	—	2	2
	2	—	—	—	—	—	—	+	+	—	1	1
3	3	—	—	+	—	—	—	+	+	—	3	3
4	4	—	—	+	—	—	+	+	+	—	2	2
5	5	—	—	+	+	—	+	+	+	—	1	1
	6	—	+	+	+	—	—	+	+	—	1	1
6	7	—	+	+	—	—	+	+	+	+	1	1
	8	—	+	+	+	+	—	+	+	—	1	1
7	9	—	+	+	—	+	+	+	+	+	1	1
	10	—	+	+	+	—	+	+	+	+	1	1

Remarks.—Five of the above streptococci, viz., Nos. 5, 7, 8, 9, 10, were not recovered from air at the inlet, which was always tested at the same time. This strongly suggests that they were added to the air at the present point.

Streptococcus No. 7 of the above was recovered from the air of the Equalising Chamber under the Bar in the same test (May 10th, 3.40 p.m. to 4.40 p.m.).

Streptococcus No. 6 was also recovered from the air of the Equalising Chamber under the Bar in the same test (May 18th, 9.35 p.m. to 11.15 p.m.).

Characters of Streptococci isolated from the Air in the Equalising Chamber, chiefly under the Bar.

Characters Positive.	No.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Glycerin.	Occasions when found	Specimens.
1	1	−	−	−	−	−	−	+	−	−		1	2
2	2	−	−	−	−	−	−	+	+	−		4	4
	3	−	−	+	−	−	−	+	−	−		2	2
3	4	−	−	+	−	−	−	+	+	−		9	11
4	5	−	−	+	−	−	−	+	+	+		1	1
	6	−	−	+	−	−	+	+	+	−		4	4
	7	−	−	−	−	+	+	+	+	−		1	1
	8	−	−	+	−	+	−	+	+	−		1	1
	9	−	+	+	−	−	−	+	+	−		1	1
	10	+	−	+	+	−	−	+	−	−		1	1
5	11	−	+	+	−	−	−	+	+	+		2	2
	12	−	−	+	+	+	−	+	+	−		1	1
	13	+	+	+	+	−	−	+	−	−		1	1
6	14	+	−	+	+	−	−	+	+	+		1	1
	15	−	+	+	−	−	+	+	+	+	+	1	1
	16	−	+	+	−	−	+	+	+	+	−	1	1
	17	−	+	+	+	+	−	+	+	−		1	1
	18	+	−	+	+	−	+	+	+			1	1*
7	19	+	+	+	+	−	−	+	+	+	+	2	2
8	20	+	+	+	+	+	−	+	+	+	−	2	2
9	21	+	+	+	+	+	+	+	+	+	+	3	3

* Also recovered from Members' boots.

Remarks.—Ten of the above streptococci, viz., Nos. 7, 9, 10, 11, 13, 14, 17, 18, 19, 20, 21, were not obtained from the air before this point.

A streptococcus identical with streptococcus No. 11 was isolated from air leaving the Debating Chamber—in a downcast shaft—the day following that on which No. 11 was found below the Bar in the Equalising Chamber air.

(C.)—Air in the Debating Chamber.

The air inside the Debating Chamber has been examined on two occasions :— Air in Debating Chamber.

i. On January 31, 1904, before the opening of Parliament; and
ii. On Friday, February 19, after the adjournment of the House.

On both these occasions neutral-red broth was the medium used. Particulars and results of the tests are as follows :—

i. *The Test made on January 31st.*

The ventilation was not in action during this test, which was made at the same time as the first control experiment in the speaking experiments to be described later.

Twenty-six broth plates were exposed: 22 on the floor, and 4 on top of the gallery rail, at points half-way along each side of the Chamber. The position of the plates exposed on the Benches on the floor in this experiment can be readily seen from the accompanying diagram.

The plates were left exposed to the air of the Chamber for 2 hours.

One of the plates was broken in transit. The remaining 25 were incubated for 48 hours anærobically at 37° C. and then examined.

Result.

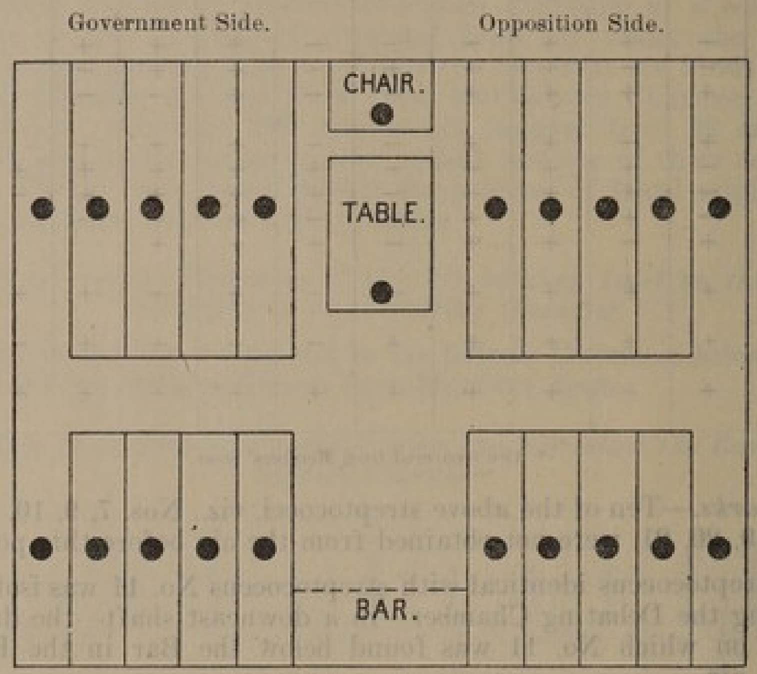
Seven of the 25 broths that had been exposed showed no growth of any kind.

None of the remaining 18 showed either B. coli or B. enteritidis.

Only three of the broths showed streptococci. On examination, two of these streptococci were found to be distinct from streptococci characteristic of saliva. The third streptococcus, however, was identified with one of the two streptococci most characteristic of saliva. This salivary streptococcus was recovered from the air over a bench in the middle of the Irish Benches.

Remarks.—The single plate infected with a streptococcus of saliva in this experiment was possibly an error of experiment.

Diagram of the Floor of the Debating Chamber showing positions in which Plates were exposed in Tests on January 31 *and February* 19, 1904



● = Position of broth plate.

ii. *The Test made on February* 19*th.*

Air in Debating Chamber.

During the Debate preceding this test, the number of persons present in various parts of the Debating Chamber had been as follows:—

Members	300
Strangers	60
Peers and official seats	18
Speaker's Gallery	22
Ladies' Gallery	28
Reporters' Gallery	34
Total	462

Owing to the fact that some Members lingered in the Chamber, it was not till between 10 and 15 minutes after the actual adjournment that the plates were exposed. The ventilation was continued until the plates were exposed, and then stopped.

The positions in which the plates were exposed on the floor were the same as in the previous test. In the galleries in the present test, however, instead of four plates, 18 were exposed, including two in the Ladies' Gallery.

Above the ceiling also in the present test 11 plates were exposed, one being placed by the large shutter at the Bar end of the roof, six along the iron bridge that spans the ceiling from end to end, and four in the mouths of the four down-cast shafts leading from above the chair end of the ceiling.

One broth plate was also placed beneath the Bar, in the Equalising Chamber. This plate was exposed before the House adjourned.

The plates in the Debating Chamber were exposed to the air for one hour and then collected.

The 52 tubes containing the neutral-red broth that had been exposed in the plates were incubated anærobically for 48 hours at 37° C. and then examined.

Result.

One of the 52 broths were broken.

Five of the 51 broths showed no growth.

None of the remaining 46 broths contained B. coli. None of the broths exposed in the Debating Chamber showed B. enteritidis sporogenes, the latter, however, was present in the plate exposed in the Equalising Chamber, and also in one of the plates exposed in the mouth of a downcast above the ceiling at the Chair end.

No less than 31 of the broths contained streptococci. In each case the streptococcus present was isolated in pure culture, sub-cultured, and examined. The result was that only three of the streptococci could be identified with one or other of the five streptococci most characteristic of saliva.

The places where the three broths infected with salivary streptococci had been exposed to the air were as follows :—

(1) On the middle of the Treasury Bench.
(2) On the middle of the back Bench under the Gallery on the Government side below the Gangway.
(3) On the middle of the second Bench from the front on the Opposition side above the Gangway.

A streptococcus giving re-actions identical with those of a streptococcus obtained previously from horse manure was obtained from a plate that had been exposed on the front Opposition Bench below the gangway.

The characters of all the streptococci obtained from the air of the Debating Chamber and roof, on January 31st and February 19th, respectively, are seen in the accompanying table. (Page 48.)

Remarks.—The fact that saliva droplets were only detected in the three places mentioned does not necessarily mean that only a few droplets of saliva had been present in the air of the Debating Chamber during the preceding debate. The loss of ten minutes at the beginning of the test would allow a large number of the droplets to settle.

Salivary pollution, therefore, was first detected in the air of the Debating Chamber itself. The results of the examination of air leaving the Debating Chamber during Debates will now be described.

(D.)—Air leaving the Debating Chamber.

i. *Air over the Ceiling.*

Air passing out of the Debating Chamber through the ceiling is disposed of diffently at each end.* At the end of the ceiling over the Chair the air is drawn down through four downcast shafts to the basement, and thence through a long passage to the exhaust furnace at the foot of the

Air after Debating Chamber.

* These conditions are now altered, all the air being extracted by a fan over the Bar end and the downcasts shut off from the Debating Chamber.

Characters of Streptococci isolated from the Air in the Debating Chamber.

Positive Characters	Number.	January 31st.	February 19th.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Specimens.	Other Sources.
I.	1	... ...	Government Bench below Gangway ...	−	−	+	−	−	−	−	−	−	1	——
II.	2	... ...	Gallery, Opposition Bench above Gangway	−	−	−	−	−	−	+	+	−	4	Frequent in air.
	3	... ...	Gallery, Treasury Bench	−	−	+	−	−	−	+	−	−	3	——
	4	... ...	Treasury Bench	−	−	+	−	−	−	−	+	−	1	——
III.	5	... ...	Gallery	−	−	+	−	−	+	+	−	−	1	——
	6	... ...	Gallery	−	−	−	−	−	+	+	+	−	1	——
	7	... ...	Benches on both sides of the Chamber ...	−	−	+	−	−	−	+	+	−	5	Frequent in air.
	8	... ...	Government Bench below Gangway ...	−	−	−	−	+	−	+	+	−	1	——
IV.	9	Gallery	Table, Government Bench below Gangway	−	−	+	−	−	+	+	+	−	3	——
	10	... ...	Gallery, Government benches above and below Gangway.	−	−	+	−	+	+	+	−	−	3	——
V.	11	Gallery	Irish Bench	−	−	+	−	+	+	+	+	−	2	Horse manure.
	12	... ...	Gallery	+	+	−	+	−	−	+	+	−	1	——
	13	Irish Bench	Government Bench below Gangway ...	+	+	+	+	+	−	−	−	−	2	Saliva.
VI.	14	... ...	Treasury Bench, Opposition Bench above Gangway.	+	+	+	+	+	−	+	−	−	2	Saliva.
VII.	15	Government Bench above Gangway.	... ...	−	+	+	+	−	+	+	+	+	1	——
VIII.	16	... ...	Government Bench below Gangway ...	+	+	+	+	+	−	+	+	+	1	——

REMARKS.—Nos. 13 and 14 are among the five commonest types of streptococci met with in saliva. None of the five streptococci in question were obtained from the air before this point.

Clock Tower. At the end of the ceiling over the Bar, on the other hand, the air is immediately drawn out by an exhaust furnace in a small tower there situated, known as the Commons Lobby Tower.

Test 1.—On July 4th. Ten plates were exposed from 10.40 p.m. till 11.10 p.m., during a Debate, in the track of the outgoing air at the end of the ceiling over the Bar. Seven of these plates contained agar, the other three Drigalski's medium. After incubation for 48 hours at 37° C. all streptococcus-like colonies that had developed on the plates were sub-cultured and examined. Three streptococci were thus obtained, but none of them could be identified with a streptococcus characteristic of saliva. The characters of these streptococci are included in the accompanying table.

No evidence of saliva in the air leaving the Chamber over the Bar end was obtained, therefore, in this test. The exposure of the plates, however, was only of 30 minutes duration.

Test 2.—On July 26th. Six agar plates were exposed across the air track at each of the two ends of the ceiling. Six plates containing Drigalski's medium were also placed at each end by the side of the agar plates. Thus 24 plates in all were used.

The plates were exposed to the air from 10 p.m. till 11 p.m., and a Debate was in progress while they were open.

All the plates were incubated at 37° C. for 48 hours, at the end of which time the colonies that had developed upon them were counted. The mean number of colonies per plate at each end was as follows :—

Situation.	Agar.	Drigalski.
Ceiling, Bar end	66	3
Ceiling, Chair end	47	1·8

The total number of bacteria deposited on both media, therefore, appeared to be considerably greater at the Bar end. This result was to have been expected in view of the fact that anemometer observations showed that considerably more air passed out at the end over the Bar than at the other end of the ceiling.

Characters of the Streptococci isolated from the Air at each end of the Ceiling in this Test.

All colonies on the agar plates in the least resembling streptococcus colonies were sub-cultured, and in this way all the streptococci present were isolated in pure culture and subjected to examination.

As a result, seven streptococci were obtained from each end of the ceiling. The number of streptococci deposited from the air at the two ends was therefore equal.

Examination of the characters of the 14 streptococci showed that only three of them could be identified with streptococci of saliva. Two of these salivary streptococci were obtained from the end over the Chair, and one from the end over the Bar.

One of the two streptococci obtained from the air at the Chair end had characters identical with those of a streptococcus 8th in frequency in saliva, 10 specimens of this micro-organism having been obtained from seven out of 22 samples of saliva. This streptococcus was isolated from a plate exposed in a doorway admitting air from above the Speaker's and Ladies' Gallery to the downcasts. The second streptococcus of saliva isolated from the Chair end came from a plate that had been exposed in the mouth of the second downcast shaft. It was identical with one of the two types most frequently present in saliva, 43 specimens of it having been isolated from 17 out of 22 samples of saliva examined.

The single salivary streptococcus obtained from the air over the ceiling at the Bar end in this observation was isolated from a plate exposed on the iron bridge near the middle shutter at that end. It was identical with a streptococcus 6th in frequency in saliva, 13 specimens of it having been obtained from 8 of 22 samples of saliva examined.

It would appear, therefore, that in spite of the larger volume of air passing out over the Bar end of the Debating Chamber, and in spite of the total number of bacteria deposited from the air at that end being greater, as many streptococci fell upon plates at the Chair end as upon plates at the Bar end, and actually more streptococci of saliva fell from the air on the plates at the Chair end than fell on the plates at the end over the Bar.

The characters of all the streptococci obtained in this test are included in the accompanying table.

It should be added that at 10.15 p.m., Dr. Hurtley made a determination of the carbonic acid in the air at the end of the ceiling over the Chair. He found 5·6 per 10,000 vols. of air—a respiratory impurity roughly of 1·6, and therefore within de Chaumont's limit. In spite of this result, however, the air at that end smelt slightly, but distinctly unpleasant, as I have frequently observed it to do during debates.*

Characters of Streptococci isolated from the Air over the Ceiling.

Positive Characters.	No.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Specimens.	Remarks.
I.	1	−	−	+	−	−	−	−	−	−	1	
II.	2	−	−	+	−	−	−	+	−	−	3	
	3	−	−	−	−	−	−	+	+	−	2	
	4	−	+	+	−	−	−	+	−	−	1	
III.	5	−	−	+	−	−	−	+	+	−	3	
	6	−	−	−	−	−	+	+	+	−	1	
IV.	7	−	−	+	−	−	+	+	+	−	2	
	8	+	−	+	+	−	−	+	−	−	1	Saliva, 6th in frequency.
V.	9	+	+	+	+	+	−	−	−	−	1	Saliva, equal 1st in frequency.
	10	−	−	+	−	+	+	+	+	−	1	
VI.	11	+	−	+	+	+	−	+	+	−	1	Saliva, 8th in frequency.
VII.	12	+	+	+	+	−	+	+	+	−	1	

ii. *Air at the Shutters of the four Downcast Shafts leading from the Chair End of the Ceiling.*

The four downcast shafts which convey air from above the Chair end of the Debating Chamber to the Clock Tower originate from a point above the Speaker's and Ladies' Gallery, and downwards for 68 feet to the basement, where tney communicate by flap-valves with a passage which extends for 240 feet until it reaches the fire at the base of the Clock Tower.

The four downcast shafts pass downwards for 68 feet to the basement, where they communicate by flap-valves with a passage which extends for 240 feet until it reaches the fire at the base of the Clock Tower.

At a point 45 feet from their origin in the ceiling, and about the level of the Equalising Chamber, the four downcast shafts have, fixed across their cavities, shutters by which, if need arise, the air passing through from the Chamber to the Clock Tower can be controlled or stopped. These shutters formed a convenient spot for examining the air passing out of the Chamber to the Clock Tower; for culture media exposed upon them

* Since the alteration made in 1905, this unpleasant smell of air passing out over the Chair end has not been perceptible.

was placed at right angles to the air descending vertically downwards inside the shafts. Both air-current and gravity, therefore, here combined to ensure the deposition of particulate matter suspended in the air in the shafts on to the surface of media exposed in plates upon the shutters.

As the mouths of the downcasts are 70 feet above the table of the Chamber, and the shutters are 45 feet below the mouths of the downcasts, particulate matter travelling from the region of the table of the Chamber to these shutters would traverse a distance of 115 feet.

Owing to the fact that the shutters of the downcasts were approachable from below the Chamber, I was able to carry out a considerable number of bacteriological observations at this point. The results obtained will now be described.

(a) The general Bacterial Incidence in each of the four Downcast Shafts.

Agar at 22° C.

On all of three occasions when this medium was exposed on the shutters, the number of bacteria deposited by the air in the second shaft was considerably in excess of that found in the other shafts. Shaft No. 2, therefore, was the best bacterial "air drain" of the four. The actual numbers are seen in the accompanying table.

Number of Bacteria Deposited on Plates by Air in the four Downcasts at the Level of the Shutters.

Agar at 22° C.

Test.	Day.	Hour.	Exposure in Minutes.	Down-cast I.	Down-cast II.	Down-cast III.	Down-cast IV.
		p.m.					
1	May 31 ...	2.30 to 3.30	60	90	193	44	68
2	June 1 ...	9 to 11	120	92	383	32	84
3	" 20 ...	7.45 to 9	75	171	287	236	230
	Mean...	... ...	85	117	287	104	124

Drigalski Medium at 37° C.

Results obtained with this medium confirmed the above inference. The mean of eight tests showed that the number of bacteria deposited by air in the second shaft* was almost double that found in the shaft next in point of numbers, and over double that found in the remaining shafts. The actual figures are seen in the following table:—

Drigalski and Conradi Medium 37° C.

Test.	Day.	Hour.	Exposure in Minutes.	Down-cast I.	Down-cast II.	Down-cast III.	Down-cast IV.
		p.m.					
1	June 1 ...	9 to 11	120	10	31	1	13
2	" 6 ...	6.55 to 10	180	1	20	7	13
3	" 7 ...	9.30 to 10.30	60	6	10	5	12
4	" 8 ...	9.20 to 11.10	110	15	28	14	14
5	" 13 ...	8.50 to 11.15	145	9	29	10	20
6	" 14 ...	9.30 to 11.30	120	26	24	6	12
7	" 28 ...	9.30 to 10.30	60	4	14	9	7
8	" 29 ...	10 to 11	60	4	11	4	1
	Mean...	... ...	107	9	20	7	11

* The shaft called II. in these experiments is the 3rd from the Government side at the ceiling opening, but second at the level of the shutters.

The general Bacterial Incidence from the Air of the Shafts: (1) *When the Chamber was empty, and* (2) *During a Debate.*

In a test made on June 27th, the number of bacteria deposited by air passing through the shafts was observed: (1) when the Chamber was empty during the adjournment for dinner, and (2) during the Debate that occurred later in the evening. Besides agar plates afterwards incubated at 37° C., Drigalski plates were exposed in these two tests. The colonies were counted after 48 hours. The results are seen in the following table:—

Number of bacteria deposited on Plates by Air in the four Downcasts at the level of the Shutters: (A) *when the Chamber was empty,* (B) *when the Chamber was full.*

Condition of Chamber.	Time of Exposure.	Downcast I.		Downcast II.		Downcast III.		Downcast IV.	
		Agar.	Drig.	Agar.	Drig.	Agar.	Drig.	Agar.	Drig.
Empty (during adjournment for dinner).	p.m. 7.45 to 8.45	108	2	261	6	226	8	162	8
Later (during debate)	10 to 11, Division at 10.20 p.m.	275	15	:26	32	260	12	302	28
Difference ...	... ...	67	13	165	26	34	4	140	20

—	Means	
	Agar.	Drig.
Chamber empty	189	6
Debate and division going on ...	290	21
Difference	101	15
Per cent. increase during Debate.	52	250

The figures show that air passing through the downcasts deposited on both media a larger number of bacteria during the Debate. The increase shown by the agar plates was at the rate of 52 per cent., but the increase shown by the Drigalski medium was at the rate of no less than 250 per cent. In brief, taking the increased development upon agar as 1, then the increase during Debate on the Drigalski medium was 4·7. As the latter medium, unlike the agar, inhibits the growth of a large number of saprophytic micro-organisms, this result implies that the chief increase produced by the presence of persons in the Chamber did not at all events occur amongst this class of micro-organisms.

(*b*) *The Incidence of B. Coli and of B. Enteritidis Sporogenes in the Air of the Downcast Shafts.*

On four occasions, plates of neutral-red broth were exposed on the shutters, but all gave a negative result as regards B. coli or B. enteritidis. On a fifth occasion, when a plate was exposed for a long time (200 minutes) in the second shaft, it became infected with B. enteritidis.

Tests with Neutral-red Broth in the Downcasts at the Level of the Shutters.

Test.	Day.	Hour.	Exposure in Minutes.	Downcast I.		Downcast II.		Downcast III.		Downcast IV.	
				Coli.	Enteritidis.	Coli.	Enteritidis.	Coli.	Enteritidis.	Coli.	Enteritidis.
		p.m.									
1	June 1	9.15 to 11.15	120	—	—	—	—	—	—	—	—
2	„ 8	9.45 to 10.45	60	—	—	—	—	—	—	—	—
3	„ 20	7.50 to 8.50	60	—	—	—	—	—	—	—	—
4	„ 28	9.30 to 11.30	60	—	—	—	—	—	—	—	—
5	July 19	4.10 to 7.30	200			—	+				

(*c*) *The Incidence of Streptococci in the Air of the Downcast Shafts.*

During debates streptococci giving reactions identical with those of streptococci characteristic of saliva were obtained from the air at the shutters on all occasions tested. The medium that was found to be most delicate for detecting them was ordinary agar subsequently incubated at 37° C., but owing to the large number of micro-organisms of all kinds developing on this medium, the isolation of streptococcus colonies was difficult. Recourse was, therefore, had chiefly to the medium of Drigalski and Conradi, which, though inhibiting to a certain extent the development of streptococci of saliva, was found to inhibit the growth of the other bacteria far more.

From the results shown by the tests of the total number of bacteria yielded by the air of the four shafts, it might have been expected that downcast No. 2 would be more likely to yield streptococci of saliva than the other three shafts. This has generally been found to be the case.

Although, when Debates were in progress, streptococci characteristic of saliva were constantly present in the downcast air, they were not obtained on two occasions when the test was applied to the downcast air in the same way with the Debating Chamber empty.

Table showing the Influence of Debates on the Presence of Streptococci of Saliva in Plates of Drigalski and Conradi Medium exposed in the four Downcasts at the Level of the Shutters.

No.	Condition of the Debating Chamber.	Day.	Hour.	Exposure in Minutes.	Downcast 1.	Downcast 2.	Downcast 3.	Downcast 4.
			p.m.					
1	Debate ...	May 31	2.45 to 3.45	60	—	+		
2	„ ...	June 1	9.12 to 11.12	120	—	+	—	—
3	„ ...	„ 6	6.55 to 10	180	—	+	—	—
4	„ ...	„ 7	9.30 to 10.30	60	—	+	—	—
5	„ ...	„ 8	9.20 to 11.10	110	—	+	+	+
6	Chamber empty	„ 20	7.45 to 9	75	—	—	—	—
7	„ „	„ 27	7.45 to 8.45	60	—	—	—	—
8	Debate ...	„ 27	10 to 11	60	+	+	—	+

+ = streptococci of saliva present.

On June 27th, the test for salivary streptococci was applied in the downcast shafts twice in the same evening, viz., during the adjournment for dinner, and later when a Debate was in progress. In the former circumstance, although all colonies on the Drigalski plates that in any way resembled streptococcus colonies were subcultured, no salivary streptococci were obtained. On the other hand, when Debate was in progress streptococci of saliva were obtained from the air of no less than three of the four shafts. The plates were, of course, exposed for an equal time on the two occasions, the area of medium exposed was equal, and the medium itself was of precisely the same composition.

The characters of the streptococci of saliva recovered on the Drigalski medium during the Debate on this occasion may be seen in the following table :—

Characters of Streptococci isolated from Air of the Downcasts at Shutters during Debate on June 27.

Downcast.	Day.	Hour.	Colony.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Order of Frequency in Saliva.	Further Particulars of the same.
I.	June 27	p.m. 10 to 11	1	+	+	+	+	+	—	—	—	—	1st ...	43 specimens obtained from 17 samples of saliva.
			2	+	+	+	+	+	—	—	—	—	" ...	" "
			3	+	+	+	+	+	—	—	—	—	" ...	" "
II.	"	"	1	+	+	+	+	+	—	—	—	—	" ...	" "
			2	—	—	+	+	+	—	—	—	—	Rare ...	5 specimens from 5 of 22 samples of saliva.
IV.	"	"	1	+	+	+	+	+	—	—	—	—	1st.	
			2	+	+	+	+	—	—	—	—	—	Equal 1st	41 specimens obtained from 18 samples of saliva.
			3	+	—	+	+	+	—	—	—	—	9th ...	14 specimens from 6 samples.

It should be added that Dr. Hurtley estimated the carbonic acid present in the mixed air of the downcasts at the shutters at 10 p.m. on June 27th, when the last test was made, and he found 6·7 vols. of carbonic acid per 10,000 vols. of air.

The carbonic acid impurity due to respiration was, therefore, about 2·7 volumes of the gas per 10,000 of air.

Characters of all Streptococci isolated during Debates from Air passing the Shutters of the Downcasts (115 feet from Table of Debating Chamber), and from Air between this Point and the Clock Tower Furnace.

No. of Positive Characters.	No.	Specimens.	Occasions on which found.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Frequently found in Saliva.	Order of Frequency in Saliva.	Remarks
I.	1	1	1	—	—	—	+	—	—	—	—	—			
	2	1	1	—	—	—	—	—	—	+	—	—			
II.	3	3	3	—	—	—	—	—	—	+	+	—			
	4	1	1	—	+	—	—	—	—	—	—	+			
	5	2	2	—	—	+	—	—	—	+	—	—			
	6	1	1	—	—	—	—	—	+	+	—	—			
	7	1	1	—	—	+	—	—	+	—	—	—			
	8	2	2	—	—	+	+	—	—	—	—	—	Yes	4th ...	16 specimens obtained from 9 samples of saliva.
III.	9	1	1	—	—	+	—	+	—	+	—	—			
	10	1	1	—	+	—	—	—	—	+	+	—			
	11	3	3	+	—	+	+	—	—	—	—	—	Yes	3rd ...	24 specimens obtained from 15 samples of saliva.
	12	4	4	—	+	+	+	—	—	—	—	—			
	13	3	1	—	—	+	+	+	—	—	—	—			
	14	5	3	—	—	+	—	—	—	+	+	—			

Characters of Streptococci, &c.—continued.

No. of Positive Characters.	No.	Specimens.	Occasions on which found.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Frequently found in Saliva.	Order of Frequency Saliva.	Remarks.
IV.	15	5	3	+	+	+	+	—	—	—	—	—	Yes	1st ...	41 specimens obtained from 18 samples of saliva.
	16	4	2	—	—	+	—	—	+	+	+	—			
	17	1	1	—	—	+	—	+	—	+	+	—			
	18	1	1	+	—	+	+	+	—	—	—	—			
V.	19	9	5	+	+	+	+	+	—	—	—	—	Yes	Equal 1st	43 specimens obtained from 17 samples of saliva.
	20	1	1	—	+	+	—	—	—	+	+	+			
	21	2	2	—	+	+	+	—	—	+	+	—			
	22	1	1	—	—	+	—	+	+	+	+	—			
	23	1	1	—	+	+	+	+	—	+	—	—			
	24	1	1	+	+	—	+	—	—	+	+	—			
	25	1	1	+	—	+	+	+	—	+	—	—			
VI.	26	1	1	—	+	+	+	+	—	+	+	—			
	27	3	3	+	+	+	+	+	—	+	—	—	Yes	Equal 4th	15 specimens obtained from 9 samples of saliva.
	28	1	1	—	+	+	+	—	—	+	+	+			
	29	1	1	—	+	+	—	+	+	+	+	—			
	30	1	1	+	—	+	+	+	—	+	+	—			
	31	1	1	+	+	+	+	+	+	—	—	—			
	32	1	1	—	+	+	+	—	+	+	+	—			
VII.	33	1	1	+	+	+	+	+	—	+	+	—			
	34	1	1	—	+	+	+	+	+	+	+	—			
	35	1	1	+	+	+	+	—	+	+	+	—			
VIII.	36	1	1	+	+	+	+	+	+	+	+	—			

Conclusion as regards Air leaving the Debating Chamber.—The chief particulate pollution detected in air passing out of the Debating Chamber to the Clock Tower consists of particles of saliva which appear to be constantly contained by it during Debates, but are not found in it when the Debating Chamber is empty.

iii. *Air between the Shutters of the Downcasts and the Exhaust Furnace at the Base of the Clock Tower.*

After passing the shutters of the downcasts, the air is drawn vertically downwards for 23 feet to the level of the basement. At this site it passes through two windows, the bars of which support flap valves, into a passage which joins with two other passages to form a straight channel extending for over 200 feet until the exhaust furnace is reached at the foot of the Clock Tower. The distance from the flap-valves to the Clock Tower furnace is about 240 feet.

One of the passages joining the exhaust airway soon after the flap valves is the "Commons pipe vault" which contains a number of steam pipes. Owing in part to the high temperature of the air passing out of this vault towards the Clock Tower fire, but owing chiefly to its dryness,* the surface of culture media exposed in plates in the long straight passage (over 200 feet) to the Clock Tower furnace, in the experiments to be described became partly dried up.

Tests were made on three occasions to determine how far beyond the shutters of the downcasts streptococci of saliva could be traced during debates.

In all these three tests streptococci of saliva were shown to be present in the air of the downcasts at the level of the shutters.

* Dry bulb 90°, wet bulb 73° = Humidity 40 per cent.; evaporative power per cubic foot of air 8·9 grains; observation made on Monday, August 2, 1904, about 8 p.m. On repeating the observation next day, similar result obtained.

Test 1.—On June 19th, plates were exposed at the site of the flap-valves. This point is 23 feet beyond the downcast shutters, and 138 feet from the Table of the Chamber. The plates were exposed between 9.45 and 10.45 p.m. Streptococci that developed on the plates were isolated and examined, with the result that one of them was identified with one of the two streptococci that are most characteristic of saliva.

Tests 2 *and* 3.—On June 21st, between 9.30 and 11.30 p.m., and again on June 22nd between the same hours, plates were exposed at intervals along the passage from the flap valves to the furnace under the Clock Tower. On each occasion 12 Drigalski plates and 24 agar plates were exposed in this passage. The plates were placed at 6 stations on tables, and were exposed at a height of between 3 and 4 feet from the ground. Plates were also exposed at the points where the two passages conveying air other than downcast air joined the passage.

After incubation for 48 hours at 37° C., all streptococci that developed on the plates were examined. Ten streptococci were obtained on June 21st, and seven on June 22nd. On each occasion a streptococcus was found that gave re-actions identical with those of a streptococcus of saliva. The streptococcus isolated on June 21st was obtained from the first station beyond the flap-valves; a point 45 feet from the downcast shutters, and therefore 150 feet from the table of the Debating Chamber.

On the second occasion, June 22nd, a streptococcus, identified from its characters with a streptococcus met with rarely in saliva, was isolated from a Drigalski plate exposed by the furnace under the Clock Tower, a point 263 feet from the shutters of the downcasts, and 378 feet from the table of the Debating Chamber.

The characters of the three streptococci obtained in these tests are seen from the following Table:—

Characters of Streptococci isolated from Air beyond the Shutters of the Downcasts.

No	Medium.	Day.	Hour.	Locality.	Distance from Table of Chamber.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Order of frequency in Saliva.	Further Particulars of the same.
1	Agar 37° C.	June 15	p.m. 9.45 to 10.45.	Flap valves	Feet. 138	+	+	+	+	+	—	—	—	—	1st	43 specimens from 17 samples of saliva.
2	Agar 37° C.	„ 21	9.30 to 11.30.	Beyond flap valves.	150	+	+	+	+	+	—	+	—	—	5th	15 specimens from 9 samples.
3	Drig. 37° C.	„ 22	9.30 to 11.30.	By Clock Tower furnace.	378	—	+	+	+	—	—	—	—	—	Rare	5 specimens from 5 of 22 samples.

Prior to the present investigation the furthest distance to which saliva particles had been proved to be air-borne was 40 feet. These results are therefore of considerable interest.

iv. *Air round the Top of the Clock Tower at the Level of the Lantern.*

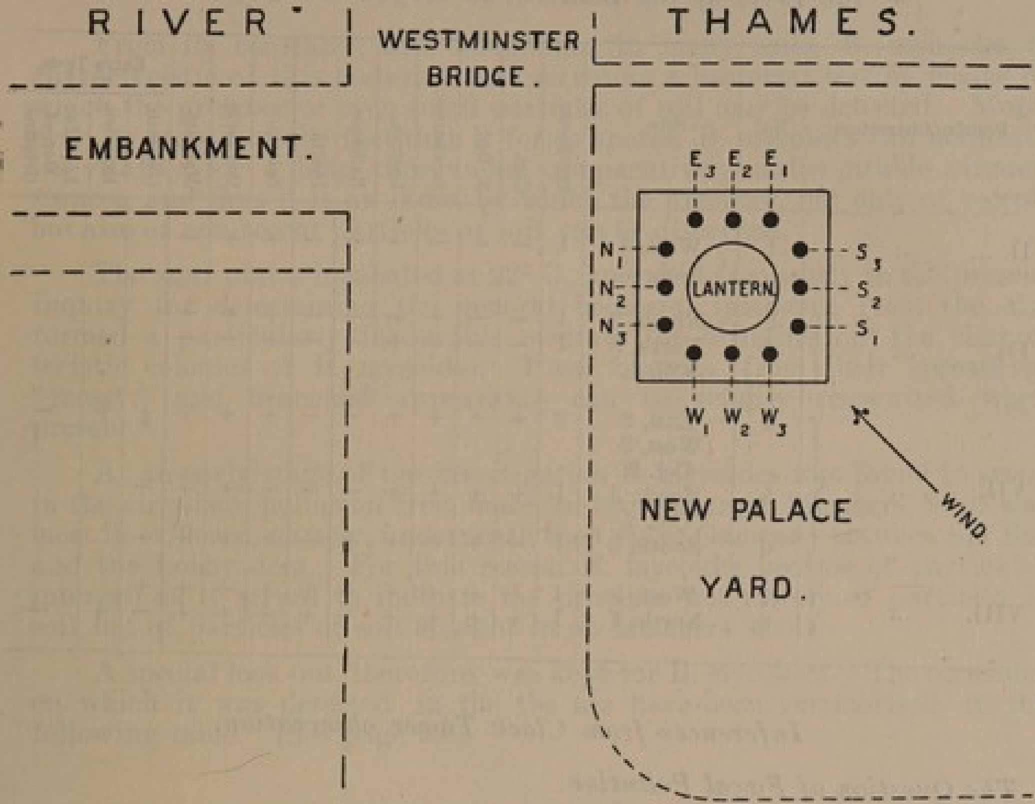
Air at Clock Tower.

On Wednesday, August 10th, 1904, from 6 p.m. till 9 p.m., 12 aluminium dishes containing neutral-red broth were exposed to the air around the lantern at the top of the Clock Tower.

There was no rain on the day that this test was made. The wind was blowing from the south-west, and was fairly strong at the height of the lantern. While the plates were exposed, carriages were frequently driving across New Palace Yard, and therefore disturbing dust.

Three broth plates were exposed on each of the four faces of the Tower, and they were placed close to the edge on an iron grating.

The following diagram shows roughly the position in which the plates were exposed round the Tower :—



The broth exposed in the plates was incubated anærobically for two days at 37° C. and examined. The results obtained are shown in the following Tables :—

Result of a Test with Neutral-red Broth on the Clock Tower at the Level of the Lantern on Wednesday, August 10th, 1904, between the hours of 6 p.m. and 9 p.m.

Side of Tower.	Enteritidis.	Coli.	Streptococci.
North 1	−	−	+
" 2	−	−	+
" 3	−	−	+
South 1	−	−	+
" 2	−	−	+
" 3	−	−	+
East 1	+	+	−
" 2	−	−	+
" 3	+	+	−
West 1	−	+	+
" 2	−	−	+
" 3	−	−	+

Characters of Three Coli-like Bacteria isolated from Air on the Clock Tower at the Level of the Lantern, August 10th, 1904.

Side of Tower.	Clot.	N. Red.	Glucose.	Lactose.	Saccharose.	Indol.	Nitrite.	Liquefaction.
East 1	+	−	+	+	+	−	−	−
East 3 ..	−	+	+	−	+	+	+	−
West 1 ...	−	−	+	−	−	−	+	−

Characters of Nine Streptococci isolated from Air on the Clock Tower at the Level of the Lantern, on August 10th, 1904.

Positive Characters.	No.	Site.	Specimens.	Clot.	N. Red.	Saccharose.	Lactose.	Raffinose.	Inulin.	Salicin.	Coniferin.	Mannite.	Extra Tests.		
													Glycerin.	Isodulcit.	Liquefaction of Gelatine.
II.	1	West, 3 Col. 1.	1	—	—	—	—	—	—	+	+	—			
III. ...	2	North, 2	1	—	—	+	—	—	—	+	+	—			
	3	North, 3 Col. 1.	1	—	—	+	+	—	—	+	—	—			
VII. ...	4	East, 2 West, 3 Col. 2.	2	+	+	+	+	—	—	+	+	+	+	+	—
	5	North, 3 Col. 2.	1	+	+	+	+	—	—	+	+	+	—		
	6	South, 3	1	—	+	+	+	+	—	+	+	+	—		
VIII. ...	7	West, 1	1	+	+	+	+	+	+	+	+	+	+		
	8	North, 1	1	+	+	+	+	+	+	+	+	+	—	+	—

Inferences from Clock Tower observation.

The Question of Fæcal Pollution.

Although coli-like bacilli and B. enteritidis sporogenes were associated in each of two plates, and a coli-like bacillus was isolated from a third plate, none of the three coli-like bacilli in question gave re-actions identical with those of the type of B. coli most frequently present in the human intestine.

While the results obtained by exposing neutral-red broth on the Clock Tower, therefore, point to the presence of fæcal matter in the air there on the occasion when the test was made, this fæcal matter was probably horse manure carried up by the wind from the surface of the ground below.

The Question of Salivary Pollution.

None of the streptococci obtained from the air round the lantern in this test could be identified with streptococci characteristic of human saliva.

The Significance of some of the Streptococci found.

The first two streptococci obtained in this test are common in air, as previous tests in the airway prove.

The number of positive re-actions given by five of the nine streptococci isolated is remarkable, and especially striking is the fact that all these five streptococci acted upon mannite. It has been previously pointed out that this character was a marked feature of a considerable proportion both of the streptococci brought in upon Members' boots and also of the streptococci found in the air below the Debating Chamber during Debates. Moreover, no less than four of the nine streptococci obtained on the Clock Tower, comprising three different types (Nos. 4, 5, and 7), are identical with streptococci previously isolated from air in the Equalising Chamber. It is practically certain that these streptococci obtained from the Equalising Chamber had been brought into the Debating Chamber on Members' boots from the streets. Their presence, therefore, in the air round the Clock Tower on the occasion in question indicates the presence therein of particulate matter derived from the surface of the ground below.

(3.) Observations of the Presence of B. Mycoides in the Air of the Airway.

From its constancy and abundance in many soils, B. mycoides is characteristic of this material, and serves as a bacterial test by means of which the presence of even small particles of soil may be detected. Moreover, by reason of the fact that it forms spores, B. mycoides can maintain its vitality for a long time under comparatively unfavourable circumstances, and thus it is an index by which the presence, not only of recent, but also of non-recent particles of soil, can be discerned.

The agar plates incubated at 22° C., and used frequently in the present inquiry for determining the general bacterial incidence from the air, formed a particularly favourable medium for bringing out the characteristic colonies of B. mycoides. These colonies, from their spreading, "mossy," and branched appearance can be readily recognised when present.*

At an early stage of the investigation B. mycoides was found to occur in the air where pollution from material brought in on Members' boots was most in evidence, namely, underneath the Centre Gangway between the Bar and the Lobby door. For this reason B. mycoides became of particular interest, as it served to indicate the presence not merely of particles of soil, but of particles of soil brought in on Members' boots.

A special look-out, therefore, was kept for B. mycoides. The occasions on which it was detected in the the air have been summarised in the following table. (*See* page 60.)

Analysis of the Results.

On two of the 26 occasions on which B. mycoides was found it occurred at the inlet. These two positive results at the inlet, however, may have been due to people walking on the grating over the north inlet.

On no less than 15 of the 26 occasions when it was found, B. mycoides was recovered from the air of the Equalising Chamber; on nine of these 15 occasions it was recovered from air under the Bar, and in the nine infected plates altogether 12 separate colonies of this micro-organism were present.

On two occasions B. mycoides was recovered under the Bar in the Equalising and Battery Chambers in the same test,† thus forming additional evidence that material brought in on Members' boots might penetrate to the latter locality.

B. mycoides was recovered from air passing out of the Debating Chamber above the ceiling on six occasions, on four of which it was found at the end of the ceiling above the Bar, and on two in the downcasts at the end over the Chair. On two occasions it was recovered above the ceiling and under the Bar in the same test.

The finding of B. mycoides on these occasions in air passing out of the Chamber through the ceiling implies that a proportion of the dirt brought in on Members' boots is drawn up into the Debating Chamber by the ascending currents of air, and thus is liable to be inhaled by Members.

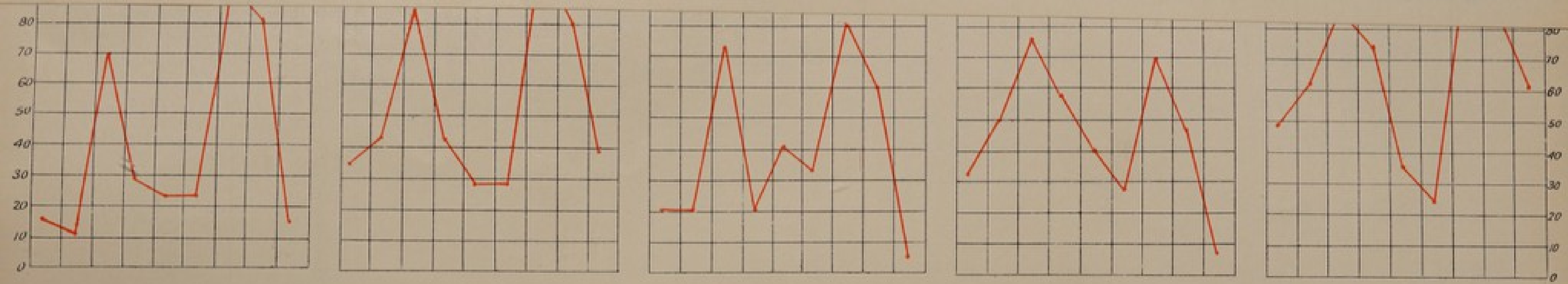
* *See* Plates V. and VI. of accompanying illustrations.
† *See* Plate V. of illustrations.

Table showing Occasions on which B. Mycoides was recovered from the Air.

Date	May 10.	May 11.	June 6.	June 8.	June 13.	June 20.	July 13.	Aug. 8.	Aug. 8.	Aug. 9.	Aug. 9.	Aug. 10.	Aug. 11.	Aug. 11.	Aug. 12.	Total.
Hour (p.m.)	3.40 to 4.40.	6.30 to 7.30.	9.30 to 11.	9.20 to 11.10.	8.50 to 11.15.	7.45 to 9.	9.30 to 10.	2 to 5.	9 to 11.30.	2 to 5.30.	5.30 to 8.	2 to 5.30.	2 to 5.30.	10 to 11.30.	12 (noon) to 3.	
Minutes exposed	60.	60.	90.	110.	145.	75.	30.	180.	150.	210.	150.	210.	210.	90.	180.	
Inlet		+				+										2
Battery Chamber under Bar.		+								+						2
Battery Chamber under Opposition Gangway.					+											1
Equalising Chamber under Lobby by door.								+ 2 colonies	+		+				+	4
Equalising Chamber under Bar.	+	+ 2 colonies						+	+ 2 colonies	+	+ 2 colonies	+	+		+	9
Equalising Chamber under Middle.			+													1
Equalising Chamber under Government Gangway.				+												1
Ceiling, Bar End, Right Channel.															+	1
Ceiling, Bar End, Middle Channel.													+			1
Ceiling, Bar End, Left Channel.											+			+		2
Ceiling, Bar End, Down-cast 3 at shutter.													+			1
Ceiling, Chair End, Down-cast 4 at shutter.							+									1
																26

+ = 1 colony of B. mycoides present, except where expressly stated otherwise.

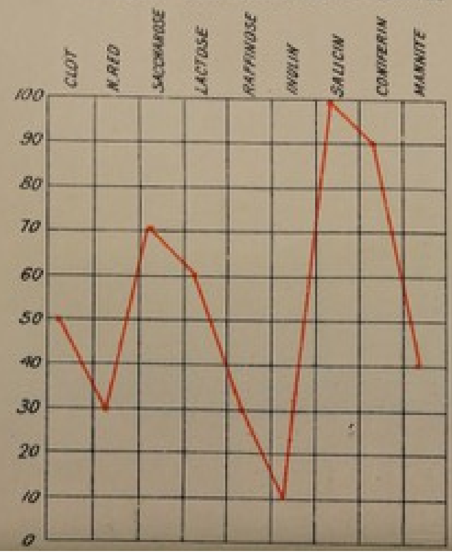
To face page 61.



STREPTOCOCCI FROM MEMBERS BOOTS

EACH PRESENT TO OVER 1000 PER GRAMME OF DEPOSIT

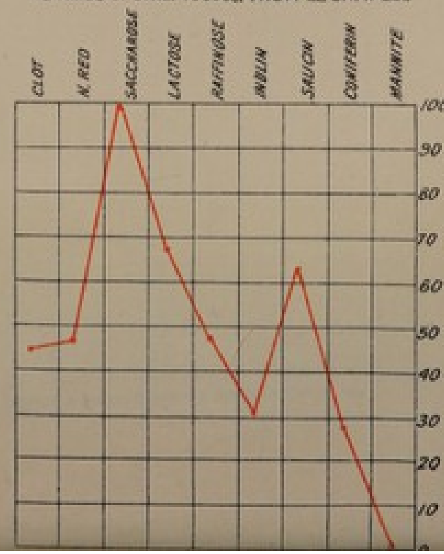
10 KINDS OF STREPTOCOCCI FROM 3 SAMPLES



STREPTOCOCCI OF SALIVA

EACH PRESENT TO OVER 100,000 PER C.C.

48 KINDS OF STREPTOCOCCI FROM 22 SAMPLES



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(4.) Summary of the preceding Results.

Curves showing the Aggregate Characters of Streptococci isolated from the Air at various Parts of the Airway.

The curves in the diagrams on opposite page express the percentage of positive re-actions given to the nine tests by the sum of the *kinds* of streptococci present in the air at different parts of the airway. Thus the characters of the various kinds of streptococci found at each spot can be viewed as a whole, and compared with those of the whole of the streptococci found at another part of the airway. Curves showing in aggregate in the same way the characters of streptococci brought in on Members' boots, and the characters of streptococci isolated from samples of saliva, are also added.

It is seen that the contour of what may be termed the "character-resultant" is different at various parts of the airway. The reason is not far to seek. The influence of streptococci shed from Members' boots on the form of the character-curve in the Equalising Chamber is distinctly perceptible; still more perceptible, however, is the influence of streptococci of saliva on the curve exhibited by streptococci present in air leaving the Debating Chamber during debates.

Summary of Subsection 3.

The result of the search for evidence of pollution may be summarised as follows :—

(1) Air at the north chamber of the inlet on the Terrace is liable to pollution from fæcal* matter derived from the boots of persons walking over the grating above the inlet in question.

(2) Air under the floor of the Debating Chamber is constantly contaminated during Debates by particulate matter shed from Members' boots. While fæcal* matter is apt to be imparted to the air in this way, no evidence was found of particles of saliva or of sputum being carried in on Members' boots from the public pavements and communicated to the air under the Chamber. The chief spot where air under the Chamber is polluted from Members' boots is below the Centre Gangway, between the Bar and the Lobby door under the Clock. Contamination of air under the Chamber also occurs from the same cause, though in less degree, under the side Gangways and behind the Speaker's Chair.

A proportion of the particulate material shed from Members' boots is carried up into the air of the Debating Chamber, and therefore is liable to be inhaled by Members.

(3) The chief particulate pollution detected in air in the Debating Chamber itself, as judged by the result of a number of examinations of air passing out of the Chamber during Debates, consists of particulate matter derived from the mouth and upper respiratory passages of persons in the Chamber.

In short, particulate pollution to which the air of the Debating Chamber is subjected is supplied chiefly by Members themselves, and is either brought in on their boots, or is derived from their mouths and upper respiratory passages. The result of the examination of air leaving the Debating Chamber indicates that during Debates the latter form of pollution is the greater of the two.

* Derived, almost certainly, from the horse.

SECTION IV. SUBSECTION 4.

THE RESULT OF INDEX-EXPERIMENTS MADE TO DETERMINE THE LIABILITY OF THE AIR OF THE DEBATING CHAMBER TO DERIVE PARTICULATE POLLUTION, AND THE VALUE OF THE VENTILATION IN THIS SENSE.

The preceding observations prove that the chief particulate pollution to which the air of the Debating Chamber is liable, is derived either from the boots or from the mouth and upper respiratory passages of Members. By either channel the air may be on occasion contaminated by specific pathogenic micro-organisms.

In order to ascertain more definitely the extent to which the air of the Chamber is liable to derive infected material through each of these two channels, the accuracy of the preceding observations has been tested by reversing the method of inquiry. This has been effected in both cases by employing a harmless, but readily recognisable, micro-organism (B. prodigiosus) as index of infection.

In order to determine the degree to which the air is liable to be contaminated by material brought in from the outside on Members' boots, the following experiment was made. Some garden earth was sterilised, infected with living emulsion of B. prodigiosus, and lightly scattered over part of a crossing in New Palace Yard near the Parliament Street entrance. After laying down material containing the index-micro-organism at the spot mentioned, agar plates were exposed in the channels by which air passes into and out of the Debating Chamber. After incubation for three days at 22° C., these plates were examined for B. prodigiosus, colonies of which are in culture readily perceptible, from their crimson hue.

Secondly, the degree of the liability of the air of the Debating Chamber to be charged with particulate material derived from the mouth and upper respiratory passages was investigated by making some speaking experiments in the Debating Chamber, in which experiments the person who orated had previously infected his mouth and pharynx with a living emulsion of B. prodigiosus. The efficiency of the ventilation for removing particulate matter disseminated in the breath in the act mentioned was determined by comparing the result of speaking experiments made respectively with the ventilation off, and with it on.

It will be convenient to describe first the experiment in which B. prodigiosus was laid down on the crossing in New Palace Yard, and subsequently the speaking experiments in the Debating Chamber.

(1.) Experiments made on Monday, August 8th, 1904, and the following days, to determine the Extent to which Particulate Matter deposited at a Spot outside the Debating Chamber is liable to be carried Inwards on Members' Boots, and thus to contaminate the Air Supply of the Debating Chamber.

The material used as "vehicle" was garden earth previously sterilised by exposing it to a temperature of 150° C. for six successive days. The earth was then richly impregnated with a living emulsion of B. prodigiosus, and sterilised sand added in quantity sufficient to absorb the excess of fluid.

A tin of about the capacity of a ¼-lb. tobacco tin, with its cover perforated, was filled with this material, and its contents lightly sprinkled over an area of about 5 square feet of the cobbled crossing in New Palace Yard, at a point between the shelter lamp-post outside Westminster Hall and the corner entrance to the yard from Parliament Street.

At a later date Mr. Patey was good enough to have the length of the distance traversed by persons passing from the infected spot direct to the Bar of the Debating Chamber measured.

The distance was found to be 576 feet, of which 96 feet were cobbled.

The day on which this experiment was made was Monday, August 8th, 1904.

The material was distributed over the spot mentioned at 1.15 p.m.

The House met at 2.

From 2 till 11.30 p.m. agar plates were exposed to the air in the following situations :—

To test Air entering the Debating Chamber.	1. Under the floor of the Lobby, immediately outside the folding-door admitting to the Debating Chamber. 2. Under the floor of the Debating Chamber, in the Equalising Chamber below the Centre Gangway, between the Bar and the aforesaid door. 3. Under the junction of the Centre and Cross Gangways. 4. Under the floor behind the Speaker's Chair. 5. In the Battery Chamber, at a point 17 feet beneath the Bar of the Debating Chamber.
To test Air leaving the Debating Chamber.	1. In the four downcast shafts that convey air from over the ceiling of the Debating Chamber at the Chair end. 2. In the three channels by which air is conveyed from over the ceiling at the Bar end.

The test was, of course, incomplete, as the air in the Debating Chamber itself should have been examined. This being impracticable, the only situations where plates could be exposed for the object in view were as above.

The agar plates exposed in these situations were changed about every three hours till 11.30 p.m. They were then incubated for three days at 22° C., and examined for colonies of B. prodigiosus.

As during the preceding three months a large number of agar plates, afterwards incubated at 22° C., had been exposed in the airways without once yielding B. prodigiosus, it was thought unnecessary to do a control-experiment before laying down B. prodigiosus at the spot mentioned in New Palace Yard.

A control-experiment, however, was provided on the following day (Tuesday, August 9th) by the zeal of a scavenger, who swept up the earth containing the index-micro-organism within half-an-hour of its being put down.

On Wednesday, August 10th, Thursday, August 11th, and Friday, August 12th, some earth containing B. prodigiosus was given to the scavenger whose duty it is to scatter gravel in the Star Court and by the Members' entrance.

He was instructed to mix this earth with the gravel, and to lay it about the places referred to.

Agar plates were exposed in the airways leading to and from the Chamber on all these five days between 2 p.m. and 11.30.

It being at the end of the Session, attendance of Members at the Chamber seemed to be somewhat diminished.

The total number of agar plates exposed to the air entering and leaving the Debating Chamber in these observations was 300.

The plates were incubated for three days at 22° C., and then examined for colonies of B. prodigiosus.

Results.

Test I.—Monday, August 8th, 1904.

Spot infected with B. prodigiosus—Cobbled crossing of New Palace Yard, 576 feet from the Bar of the Chamber.

The positive results yielded by the plates as regards B. prodigiosus were as follows:—

A. Plates exposed from 2 to 4 p.m.:—

(1) A plate exposed in the extension of the Equalising Chamber under the Lobby floor outside the door of the Debating Chamber at the Bar end showed two colonies of B. prodigiosus This was the nearest point to the infected spot at which a plate was exposed.

(2) A plate exposed in the Equalising Chamber under the portion of the Centre Gangway between the Bar and the door showed one colony of B. prodigiosus.

The rest of the plates exposed during this period were negative as regards B. prodigiosus.

B.—Plates exposed between 4 and 7 p.m.:—

(1) A plate exposed in the same situation as No. (1) in A., that is, beneath the floor of the Lobby outside the door of the Chamber, showed one colony of B. prodigiosus.

(2) A plate exposed in the same locality as No. (2) in A., namely, beneath the centre gangway between the Bar and the door, showed one colony of B. prodigiosus.

The other plates exposed during this interval were all negative as regards B. prodigiosus.

C.—Plates exposed between 7.30 and 11.30 p.m.:—

In this test a plate exposed in the Battery Chamber at a point 17 feet below the floor of the Chamber at the Bar end showed one colony of B. prodigiosus.

The plate was one of four exposed in this place where previous tests had shown that dirt from Members' boots might penetrate.

All the other plates exposed in C. were negative as regards the index micro-organism.

The failure of the Equalising Chamber plates in this 3rd series to show B. prodigiosus was probably due to the traffic over the infected spot during the adjournment for dinner. Cabs,. &c., would be driving backwards and forwards, and passengers continually passing over the place where the earth had been sprinkled at 1.15. When I examined the spot at midnight no trace of the earth could be seen.

Probably it disappeared much before this hour.

Test II.—Tuesday, August 9th.

The material was laid down as on the previous day, but was swept up within half hour by a diligent scavenger.

The result of this experiment must be read chiefly as a control of Test I.

Result.—Only one of the plates showed B. prodigiosus. The plate in question showed one colony of that micro-organism, and had been exposed under the Bar of the House from 2 to 4 p.m.

Tests III., IV., and V., on Wednesday, Thursday, and Friday.

The scavenger mixed the earth containing B. prodigiosus with his gravel, and scattered it about near Members' entrance and over the Star Court.

On Thursday there was continuous rain all the morning.

The results of these tests was that I only got B. prodigiosus twice. A plate exposed in the third downcast shaft from the ceiling on Wednesday between 5.30 and 9 p.m. showed one colony of B. prodigiosus.

Lastly, a plate exposed in the Equalising Chamber below the Bar on Friday, August 12th, from 6 p.m. till the adjournment about 8.30 p.m., showed one colony of B. prodigiosus.

The largely negative result of these latter tests when the scavenger spread the material was certainly due in great part to the fact that few Members walked over the places where the earth and gravel had been spread.

Members I saw alighting from cabs at the Members' entrance invariably jumped straight on to the pavement without walking on the gravel.

Upon the negative results of these experiments, therefore, much stress is not to be laid.

Summary.

Summary of Test I.—Particulate material deposited at a point 576 feet from the Bar of the Chamber was carried into the Debating Chamber on Members' boots, and fell through the air of the Equalising Chamber down to a point in the Battery Chamber, 17 feet below the floor of the Debating Chamber, at the Bar end. No evidence, however, was obtained of this particulate pollution in the other parts of the Equalising Chamber tested. The air passing out of the Debating Chamber above the level of the ceiling on the day when this test was made, also failed to yield B. prodigiosus.

The remaining tests were incomplete. On Tuesday the infected material was swept up. On the three remaining days the material appears to have been laid down in places where comparatively few Members who walked into the Debating Chamber trod. It is doubtful, also, if the amount of earth I was able to provide was sufficient for the area over which, after being mixed with the gravel, it was spread.

The finding of B. prodigiosus on Tuesday and Friday under the Bar, taken with the results of Test I., confirms previous observations made with other methods, and strengthens the conclusion that this is the chief place where air entering the Debating Chamber is subject to pollution from material brought in on Members' boots.

The finding of B. prodigiosus once in the air leaving the Chamber, viz., in downcast 3 on Wednesday, between 5.30 and 9 p.m., is not a matter upon which much stress can be laid. It is only a single observation.

At the same time, B. mycoides was sometimes obtained from the air passing through the ceiling during the present tests, and the same micro-organism was frequently found under the Bar. There is evidence, therefore, that some particulate material brought in upon boots does get carried up into and through the air of the Chamber.

Conclusion.

Particulate material deposited outside the Debating Chamber on the surface of the ground can be carried by pedestrian Members into the Chamber from a distance of at least 576 feet.

As some Members drive up, they are, of course, liable to bring material from considerable distances.

The chief place where material brought in on Members boots contaminates the air-supply of the Chamber is under the Centre Gangway, between the Bar and the folding-door at that end of the Chamber. It is not possible to decide the extent to which the air inside the Debating Chamber actually suffers from this form of pollution without further tests, in which the air is examined in the Chamber itself.

(2.) Experiments to determine the Extent to which the Air of the Debating Chamber is liable to be polluted by Particulate Matter given off in the Breath in Performance of the Act of Oration; and the Value of the Ventilation for removing such Material from the Air of the Chamber.

i. *General Plan of the Experiments.*

The act tested has been that of loud speaking, and the spread of particulate matter (droplets of saliva) emitted from the mouth of a person during the performance of this act for a period of one hour has been determined (1) with the Ventilation off, and (2) with the Ventilation on.

In the former case the air supply was cut off in the airway between the inlet on the Terrace and the Equalising Chamber. As regards the outlet, the large shutter above the ceiling of the Debating Chamoer by means of which the volume of vitiated air passing from the Chamber to the extraction fire in the Lobby Tower is controlled, was closed, and communication between the four downcast shafts and the extraction fire in the Clock Tower was also cut off. The gaslights in the ceiling were not burning, but their by-passes were alight.

On the other hand, in the experiments with the Ventilation full on, the airway between the inlet and the Equalising Chamber was open, and the fan and scrim-cloth screen in the basement were in action. The condition with regard to the gaslights in the ceiling was the same as in the previous experiments, but there was in the present case free communication between the Chamber above the ceiling of the Debating Chamber and the fire in the Lobby Tower at the one end; and the four downcast shafts at the other end were aso in free communication with the fire in the Clock Tower.

In all the experiments the cotton-wool screen in the basement was not in action.

In both the speaking experiments herein described B. prodigiosus was used as index of infection, the mucous membrane of the mouth and pharynx of the person who spoke being infected with a living emulsion of this micro-organism immediately prior to speaking. On both occasions, except as regards the ventilation, an attempt was made to observe the same conditions; thus, the emulsion of B. prodigiosus was made from the same amount of culture, and in exactly the same way; and the time occupied in infecting the mouth and throat with it was the same. In both cases, again, after half an hour's continuous speaking, the person who spoke withdrew for a few minutes to re-infect his mouth and pharynx with a further measured amount of the prodigiosus emulsion. The same person spoke on both occasions, and the place where the speaking took place was the same, namely, by the box which is fixed on the Ministerial side of the table of the Debating Chamber. On both occasions the speaking lasted for one hour, the person who spoke addressing himself to each quarter section of the House in turn for a quarter of an hour each, beginning with the block of Opposition benches above the Gangway, and ending with the block of benches originally behind him, namely, the Ministerial Benches above the Gangway. The words spoken on both occasions were, as far as possible, the same, and consisted of recitations, in a loud voice, from Shakespeare's plays, " King Henry V." and " Julius Cæsar."

The experiments made were altogether four in number, two of them being control-experiments, that is to say, experiments made on each of the two occasions immediately prior to the speaking experiments proper; and the object in making them was to exclude any error due to the possibility of B. prodigiosus being already present in the air of the Chamber. The speaking experiments were made on two successive days, an interval of 17 hours elapsing between the closing of the plates in Experiment II. and the opening of the plates in Experiment III. The experiments were arranged as follows:—

Ventilation off (First Day).

Experiment I. (Control Experiment.)—Time of exposure, 2 hours. Number of plates exposed, 66.

Experiment II. (Speaking Experiment.)—Speaking for one hour, and a further interval of half an hour allowed for the droplets to settle down. Number of plates exposed, 208.

Ventilation on (Second Day).

Experiment III. (Control Experiment).—Time of exposure, 1½ hours. Number of plates exposed, 110.

Experiment IV. (Speaking Experiment).—Repetition of Experiment II. Exposure as in that case for 1½ hours. Number of plates exposed, 211.

The medium used in all these experiments was ordinary agar solidified in round flat glass capsules with covers, commonly called Petri-dishes or simply " plates." The flat circular area of agar exposed in each of these plates was from 3½ to 4 inches in diameter. For purposes of transport each plate was kept tightly closed by surrounding it with a sterilised rubber band, was enclosed in a sterilised paper envelope, and was packed, with others, in boxes lined with sterilised wool. Eleven such boxes were found necessary. As an extra precaution, the hands were disinfected on each occasion before handling the plates. After exposure in the experiments, the covers were replaced on the plates, the plates were labelled, the rubber bands slipped over them, and each plate put into its envelope and repacked in the boxes for removal to the laboratory. After exposure the plates were kept inverted. In Experiments I. and II. the plates were incubated for 48 hours at 22° C., and then left for a further period of 48 hours at the laboratory temperature; in Experiments III. and IV. the process was reversed, a procedure necessitated by the fact that the two latter experiments had to be carried out at an interval of 17 hours after the first two experiments had been completed, and the incubator at my disposal was only large enough to take half the total number of plates used in these experiments at a time.

I am much indebted to Messrs. Draper, Laws, and Priestley, and to my brother, Mr. E. Gordon, for their help in carrying out these experiments. I have also to thank my brother for the plans which illustrate these experiments.

ii. *Position of the Plates.*

In all four experiments agar plates were exposed on the floor of the Equalising Chamber. In the Debating Chamber plates were exposed on the arms of the Speaker's Chair, on the Table, and on all the rows of benches. Plates exposed on the front and back rows of the benches were placed on the seats, but in the case of the three intermediate rows they were exposed in a slightly oblique position near the tops of the backs of the benches and immediately in front of the ticket slots. This was effected by means of specially made wire catches which were slipped over the tops of the backs of benches saddle-wise. The situations in which plates were exposed is best seen by referring to the accompanying diagrams. In both the speaking experiments, namely, in Experiments II. and IV., 14 horizontal rows of plates were exposed on the five rows of benches that are fixed in ascending tiers longitudinally on either side of the Debating Chamber. These horizontal rows of plates were at intervals of about 3 feet apart, and were, in fact, placed in line with every alternate ticket slot on the back benches, so that in both speaking experiments one plate was exposed for every two seats on the benches. In addition, plates were also exposed in the Opposition Gangway in Experiment II., and in both the Ministerial and Opposition Gangways in Experiment IV.

In the Gallery, plates were exposed all around behind the rail that divides it from the well of the Debating Chamber. In the Members' and Peers' Galleries the plates were exposed on the seats in the front row; in the case of the Press Gallery they were exposed on the writing ledge. In the Ladies' and Speakers' Galleries plates were exposed on the front row of chairs behind the grille. In the Strangers' Gallery two plates were exposed on the top of two posts situated on either side of the centre stairway.

In the chamber in the roof above the ceiling of the Debating Chamber plates were exposed: (1) by a grating situated over the Strangers' Gallery; (2) by an opening which was made by removing one of the panels of the ceiling; (3) along the iron bridge which crosses from end to end above the panelling and gaslights in the ceiling; and (4) in the entrances to the four downcast shafts which communicate with the Clock Tower. Finally plates were also exposed in all the experiments in the common duct into which all the pipes which carry off the fumes from the gasburners in the ceiling discharge.

All the plates were exposed to the air in a horizontal position except those plates on the backs of the three intermediate rows of benches on the floor, which were slightly inclined.

In order to ensure the plates being exposed on the same spots in both speaking experiments, the places in which it was intended that they should be exposed were marked out beforehand by means of pieces of white tape which were fixed *in situ*. The number of agar plates exposed in each situation in each experiment is seen from the following table :—

TABLE showing the NUMBER of AGAR PLATES exposed in Various Parts of the DEBATING CHAMBER, and in the AIRWAYS, in the four Experiments described. The Table reads from left to right.

Condition of the Ventilation	Off.		On.	
Number of the Experiment	I.	II.	III.	IV.
Duration of the Exposure	2 Hours.	1½ Hours.	1½ Hours.	1½ Hours.
Nature of the Experiment	Control.	Speaking.	Control.	Speaking.
Equalising Chamber	2	4	4	4
Floor :				
Speaker's Chair	1	2	2	2
Table	2	4	2	5
Ministerial Benches above Gangway ...	10	41	20	41
" " below " ...	10	30	15	30
Opposition " above " ...	10	41	20	41
" " below " ...	10	30	15	30
In gangways	0	4	0	8
Galleries :				
*Members' Gallery, Ministerial side ...	2	9	4	9
* " " Opposition " ...	2	9	4	9
†Peers' Gallery	2	7	3	7
Press "	2	7	3	7
Ladies' "	2	4	3	4
Speakers' "	2	2	2	0
Strangers' "	0	2	1	2
Roof :				
Grating over Strangers' Gallery	1	1	1	1
At removed panel of ceiling	1	1	1	1
Bridge over ceiling	4	4	4	4
Downcasts	2	4	4	4
Duct from gasburners	1	2	2	2
Total	66	208	110	211

* The term Members' Gallery includes the whole of the Gallery on this side of the House.
† The term Peers' Gallery includes also the Special Strangers' Gallery.

The plans attached to the report show the positions in which plates were exposed in the Debating Chamber and the results as regards B. prodigiosus yielded by them after incubation. Photographs of the infected plates are also attached.

On both days while the experiments were in progress a dry and wet bulb hygrometer was exposed on the Table of the Debating Chamber. The readings were approximately as follows :—

Hygrometer Readings.

——	Dry Bulb.	Wet Bulb.	Corresponding Humidity of the Air (Glaisher), Saturation = 100.
Experiments I. and II. ...	59 degrees ... 58 " ...	52 degrees ... 51 " ...	61 per cent. 61 "
Experiments III. and IV. ...	60 " ... 59 " ...	53 " ... 52 " ...	62 " 61 "

From which it appears that the humidity of the air was practically the same in both the speaking experiments.

iii. *Result of the Experiments as regards the Spread of B. Prodigiosus through the Air of the Debating Chamber.*

After incubation of the plates the result of the experiments was found to be as follows :—

A. Control Experiments.

Control Experiments.

Experiment I.—Not one of the 66 plates exposed in Experiment I. showed a colony of B. prodigiosus. Although there was a good enough growth of colonies of other micro-organisms deposited from the air on the surface of the plates, none of these colonies in any way approached the crimson colour of colonies of B. prodigiosus. Such pinkish colonies as were present were always examined microscopically, and they were found in every case to be colonies of the pink torula that is so commonly met with in air.

Experiment III.—Of the 110 plates exposed in this experiment one plate alone showed infection with B. prodigiosus, of which it developed one colony. This plate had been exposed in the Equalising Chamber. The remaining 109 plates were entirely negative as regards B. prodigiosus. This fact goes to confirm previous experience, viz., that the overwhelming majority of the droplets do not remain suspended in the air for an indefinite time.

B. Speaking Experiments.

Experiment II. Speaking, Ventilation off.

Experiment II.—Ventilation off.—Plates exposed for 1½ hours, *i.e.*, for one hour whilst speaking was in progress, and for half an hour after it had ceased.

A surface agar plate made at the end of the hour's speaking from a small quantity of the saliva of the person who spoke showed after 48 hours' incubation at 22° C. a growth that was crimson from the presence of innumerable colonies of B. prodigiosus.

Out of a total of 208 plates exposed in this experiment, 57 became infected with B. prodigiosus. The results shown by plates exposed in the various parts will now be considered in detail.

1. *Plates exposed in the Equalising Chamber in Experiment II.*

Four plates exposed on the floor of the Equalising Chamber during the experiment failed to yield B. prodigiosus.

2. *Plates exposed in various Situations on the Floor of the Debating Chamber in Experiment II.*

(a.) *Table.*

Of four plates exposed upon the Table, two became infected with B. prodigiosus. A plate exposed on the Ministerial box immediately in front of the person who spoke showed 84 colonies, of which 83 were colonies of B. prodigiosus. A plate exposed on the table in front of the Clerk's seat on the Ministerial side showed also four colonies of B. prodigiosus. On the other hand, plates exposed on the box on the Opposition side of the Table, and on the Table in front of the Clerk's seat on the Opposition side, showed in both cases no colonies of B. prodigiosus.

(b.) *The Speaker's Chair.*

A plate exposed on the arm of the chair on the Ministerial side showed amongst other colonies, one of B. prodigiosus. The plate on the arm of the chair nearest the Opposition was not infected with this micro-organism.

(c.) *The Benches.*

The total number of plates exposed on the Benches on both sides of the House in this experiment was 142, of which 38 showed infection with

B. prodigiosus—a proportion of 26 per cent. The aggregate of the prodigiosus colonies present on these plates was 42. More plates were infected on the Ministerial side of the House than on that of the Opposition. Of 71 plates exposed on the former side, 24 were infected, a proportion at the rate of 33 per cent., with an aggregate of 27 colonies of B. prodigiosus. Of 71 plates exposed on the Opposition Benches 14 were infected—a proportion of 19 per cent.—with an aggregate of 15 colonies of B. prodigiosus. Further particulars as regards these plates are as follows :—

Benches on the Ministerial Side of the House.

Benches above the Gangway.

Of 41 plates exposed 12 were infected, and the infected plates showed an aggregate of 14 colonies of B. prodigiosus. With regard to the distribution of the infected plates, a glance at the plan will show that the plates exposed on the front or Treasury Bench were most heavily infected. Of the eight plates exposed on this bench, no less than five were infected, and yielded altogether seven colonies of B. prodigiosus, that is to say, half of the total number of prodigiosus colonies yielded by the block. As regards the position of the other infected plates in this block, it is noticeable that the bench furthest back—under the Gallery, in fact—was more highly infected than the two benches immediately in front of it.

Benches below the Gangway.

Twelve out of 30 plates exposed on these benches became infected, with an aggregate of 13 colonies of B. prodigiosus. As in the case of the preceding block, the front bench was more highly infected than the rest, four of six plates exposed there being infected and yielding altogether five of the 13 prodigiosus colonies shown by the block. After the front bench, the incidence was heaviest on the third bench, three out of six plates there exposed becoming infected. It may be observed also in the case of this block, that in the third horizontal row, of five plates exposed, four were infected.

Benches on the Opposition Side of the House.

Benches above the Gangway.

Of 41 plates exposed, 10 were infected, and the infected plates showed an aggregate of 11 colonies of B. prodigiosus. On each bench two of the eight plates exposed became infected. Four out of the five plates exposed in the first horizontal row in this block became infected.

Benches below the Gangway.

Out of 30 plates exposed, four became infected, each of the latter developing one colony of B. prodigiosus. Three of the infected plates were rather close to one another.

The figures with regard to the floor benches as a whole in this experiment are summarised in the following table :—

Floor Benches in Experiment II.

Situation.	Ministerial Side.			Opposition Side.		
	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus.	Colonies of B. Prodigiosus.	Plates Infected.	Plates Exposed.
Above Gangway ...	41	12	14	11	10	41
Below Gangway ...	30	12	13	4	4	30
Total	71	24	27	15	14	71

(d) *The Gangways.*

Besides the plates exposed on the benches, four plates were exposed in the Opposition Gangway in this experiment.

They were not infected with B. prodigiosus.

3. *Plates Exposed in the Galleries in Experiment II.*

Out of 40 plates exposed in the galleries in this experiment, 13 showed infection with B. prodigiosus—a proportion at the rate of 32 per cent.—yielding an aggregate of 18 colonies of B. prodigiosus.

The incidence of B. prodigiosus on the plates exposed in the various galleries will now be considered in detail.

(a) *Members' Gallery.*

1. *Ministerial Side.*—Of nine plates exposed, two were infected, yielding five colonies of B. prodigiosus.

2. *Opposition Side.*—Four of the nine plates exposed on this side were infected, but they yielded an aggregate of only four colonies of B. prodigiosus.

(b) *The Peers' Gallery.*

Of seven plates exposed, one was infected, showing one colony of B. prodigiosus.

(c) *The Press Gallery.*

Of seven plates exposed, two were infected, each with two colonies of B. prodigiosus.

(d) *The Ladies' Gallery.*

Of four plates exposed, two were infected, each developing one colony of B. prodigiosus. These plates were about 50 feet distant from the person who spoke.

(e) *The Speaker's Gallery.*

Of two plates exposed, one developed one colony of B. prodigiosus.

(f) *The Strangers' Gallery.*

Of the two plates exposed, each on one of the posts on either side of the stairway in the middle of this Gallery, one plate developed one colony of B. prodigiosus.

The posts on which these plates were exposed were 61 feet from the person who spoke.

The figures with regard to the Galleries as a whole are seen in the following table:—

The Galleries in Experiment II.

Situation.	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus.
Members' Gallery, Ministerial side ...	9	2	5
" " Opposition side ...	9	4	4
Peers' Gallery	7	1	1
Press Gallery	7	2	4
Ladies' Gallery	4	2	2
Speaker's Gallery	2	1	1
Strangers' Gallery	2	1	1
Total	40	13	18

4. *Plates Exposed in the Roof in Experiment II.*

Of six plates exposed in the chamber above the ceiling, three were infected, yielding in aggregate four colonies of B. prodigiosus. The plate that showed two colonies of that micro-organism had been exposed on the bridge about 10 feet inside the shutter over the Bar end. The distance of this plate from the person who spoke was 71 feet. The other infected plate had been exposed by a grating over the Strangers' Gallery.

As might be expected, the four plates exposed in the entrances to the downcasts in this experiment remained uninfected with B. prodigiosus. Two plates in the common duct from the gasburners in the ceiling also remained uninfected with B. prodigiosus.

Roof in Experiment II.

Situation.	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus.
On floor above ceiling	6	3	4
In downcasts...	4	0	0
In duct from gasburners	2	0	0
Total	12	3	4

Analysis of the Result of Experiment II.

Situation of the Infected Plates.

Out of 208 plates exposed to the air in this experiment, altogether 57 became infected with B. prodigiosus. The number of plates infected in each part of the Debating Chamber was as follows:—The Speaker's chair, 1; Table, 2; Ministerial Benches, 24; Opposition Benches, 14; Galleries, 13; Chamber above ceiling, 3.

Number of Colonies of B. Prodigiosus shown by these Plates.

Eleven of the 57 plates showed more than one colony of B. prodigiosus. The plate showing the greatest amount of infection was the one that had been exposed nearest to the person who spoke. This plate, which had been laid on the Ministerial box, developed 83 colonies of B. prodigiosus. There was a considerable drop between this plate and the one showing the next highest yield of B. prodigiosus, which was a plate that had been placed on the Table in front of the Clerk's seat on the Ministerial side, and developed four colonies of B. prodigiosus. The third most highly infected plate showed three colonies of that micro-organism, and had been exposed on the Ministerial side of the Members' Gallery. Eight plates each showed two colonies of B. prodigiosus. The places where they had been exposed were Ministerial benches, three plates; Opposition Benches, one plate; Ministerial side of the Members' Gallery, one plate (exposed next to the plate yielding three colonies); Press Gallery, two plates; and bridge over ceiling, one plate. The remaining 46 plates infected in the experiment showed only one colony of B. prodigiosus apiece.

Experiment IV.—Ventilation on.—As in Experiment II., a surface agar plăte made at the end of the speaking, from the saliva of the person who spoke, showed after 48 hours at 22° C. innumerable colonies of B. prodigiosus. Experiment IV. Speaking, Ventilation on.

Out of a total of 211 plates exposed in this experiment, 62 became infected with B. prodigiosus. The results shown by plates exposed in the various parts will now be considered in detail.

1. *Plates Exposed in the Equalising Chamber in Experiment IV.*

Four plates exposed in this situation failed to develop B. prodigiosus.

2. *Plates Exposed in various Situations on the Floor of the Debating Chamber in Experiment IV.*

(*a*) *Table.*—Three out of five plates exposed on the Table were infected with B. prodigiosus. A plate exposed on the Ministerial box became very heavily infected with B. prodigiosus in this experiment; being estimated to contain no less than 1,384 colonies of that micro-organism. A plate exposed in the middle of the space between the two brackets, on which the Mace rests when in position on the Table, showed 18 colonies of B. prodigiosus. A plate exposed on the Opposition box yielded nine colonies of the same micro-organism. On the other hand, both the plates exposed on either side of the Table in front of the Clerks' seats escaped infection.

(*b*) *The Speaker's Chair.*—Both plates exposed on the arms of the Chair in this experiment remained uninfected with B. prodigiosus.

(*c*) *The Benches.*—As in the case of Experiment II., the total number of plates exposed on the benches on both sides of the House was 142, of which, in the present experiment, 36 were infected with B. prodigiosus—a proportion of 25 per cent. The aggregate of the prodigiosus colonies yielded by these plates was 47. Again, more plates were infected on the Ministerial than on the Opposition side of the House. Of 71 plates exposed on the Ministerial side, 21 were infected—a proportion of 29 per cent., with an aggregate of 27 colonies of B. prodigiosus. Of 71 plates exposed on the Opposition side, 15 were infected—a proportion of 21 per cent., with an aggregate of 20 colonies of B. prodigiosus.

Benches on the Ministerial Side of the House.

Benches above the Gangway.

Out of 41 plates exposed, 11 were infected; and the aggregate of prodigiosus colonies yielded by them was 13. A reference to the diagram shows that in the present case the incidence was heaviest upon the plates exposed on the back row under the Gallery, five out of nine plates exposed on the seat of the row in question being infected, and yielding in aggregate seven colonies of B. prodigiosus; that is, over half the total number of prodigiosus colonies yielded by the block. On the other hand, the Treasury Bench only had two out of eight plates exposed thereon infected, and each of these infected plates showed one colony of B. prodigiosus. It is noteworthy that although the bench underneath the Gallery exhibited such a high incidence in the present experiment, the bench immediately in front of it escaped. The distance of the infected plate at the top end of the second bench, that is to say, at the end nearest to the Speaker's Chair, was 20 feet from the person who spoke.

Benches below the Gangway.

Out of 30 plates exposed, 10 became infected, yielding on aggregate of 14 colonies of prodigiosus. With regard to the distribution of the infected plates, the same feature is seen as in the case of the block above the gangway. Once more the back row plates are the most heavily infected, four out of six of them being positive, and yielding in aggregate five of the 14 prodigiosus colonies yielded by the block. It is noteworthy also that the plate furthest away in the back row was infected. The distance of this plate from the person who spoke was 33 feet. Another point worthy of remark in reference to the present group of benches is that, as in Experiment II., the third horizontal row was more heavily infected than the others, the three plates infected in this position giving an aggregate of no less than six colonies of B. prodigiosus.

Benches on the Opposition Side.

Benches above the Gangway.

Out of 41 plates exposed on these benches, 10 were infected, and the aggregate of prodigiosus colonies yielded by them was 14. The highest incidence is seen to have fallen on the Front Opposition Bench, where three out of eight plates exposed were infected, and yielded an aggregate of seven colonies of B. prodigiosus. Half of the total prodigiosus colonies of the block were, therefore, provided by the plates on the front bench. The single plate in the first horizontal row that was infected, namely, the plate at the upper end of the third bench, was 25 feet away from the person who spoke at the Ministerial box.

Benches below the Gangway.

Out of 30 plates exposed five were infected. The aggregate of B. prodigiosus colonies yielded by them was six. Three of the five infected plates in this block are seen to have been near one another and far back, two of them being on the back bench. The distance of the infected plate on the third bench from the person who spoke at the Ministerial box was 27 feet.

The figures as regards infection of the plates on the floor benches in this experiment are summarised in the following table:—

Floor Benches in Experiment IV.

Situation.	Ministerial Side.			Opposition Side.		
	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus	Colonies of B. Prodigiosus.	Plates Infected.	Plates Exposed.
Above Gangway	41	11	13	14	10	41
Below Gangway	30	10	14	6	5	30
Total	71	21	27	20	15	71

(*d*) *The Gangways.*—Four plates were exposed in each of the two Gangways in this experiment. The only plate showing infection with B. prodigiosus was one that had been placed on the bottom step of the Opposition Gangway.

3. *Plates Exposed in the Galleries in Experiment IV.*

Out of the 38 plates exposed in the Galleries in Experiment IV., 19 were infected with B. prodigiosus—a proportion at the rate of 50 per cent.—these infected plates yielding an aggregate of no less than 32 colonies of B. prodigiosus.

The incidence of B. prodigiosus on the plates in the various galleries was as follows:—

(*a*) *Members' Gallery.*

Ministerial Side.—Out of nine plates exposed, three became infected, with an aggregate of four colonies of B. prodigiosus.

Opposition Side.—Of the nine plates exposed in this situation, no less than seven showed infection with B. prodigiosus, and gave an aggregate of 14 colonies.

(*b*) *The Peers' Gallery.*

Out of seven plates exposed, three became infected, and showed an aggregate of four colonies of B. prodigiosus.

(*c*) *The Press Gallery.*

Of the seven plates exposed, two became infected and showed an aggregate of three colonies of B. prodigiosus.

(*d*) *The Ladies' Gallery.*

Of four plates exposed, two became infected, each with one colony, of B. prodigiosus.

(*e*) *The Speaker's Gallery.*

Through an oversight, plates were not exposed in experiment IV. in this Gallery.

(*f*) *The Strangers' Gallery.*

Both the plates exposed on the posts in this Gallery were infected. One plate showed two colonies, the other three colonies of B. prodigiosus. The distance of these plates from the person who spoke was 62 feet.

The figures as regards the various Galleries in Experiment IV. are summarised in the following table:—

The Galleries in Experiment IV.

Situation.	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus.
Members' Gallery, Ministerial side ...	9	3	4
" " Opposition side ...	9	7	14
Peers' Gallery	7	3	4
Press Gallery	7	2	3
Ladies' Gallery	4	2	2
Speaker's Gallery	—	—	—
Strangers' Gallery	2	2	5
Total	38	19	32

4. *Plates Exposed in the Roof in Experiment IV.*

Of six plates exposed in the same places in the chamber above the ceiling where plates had been exposed in Experiment II., two showed infection with B. prodigiosus, and each presented one colony of that micro-organism. One of these infected plates had been exposed on the middle of the bridge, and the other infected plate had been exposed by the grid over the Strangers' Gallery. The plate exposed in the latter situation was, therefore, infected in both Experiments II. and IV.

In this experiment one of the four plates exposed in the entrances to the downcast shafts that communicate with the Clock Tower was infected. It had been exposed in the second downcast shaft, and presented one colony of B. prodigiosus. The distance of this plate from the person who spoke was 70 feet.

As in Experiment II., two plates exposed in the common duct from the gasburners in the ceiling were not infected with B. prodigiosus.

Roof in Experiment IV.

Situation.	Plates Exposed.	Plates Infected.	Colonies of B. Prodigiosus.
On floor of chamber above ceiling ...	6	2	2
In downcasts...	4	1	1
In duct from gasburners	2	0	0
Total	12	3	3

Analysis of the Result of Experiment IV.

Situation of the Infected Plates.

Out of 211 plates exposed to the air in this experiment altogether 62 became infected with B. prodigiosus. The number of plates infected in each part of the Debating Chamber was as follows:—The Table 3, Ministerial Benches 21, Opposition Benches 15, Opposition Gangway 1, Galleries 19, chamber above the ceiling 3.

Number of Colonies of B. Prodigiosus shown by these Plates.

Nineteen of the 62 infected plates showed more than one colony of B. prodigiosus. As in the previous experiment, the plate showing the greatest amount of infection was the one exposed nearest to the person who spoke, *i.e.*, the plate laid upon the Ministerial box. The actual number of colonies was estimated to be 1,384. The plate next highest in prodigiosus yield was one that had been exposed in a spot not tested in Experiment II., namely, on the Table between the brackets whereon the Mace rests, and it yielded 18 colonies of B. prodigiosus. The third most highly infected plate was that exposed on the box on the Opposition side of the Table, it had nine colonies of B. prodigiosus. The fourth most highly infected plate was one that had been exposed on the front seat about half-way along the Members' Gallery on the Opposition side of the Debating Chamber; it developed no less than four colonies of B. prodigiosus. Six plates each presented three colonies of B. prodigiosus. They had been exposed as follows:—Ministerial Benches 2 plates, Opposition Benches 2 plates, Members' Gallery (Opposition side) 1 plate, and Strangers' Gallery 1 plate. Nine plates each presented two colonies of B. prodigiosus. They had been exposed thus:—Ministerial Benches 2, Opposition Benches 1 (in both cases below the Gangway); Members' Gallery (Ministerial side) 1, Peers' Gallery 1, Members' Gallery (Opposition side) 2, Press Gallery 1, and Strangers' Gallery 1.

iv. *The Effect of the Ventilation on the Spread of Particulate Matter emitted in the Breath.*

Effect of Ventilation.

The results of the control Experiments I. and III. show that B. prodigiosus was not present in the air of the Debating Chamber on either occasion before the speaking began. The presense of this micro-organism, therefore, in the plates exposed in Experiments II. and IV., indicates the presence in them of particulate material derived from the mouth of the person who performed the act of speaking. If further evidence were needed of the correctness of this inference it is seen in the fact that in both experiments, at the end of speaking, the saliva of the person who spoke was demonstrated to contain B. prodigiosus in large numbers, and also by the fact that on both occasions of all the plates exposed, the one nearest to him, namely, the plate on the Ministerial box, was far more extensively infected with B. prodigiosus than any other plate.

The development, therefore, of a colony or mass of growth of B. prodigiosus in a plate exposed in either of these two speaking experiments was the result of its having been infected by a particle or droplet derived from the mouth of the person who performed the act of speaking, and the development of two or more separate masses of growth or colonies of B. prodigiosus in any of these plates indicates the infection of such a plate by two or more separate particles or droplets derived from that source.

By comparing the prodigiosus yield of the plates exposed in the various parts of the Debating Chamber in the two experiments with the ventilation off and on respectively, an estimate can be formed of the effect of the ventilation on the spread of droplets emitted on both occasions from the mouth in performance of the act of loud speaking.

Comparison between the Results of Experiments II. and IV.

In comparing the results of these two experiments, only the plates exposed in the same spots in each situation will be taken into consideration.

A. *The Number of Plates Infected in various Parts of the Debating Chamber in each of the Two Experiments, and the Number of Colonies of B. Prodigiosus yielded by these Plates.*

1. *The Floor of the Debating Chamber.*

(a) *The Table.*—In both experiments four plates were exposed on the Table in the same spots. On each occasion two of these plates became infected with B. prodigiosus. The number of colonies yielded by the two infected plates, however, was very different. In the experiment with the ventilation off 87 colonies of B. prodigiosus were present, whereas in the experiment with the ventilation on the two plates yielded 1,393 colonies of that micro-organism. The plate mainly responsible for this difference was that exposed on the Ministerial box immediately in front of the person who spoke. This plate developed 83 colonies of B. prodigiosus in the experiment when the ventilation was off as compared with 1,384 colonies when the ventilation was on.

(b) *The Speaker's Chair.*—Although a plate exposed on the right arm of the chair showed one colony of B. prodigiosus in the experiment with the ventilation off, neither this plate nor that exposed on the other arm of the chair was infected in the experiment with the ventilation on.

(c) *The Benches.*—Out of a total of 142 plates exposed on the benches in each of the two experiments the number infected when the ventilation was off was 38, as compared with 36 when the ventilation was on. The proportion of plates infected, therefore, was 26 per cent. when the ventilation was off, and 25 per cent. when it was on. On the latter occasion, however, the infected plates yielded 47 colonies of B. prodigiosus, a number five in excess of that obtained when the ventilation was off.

From those figures it cannot be said that the ventilation produced much effect on the gross incidence of droplets on the plates exposed on the benches.

(d) *The Incidence of B. Prodigiosus upon the Benches on each Side of the Chamber separately.*—Comparing next the incidence of B. prodigiosus upon the benches on each side, it is seen that with the ventilation off, the Ministerial Benches showed 24 infected plates and the Opposition Benches 14. When the ventilation was on, the Ministerial side showed 27 infected plates, while the number infected on the Opposition side was practically the same as before, viz., 15.

The number of colonies of B. prodigiosus yielded by the plates was as follows:—When the ventilation was off, the plates on the Ministerial side gave 27 colonies, those on the Opposition side 15 colonies; when the ventilation was on, the former side gave 27 colonies as before, but the Opposition side now gave 20 colonies of B. prodigiosus.

On both occasions, therefore, the incidence of B. prodigiosus was heavier on the benches on the Ministerial side than on the Opposition Benches. A comparison of the number of colonies of B. prodigiosus yielded by the plates on the two sides shows that the actual number of droplets falling on the plates on the Ministerial side was the same in both experiments. In the experiment with the ventilation on, however, a few more droplets were found to have fallen on the Opposition Benches than had been the case in the previous experiment.

2. *The Gallery.*

On comparing the results shown by the plates exposed in the galleries in the two experiments it is seen that of 38 plates exposed in the same spots in each experiment, 12 were infected with B. prodigiosus when the ventilation was off, as against 19 infected when the ventilation was on. The number of colonies of B. prodigiosus yielded by the plates exposed on the former occasion was 50, as compared with 79 colonies yielded by the plates when the ventilation was on. The difference between the results of the two experiments is therefore considerable, and indicates that in the experiment with the ventilation on, the incidence of droplets on the gallery plates was increased by 50 per cent.

The incidence of B. prodigiosus on the plates exposed in the various parts of the Gallery in the two experiments will now be compared.

The Members' Gallery.

1. Ministerial Side.—Out of the nine plates exposed on the front seat of this Gallery in each of the two experiments, two were infected when the

ventilation was off and three when the ventilation was on. The number of colonies of B. prodigiosus, however, yielded by the plates was five when the ventilation was off, and three when it was on. This result was due to the fact that on the former occasion one of the plates showed three colonies of B. prodigiosus, thus being more highly infected than any plate exposed on the benches on the floor in the same experiment.

The above figures show that the incidence of droplets was slightly diminished in this Gallery when the ventilation was on.

2. Opposition Side.—In both experiments this side of the Members' Gallery was more heavily infected than the other. Of nine plates exposed on each occasion, four were infected with B. prodigiosus when the ventilation was off, and each of them showed one colony of B. prodigiosus. When the ventilation was on, seven of the nine plates were infected, and yielded in aggregate 14 colonies of B. prodigiosus. One of these infected plates showed no less than four colonies of that micro-organism, so that in this experiment also a Gallery plate was more heavily infected than any plate exposed on the benches.

From these results it would appear that the incidence of droplets in this Gallery was increased threefold in the experiment when the ventilation was on.

The Peers' Gallery.

In each of the two experiments seven plates were exposed in this Gallery. When the ventilation was off, one plate was infected, and it showed one colony of B. prodigiosus. When the ventilation was on, three plates were infected, and they yielded four colonies of B. prodigiosus.

The incidence of droplets was, therefore, four times increased in this Gallery in the experiment with the ventilation on.

The Press Gallery.

In this Gallery, also, seven plates were exposed in each of the two experiments, with the result that on both occasions two of the plates became infected. The number of colonies of B. prodigiosus yielded by the infected plates was four when the ventilation was off and three when it was on.

The incidence of droplets in this Gallery was, therefore, slightly diminished in the experiment with the ventilation on.

The Ladies' Gallery.

In both experiments two out of the four plates exposed in this Gallery became infected, and in both, each of the infected plates showed one colony of B. prodigiosus.

No alteration, therefore, was seen in the incidence of droplets in this Gallery when the ventilation was on.

The Strangers' Gallery.

In both experiments two plates were exposed on the tops of two posts in this gallery. When the ventilation was off, only one of the two plates became infected, and it showed one colony of B. prodigiosus. When the ventilation was on, however, both plates became infected, one showing two colonies of B. prodigiosus, the other three.

The incidence of droplets in this Gallery, therefore, was five times increased in the experiment when the ventilation was on.

3. *The Roof.*

On both occasions a plate exposed by a grating above the Strangers' Gallery became infected, and showed one colony of B. prodigiosus. Of four plates exposed on the bridge over the ceiling in each experiment, two were infected when the ventilation was off, and one when it was on. In the former case three prodigiosus colonies developed, in the latter one. In the experiment with the ventilation on, the plate in the mouth of a downcast shaft became infected and showed one colony of B. prodigiosus.

These results prove that when the ventilation was off, droplets, nevertheless, were carried out through the apertures in the ceiling to the chamber above.* In the experiment with the ventilation off, more droplets were deposited on the plates on the bridge than when the ventilation was on. In the latter case, however, at any rate one downcast shaft was proved to be carrying off a droplet emitted from the mouth of the person who spoke at the Ministerial box.

Table showing Side by Side the Results of the two Speaking Experiments.

Situation.	No. of Plates Exposed.	Number of Plates Infected.		Number of Colonies of B. Prodigiosus.	
		Ventilation.		Ventilation.	
		Off.	On.	Off.	On.
Floor :					
The Speaker's Chair	2	1	0	1	0
Table	4	2	2	87	1,393
Ministerial Benches above Gangway ...	41	12	11	14	13
" " below " ...	30	12	10	13	14
Opposition " above " ...	41	10	10	11	14
" " below " ...	30	4	5	4	6
Gallery :					
Members' Gallery, Ministerial side ...	9	2	3	5	4
" " Opposition side ...	9	4	7	4	14
Peers' Gallery	7	1	3	1	4
Press Gallery	7	2	2	4	3
Ladies' Gallery	4	2	2	2	2
Strangers' Gallery	2	1	2	1	5
Roof :					
Over Strangers' Gallery	1	1	1	1	1
Bridge over ceiling	4	2	1	3	1
Downcasts	4	0	1	0	1

B. Comparison of the Result of the two Experiments in respect of Plates showing more than one Colony of B. Prodigiosus, the Plates exposed on the Table in each Experiment being excluded from Consideration.

In the experiment when the ventilation was off, the number of plates showing more than one colony of B. prodigiosus was 11; in the experiment when the ventilation was on the number rose to 18.

Plates showing two Colonies of B. Prodigiosus.

When the ventilation was off eight plates showed two colonies of B. prodigiosus. Four of these plates had been exposed on the Benches, three of them on the Ministerial side. Of the remaining four plates, two had been exposed in the Press Gallery, one on the Ministerial side of the Members' Gallery, and one on the bridge over the ceiling.

In the experiment when the ventilation was on, nine plates showed two colonies of B. prodigiosus. Three of these plates had been exposed on the benches, two of them on the Ministerial side. The remaining six plates had all been exposed in the Gallery, three in the Members' Gallery, and one each in the Peers', Press, and Strangers' Galleries.

Plates showing three Colonies of B. Prodigiosus.

In the experiment with the ventilation off, one plate showed three colonies. It had been exposed in the Members' Gallery on the Ministerial side of the Chamber.

* The panels in the ceiling of the Debating Chamber are raised 1½ inches from the framework in order to permit the passage of air upwards.

In the experiment with the ventilation on, six plates each showed three colonies of B. prodigiosus. Four of these had been exposed on the benches, two on each side. Both of the remaining plates had been exposed in the Gallery, one in the Members' Gallery on the Opposition side of the Chamber, the other in the Strangers' Gallery.

Plates showing four Colonies of B. Prodigiosus.

In the experiment with the ventilation on, one plate showed four colonies of B. prodigiosus. It had been exposed in the Members' Gallery on the Opposition side of the House.

C. Comparison of the Distribution of the Infected Plates in the two Experiments. The Floor.

1. The Table and neighbouring parts.

The fact that the plate on the Ministerial box was by far the most heavily infected in each of the two experiments has been previously referred to, as also has the great difference in the extent to which this plate became infected on the two occasions.

If the positions of the plates second in degree of infection on the Table in each of the two experiments are now compared, it will be seen that the main stream of droplets falling in this part of the Debating Chamber fell on different spots in the two experiments. When the ventilation was off, the plate in front of the Clerk's seat on the Ministerial side of the Table was the second largely infected plate; and a glance at the diagram showing the position of the plates infected in this experiment suggests that the main direction in which falling droplets were carried, was towards the right of the Speaker's Chair, and on to the front Ministerial Bench adjacent thereto.

On the other hand, in the experiment when the ventilation was on, these spots, including the portion of the Table in front of the Clerk's seat, escaped infection. In the present case the stream of falling droplets appears to have been carried directly across the Table. The extra plate exposed in this experiment between the brackets whereon the Mace rests when on the Table, showed 18 colonies of B. prodigiosus; and the plate on the Opposition box, nine. The comparatively high rate of infection of the plates exposed on the front Opposition Bench in this neighbourhood in the present experiment, as also the fact that a plate exposed in the Gangway was infected; confirms the view that in the present case, unlike the former one, the main stream of droplets was carried directly across the Table.

2. The Benches.

In comparing the positions of plates infected on the benches in each experiment, it will be convenient to exceed the usual differentiation by means of the Gangway, and to examine the whole of the benches on each side, first lengthwise, and secondly, cross-wise. When the benches are viewed in the former direction, 14 plates are examined in each row; when in the latter, five.

The Distribution of Droplets on the Ministerial Benches in the two Experiments.

When the ventilation was off, the first or front bench all along its length was the most heavily infected of all the five rows of benches on this side, no less than nine of the 14 plates exposed at intervals of about 3 feet apart along this bench becoming infected, and yielding an aggregate of 12 colonies of B. prodigiosus. Between this row and the next in infection rate there was a great drop. After the front row, incidence was equally heavy on the second and on the back rows, each of which had five plates infected with one colony of B. prodigiosus apiece. The row least infected was the fourth, which showed only one infected plate.

Very different is the distribution of B. prodigiosus on the same benches in the experiment when the ventilation was on. The row most heavily infected is now found to be the back row, which has nine of its 14 plates infected, and an aggregate of 12 colonies of B. prodigiosus. As in the former experiment, there is a great drop between this and the bench next in infection rate, which is the third row in the present case, with five infected plates, and an aggregate of five colonies of B. prodigiosus. The front row in this experiment showed only three infected plates; yielding between them three colonies of B. prodigiosus. As in the previous experiment, the fourth row was the least infected. The single positive plate, however, had no less than three colonies of B. prodigiosus. Its position was very near to that of the single plate infected in the same row in the experiment when the ventilation was off.

If the position of the infected plates on this side is now viewed cross-wise, it is seen that the row most infected was the same on both occasions, namely, the third horizontal row below the Gangway. When the ventilation was off, four of five plates exposed in this row were infected; and each showed one colony of B. prodigiosus. When the ventilation was on, three of the five plates were infected; but they showed six colonies of B. prodigiosus.

So far as the Ministerial Benches are concerned, therefore, the ventilation appears to have diminished the incidence of droplets on the front bench, and to have increased it upon the back bench, which is situated under the Gallery. A glance at the diagram will show that this feature holds both for the Ministerial Benches above, and also for those below the Gangway.

The Distribution of Infection on the Opposition Benches in the two Experiments.

In both experiments the block below the Gangway was less heavily infected than the block above.

Viewing the benches lengthwise, it is seen that when the ventilation was off, there was no marked difference between the number of plates infected in each row; three becoming infected in each, except in the fourth row. When the rows are viewed cross-wise, however, it is seen that in the first row of five plates no less than four were infected, and that in the second cross row two plates were infected; being situated on the first and second benches respectively. The third cross row also showed two infected plates. The incidence of B. prodigiosus on the Opposition Benches in this part was, therefore, very marked in the experiment when the ventilation was off.

On the other hand, when the ventilation was on, the front bench was the most heavily infected, especially that part of it near the Opposition box on the table; four plates being here infected with an aggregate of nine colonies of B. prodigiosus. A plate in the Gangway in this experiment also developed a colony of B. prodigiosus. It has been pointed out previously that the main stream of falling droplets in this experiment evidently travelled over the Opposition box. After the front row, the row next in prodigiosus incidence was the back row, which had four plates infected, showing an aggregate of four colonies.

The heavy incidence on the first three cross rows in the neighbourhood of the Chair when the ventilation was off did not take place in the experiment with the ventilation on.

It would appear, therefore, that in the experiment with the ventilation on, the incidence of droplets on the Opposition benches was higher on the front bench near the box than had been the case in the previous experiment. The actual number of plates infected on the front bench was equalled, however, by the back; although the latter plates only yielded four colonies of B. prodigiosus as against nine developed by the plates on the front bench.

The Distribution of Droplets in the Gallery in the two Experiments.

The fact that in the experiment with the ventilation off, the rate at which the plates exposed in the Gallery became infected with B. prodigiosus was higher than the rate at which plates exposed on the benches on the floor in the same experiment were infected is very remarkable, and is worthy of further investigation.

It is also noteworthy that, in both experiments, after the plates which were exposed on the Table and found to become infected with B. prodigiosus, the plate most highly infected with B. prodigiosus had been exposed in the Gallery. In both experiments this plate had been exposed in the Members' Gallery, but in the experiment with the ventilation off, the plate—which showed three colonies of B. prodigiosus—had been placed in the Gallery on the Ministerial side and near the end of it that abuts on the Press Gallery; whereas in the experiment with the ventilation on, the plate was one that had been exposed about half-way along the Members' Gallery on the Opposition side, and it showed four colonies of B. prodigiosus.

If the position of the gallery plate that showed three colonies of B. prodigiosus in the experiment with the ventilation off, is viewed in reference to the position of the infected plates on the floor; it will be seen that the shower of falling droplets that passed from the Ministerial box to the right of the Speaker's Chair in this experiment might have been continued to the spot in the Gallery where that plate was exposed. Thus the corner of the front Ministerial Bench hard by the Chair had two doubly-infected plates, the Press Gallery above had one as well, and this last plate was close to the plate in the Members' Gallery that showed three colonies.

On the other hand, if a line is drawn from the Ministerial box on the table to the position in the Members' Gallery on the Opposition side where the plate was exposed that developed four colonies in the experiment with the ventilation on, the line will be seen to travel for the first part of its journey over the plates that, exposed on the Opposition box and front Opposition Bench, showed such a high incidence of B. prodigiosus in this experiment. The heavy incidence of B. prodigiosus on the other plates in the Opposition side of the Members' Gallery in this experiment is also suggestive of a shower of droplets, perhaps dragged up from the neighbourhood of the Opposition box by the ventilation and deposited in this Gallery.

Viewing the position of the plates infected in the Gallery as a whole in each of the two experiments, the 50 per cent. increase in the incidence of droplets that took place in the experiment with the ventilation on is seen to have chiefly occurred towards the end of the Gallery which is behind the Clock and which contains the Peers' and Strangers' Galleries. Moreover, on both sides towards this end of the Debating Chamber, but especially on the Opposition side, the Members' Gallery showed an increase in the incidence of droplets when the ventilation was on.

It seems quite possible that the action of the extraction fire in the Lobby Tower was responsible for this increased incidence.

v. *Conclusions from the Speaking Experiments.*

In the first place it must be admitted that the fact that the plate exposed nearest to the person who spoke was so much less extensively infected in the speaking experiment when the ventilation was off than in the experiment when the ventilation was on, may be taken to imply that, in spite of all attempts to keep the two experiments as parallel as possible, a smaller number of droplets was sprayed into the air on the former occasion.

It is not fair, therefore, to discredit the ventilation to the extent that strict comparison of the results obtained in the two experiments would indicate.

At the same time, the result of the experiment with the ventilation off must not be allowed to obscure the chief point which these experiments were undertaken to determine, namely, the effect of the ventilation on the spread throughout the Debating Chamber of droplets sprayed from the mouth in performance of the act of loud speaking.

And though it be granted that more droplets were sprayed into the air in the experiment when the ventilation was in action than had been the case in the previous experiment when the ventilation was cut off; it is nevertheless true that the act in performance of which such dissemination occurred, though not, perhaps, of the same degree of intensity in both experiments, was of the same character, and of the same duration.

This being so, it is impossible to avoid the conclusion that the proportion of plates infected by particulate material derived from the mouth of the person who spoke was sufficiently great in the experiment when the ventilation was in action to show that, from this point of view, the influence of the ventilation under the conditions then obtaining was far from satisfactory, for in this experiment 25 per cent. of the plates exposed on the benches, and no less than 50 per cent. of the plates exposed in the galleries, were infected by droplets given off from the mouth in performance of the act of loud speaking.

vi. *Addenda.*

(a.) *Observations made with Frankland's Method during Exposure of the Plates in each Experiment.*

In each of the four experiments 250 litres of the air of the Debating Chamber was aspirated through a Frankland tube placed at the end of the Debating Chamber under the Clock. The tube was fixed in a clamp at a point on the Opposition side of the Centre Gangway, about 10 feet from the Lobby door and at a height of about 5 feet from the floor. The air was drawn through the plugs by a Petri air-pump connected with an air-meter which communicated directly with the Frankland tube by a piece of rubber tubing. The first two glass wool plugs in each of the Frankland tubes were pounded up in 1 c.c. of sterile salt solution and the emulsion spread over the surface of a series of six agar plates. The plates were then incubated at 22° C. Although many colonies developed on the 24 plates, no colonies of B. prodigiosus were found.

(b.) *The Number of Micro-organisms, and of Bacteria and Moulds, respectively, developing on the Plates.*

The chief object of the four experiments being to determine the effect of the Ventilation on the spread of particulate matter from the mouth, the chief feature observed after incubating the plates was the presence or absence of the micro-organism of index, B. prodigiosus. A record, however, was also kept of the aggregate of colonies of all kinds present on each plate, and also of the relative number of bacteria and moulds respectively.

The following tables give the averages in these three respects shown by the plates exposed in each locality. The enumeration was done after four days, for two of which the plates had been kept in the incubator at 22° C., and for two others at the temperature of the laboratory.

In considering these results it should be borne in mind that in Experiment I. the plates were exposed to the air for half an hour longer than in any of the other three experiments.

The figures show very plainly that when the ventilation was on, a great increase occurred in the number of micro-organisms, bacteria, and moulds in the air of the Debating Chamber. This increase would appear to be more marked in the case of plates exposed in the Equalising Chamber than in plates exposed elsewhere, but the plates exposed in the former situation were not sufficiently numerous to warrant a definite conclusion upon this point.

For some reason, which is not obvious, the number of moulds shows a remarkable increase in Experiment IV.

The kinds of bacteria present were chiefly cocci commonly met with in air, such as sarcinæ and staphylococci. A pink torula was observed in 28 plates.

B. mycoides was present in a plate exposed on the bridge over the ceiling of the Debating Chamber in Experiment II. It was also present in a plate exposed on the Treasury Bench in Experiment IV. As the experiments, however, were not made while the House was sitting, I have not included these observations in the table of mycoides results previously given.

1.—*Number of Plates exposed in each Locality in each Experiment.*

—	Experiments.			
	I.	II.	III.	IV.
Equalising Chamber	2	4	4	4
Floor :—				
Table and Chair	3	6	4	7
Ministerial Benches above Gangway	10	41	20	41
" " below "	10	30	15	30
Opposition " above "	10	41	20	41
" " below "	10	30	15	30
Total Floor plates	43	148	74	149
Galleries :—				
Members' Gallery, Ministerial side	2	9	4	9
" " Opposition "	2	9	4	9
Peers, &c. "	2	7	3	7
Press "	2	7	3	7
Ladies' "	2	4	3	4
Speaker's "	2	2	2	0
Strangers' "	0	2	1	2
Total Gallery plates	12	40	20	38
Roof :—				
Roof	6	6	6	6
Downcasts	2	4	4	4
Total Roof plates	8	10	10	10

2.—*Average Number of Micro-organisms per Plate.*

—	Experiments.			
	I.	II	III.	IV.
Equalising Chamber	17·0	11·2	186·0	180·5
Floor :—				
*Table and Chair	7·9	8·4	60·7	86·7
Ministerial Benches above Gangway	14·0	19·5	60·5	40·4
" " below "	23·2	11·3	45·8	56·8
Opposition " above "	25·4	6·6	41·8	55·7
" " below "	28·4	10·4	73·7	71·6
Mean per plate on Floor	19·7	11·2	56·5	62·2
Galleries :—				
Members' Gallery, Ministerial side	27·5	9·5	69·2	66·8
" " Opposition "	11·5	8·3	67·3	80·1
Peers "	8·5	11·2	65·9	85·9
Press "	16·0	9·5	81·2	76·4
Ladies' "	18·0	10·2	90·6	68·4
Speaker's "	14·5	11·0	114·0	—
Strangers' "	—	13·0	116·0	92·5
Mean per plate in Gallery	16·0	10·3	86·3	78·3
Roof :—				
Roof	9·7	12·8	47·6	74·0
Downcasts	17·0	8·0	67·2	74·7
Mean per plate in Roof	13·3	10·4	57·4	74·3

* Omitting plate on Ministerial Box in Experiments II. and IV.

3.—*Average Number of Bacteria per Plate.*

—	Experiments.			
	I.	II.	III.	IV.
Equalising Chamber	12·5	10·7	174·5	164·0
Floor :—				
*Table and Chair	4·6	7·0	55·0	65·6
Ministerial Benches above Gangway	9·2	16·8	53·0	33·0
" " below "	17·3	10·0	40·8	46·9
Opposition " above "	18·5	5·0	34·8	43·9
" " below "	22·9	8·9	66·3	58·3
Mean per plate on Floor	14·5	9·5	49·9	49·5
Galleries :—				
Members' Gallery, Ministerial side	19·0	7·5	61·5	48·0
" " Opposition "	7·5	6·5	56·3	61·3
Peers' "	4·5	9.1	59·6	66·1
Press "	12·5	7·5	72·6	57·4
Ladies' "	14·5	6·2	79.0	49·7
Speaker's "	10·5	9.0	104·5	—
Strangers' "	—	11·0	104·0	69·0
Mean per plate in Gallery	11·4	8·1	76·7	58·5
Roof :—				
Roof	5·1	8·0	39·3	55·5
Downcast	12·5	6·0	57·7	60·5
Mean per plate in Roof	8·8	7·0	48·5	58·0

* Omitting plate on Ministerial Box in Experiments II. and IV.

4.—*Average Number of Moulds per Plate.*

—	Experiments.			
	I.	II.	III.	IV.
Equalising Chamber	4·5	1·5	11.5	16·5
Floor :—				
Table and Chair	3·3	1·4	5·7	21·1
Ministerial Benches above gangway	4·8	2·7	7·5	7·4
" " below "	5·9	1·3	5·0	9·9
Opposition " above "	6·9	1·6	6·8	11·8
" " below "	5·5	1·5	7·4	13·3
Mean per plate on Floor	5·2	1·7	6·4	12·7
Galleries :—				
Members' Gallery, Ministerial side	8·5	2·0	7·7	18·8
" " Opposition "	4·0	1·8	11·0	18·8
Peers' "	4·0	2·1	6·3	19·8
Press "	3·5	2·0	8·6	19·0
Ladies' "	3·5	4·0	11·6	18·7
Speaker's "	4·0	2·0	9·5	—
Strangers' "	—	2·0	12·0	23·5
Mean per plate in Gallery	4·5	2·2	9·5	19·7
Roof :—				
Roof	4·6	4·8	8·3	18·5
Downcasts	4·5	2·0	9·5	14·2
Mean per plate in Roof	4·5	3·4	8·9	16·3

SECTION IV. SUBSECTION 5.

The results of the bacteriological investigation lead to the following conclusions :—

1. The chief particulate pollution to which the air of the Debating Chamber is subjected is derived from the presence of Members themselves, and is in part derived from their boots and in part from their mouths and upper respiratory passages.

2. The result of the examination of air passing out of the Debating Chamber indicates that, during Debates, the air of the Chamber receives more pollution, that is to say, a larger number of adventitious particles, from material derived from Members' mouths and upper respiratory passages than from material brought in upon their boots.

3. The results of the experiments made with B. prodigiosus as index of infection confirm No. 1 of the preceding conclusions as to the two chief sources from which the air of the Debating Chamber is liable to be contaminated, and while emphasising the liability of the air of the Chamber to derive adventitious particles by either of these two channels, undoubtedly also support conclusion No. 2 that the liability from material derived from the mouth and upper respiratory passages is the greater liability of the two.

4. The result of the experiments made to determine the value of the ventilation* for removing from the air of the Debating Chamber

* The air supply has been approximately doubled since these experiments.

particulate matter disseminated in the breath, showed that, so far from removing this particulate matter, the ventilation merely dispersed it over a wider area inside the Chamber than had been the case in a preceding experiment in which the ventilation was not in action.

5. The result of the examination of the significance of micro-organisms recovered from the air of the Debating Chamber serves to emphasise the advisability of excluding as far as possible pollution of the air of the Chamber by material brought in upon Members' boots. The chief spot where air entering the Chamber is polluted from this cause is below the Centre Gangway, between the Bar and the Lobby door under the Clock; but contamination from the same source also occurs, though in less degree, under the side Gangways and under the Centre Gangway behind the Speaker's Chair.

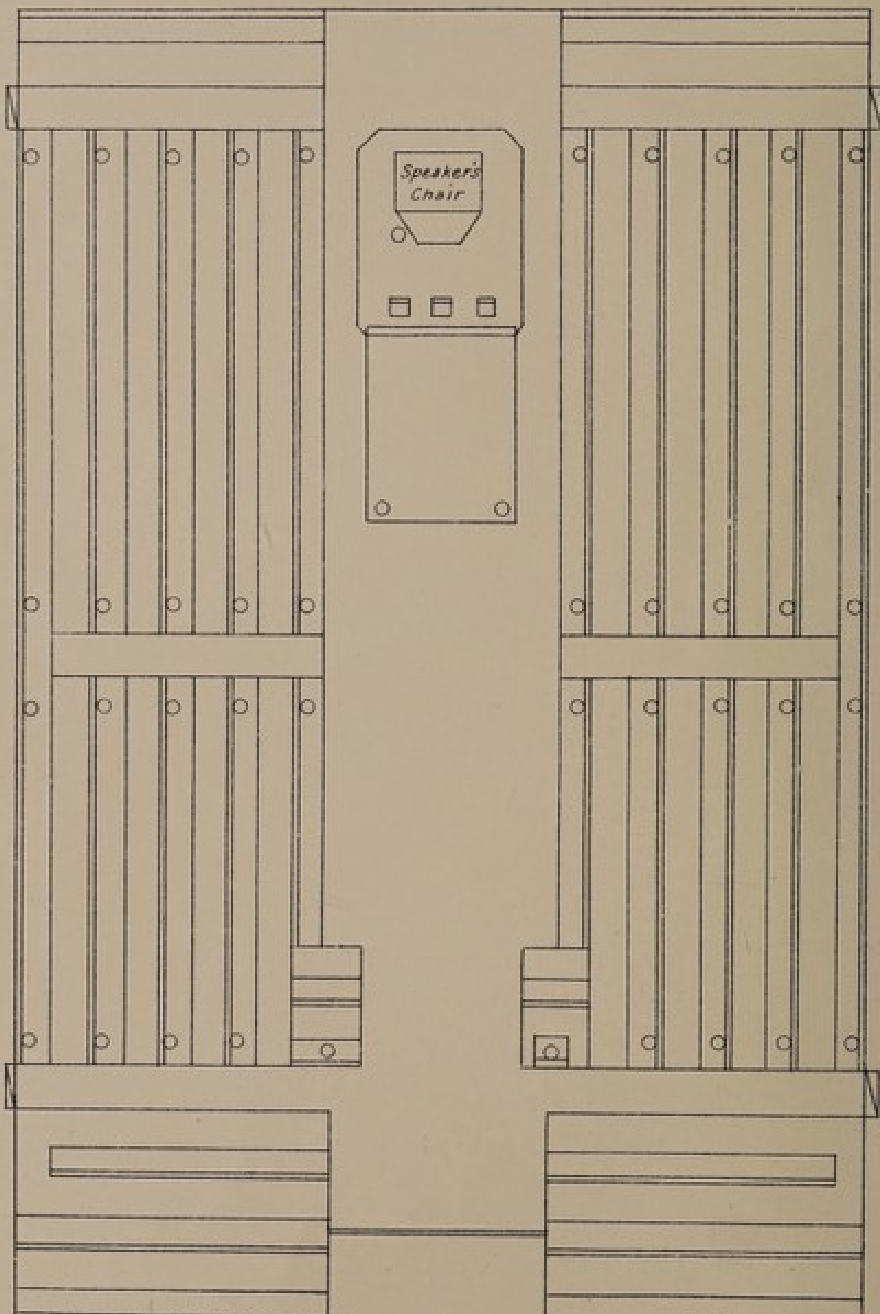
6. Air entering the north chamber of the inlet by the Terrace is liable to pollution with particulate material derived from the boots of persons walking over the grating above the inlet in question.

Plans illustrating the Result of the Speaking Experiments in the Debating Chamber with the Ventilation off, and on, respectively.

Ground Plan

EXPERIMENT I

Control, Ventilation off.



● Plates affected
○ Plates unaffected

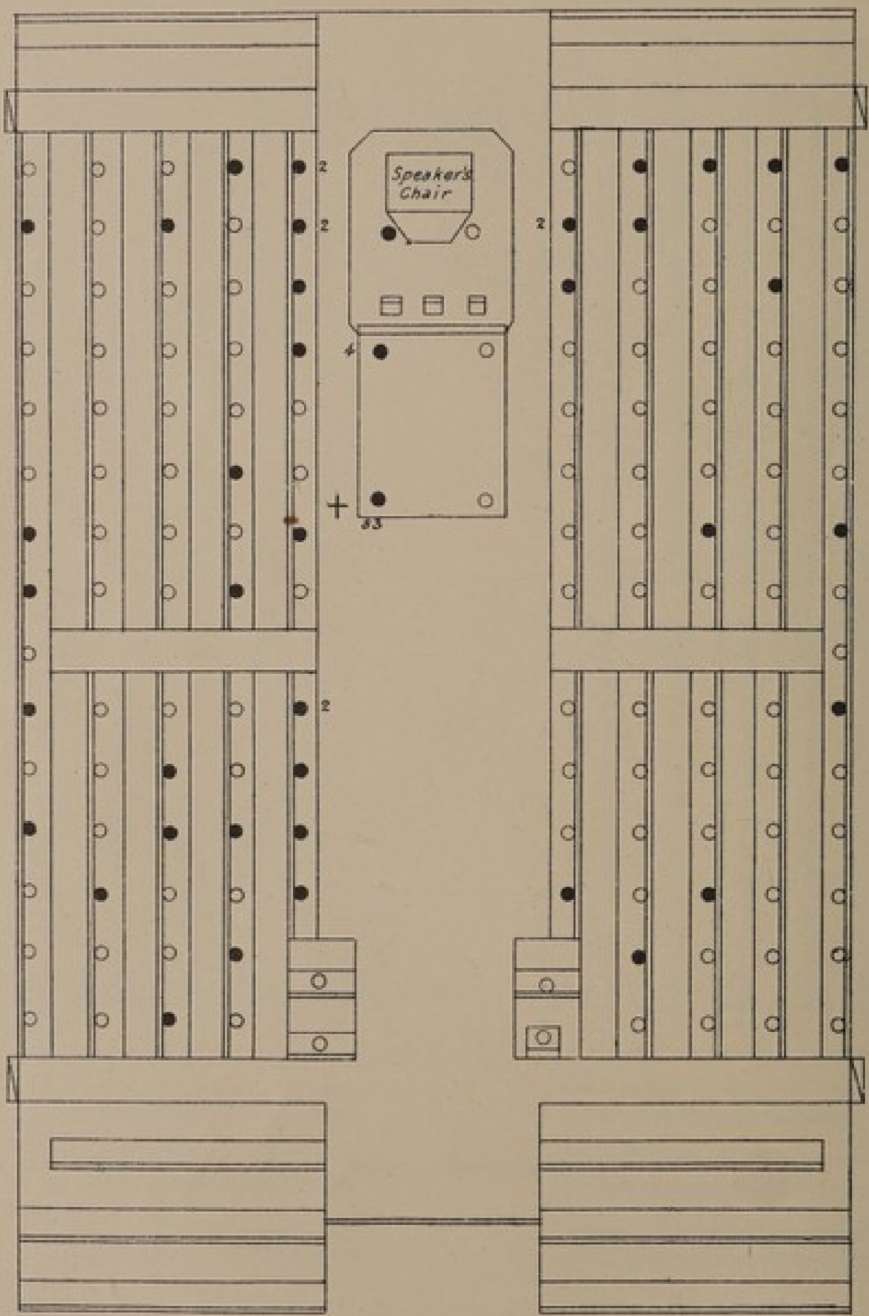
5598.1 04

Weller & Graham, Ltd. Litho. London.

Ground Plan

EXPERIMENT 2.

Speaking, Ventilation off.



● Plates affected
○ Plates unaffected
+ Position of person who spoke

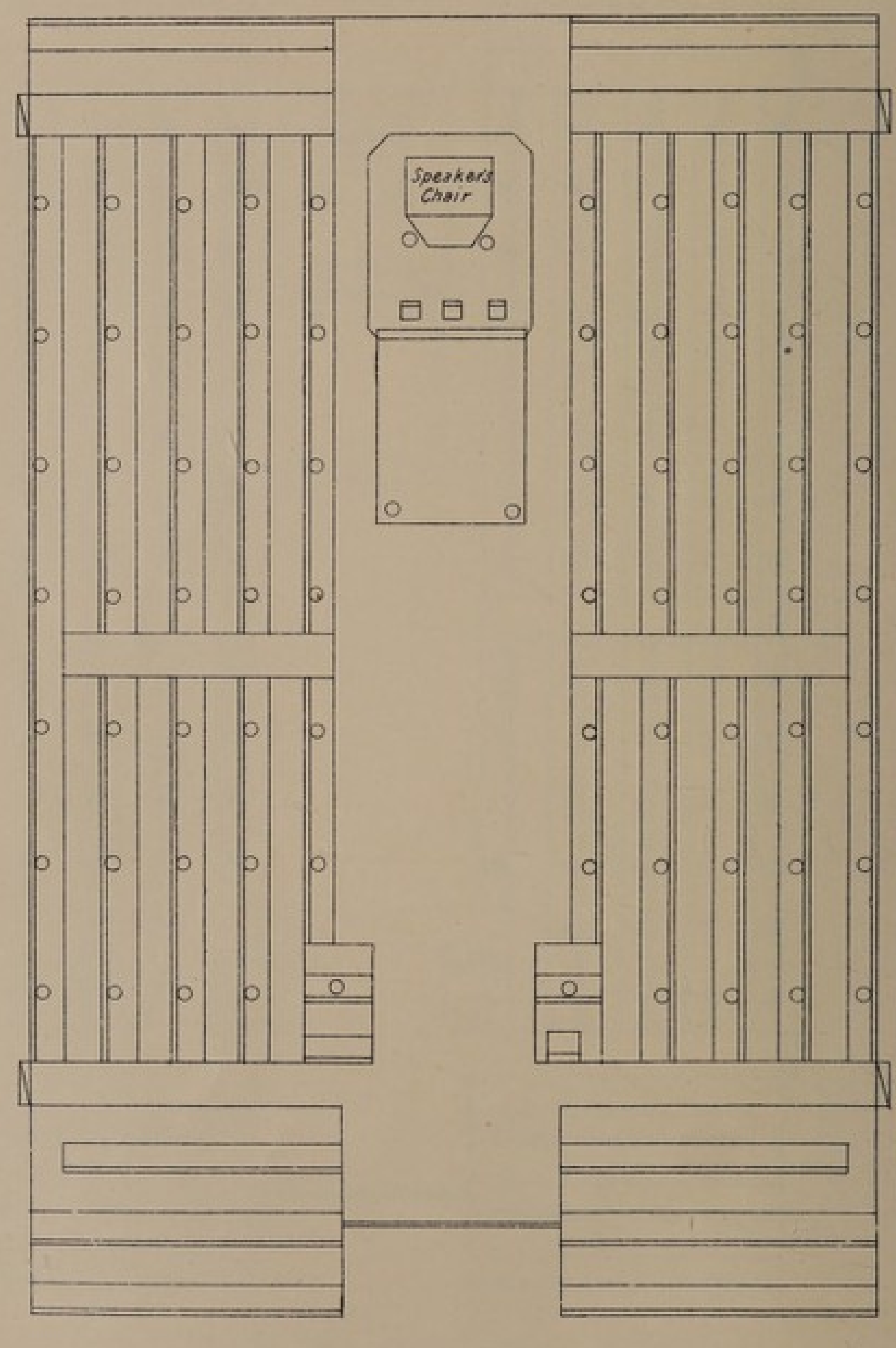
598. 1. 06

Weller & Graham, Ltd Litho. London.

Ground Plan

EXPERIMENT 3

Control, Ventilation on.



● Plates affected
○ Plates unaffected

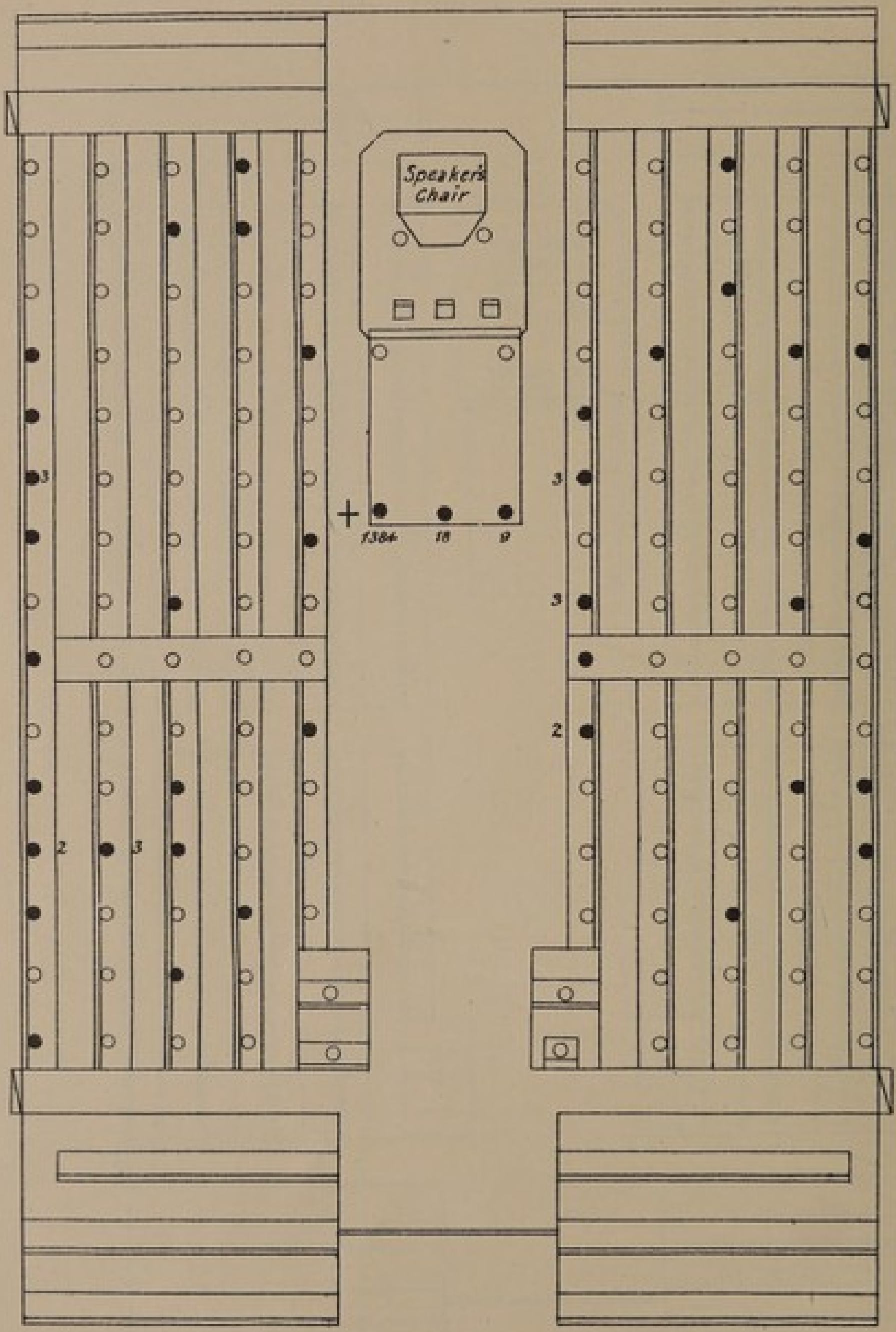
5598. 1. 06

Weller & Graham, Ltd Litho. London.

GROUND PLAN

EXPERIMENT 4.

SPEAKING, VENTILATION ON.

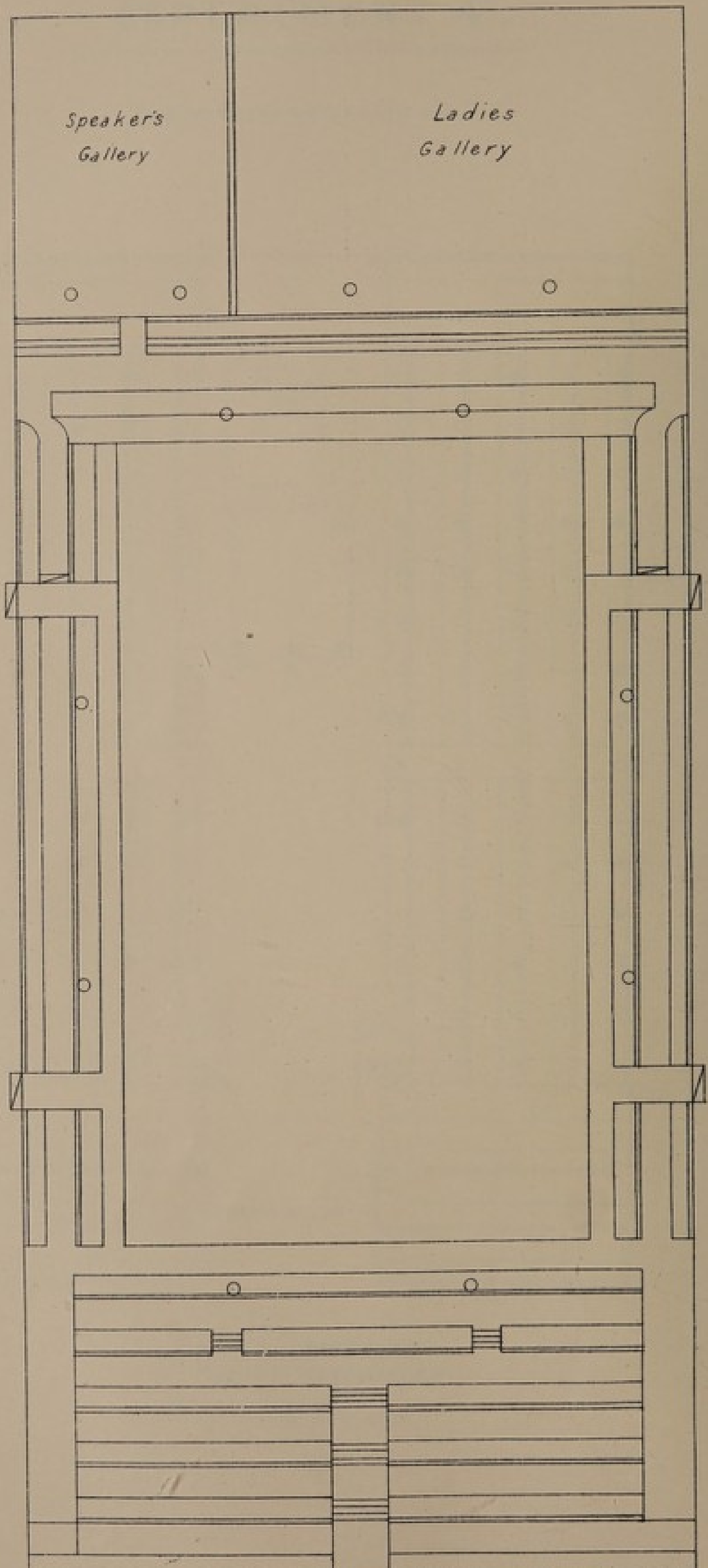


● PLATES AFFECTED
○ PLATES UNAFFECTED
+ POSITION OF PERSON WHO SPOKE

Weller & Graham, Ltd Litho. London.

Plan of Gallery

Experiment I.



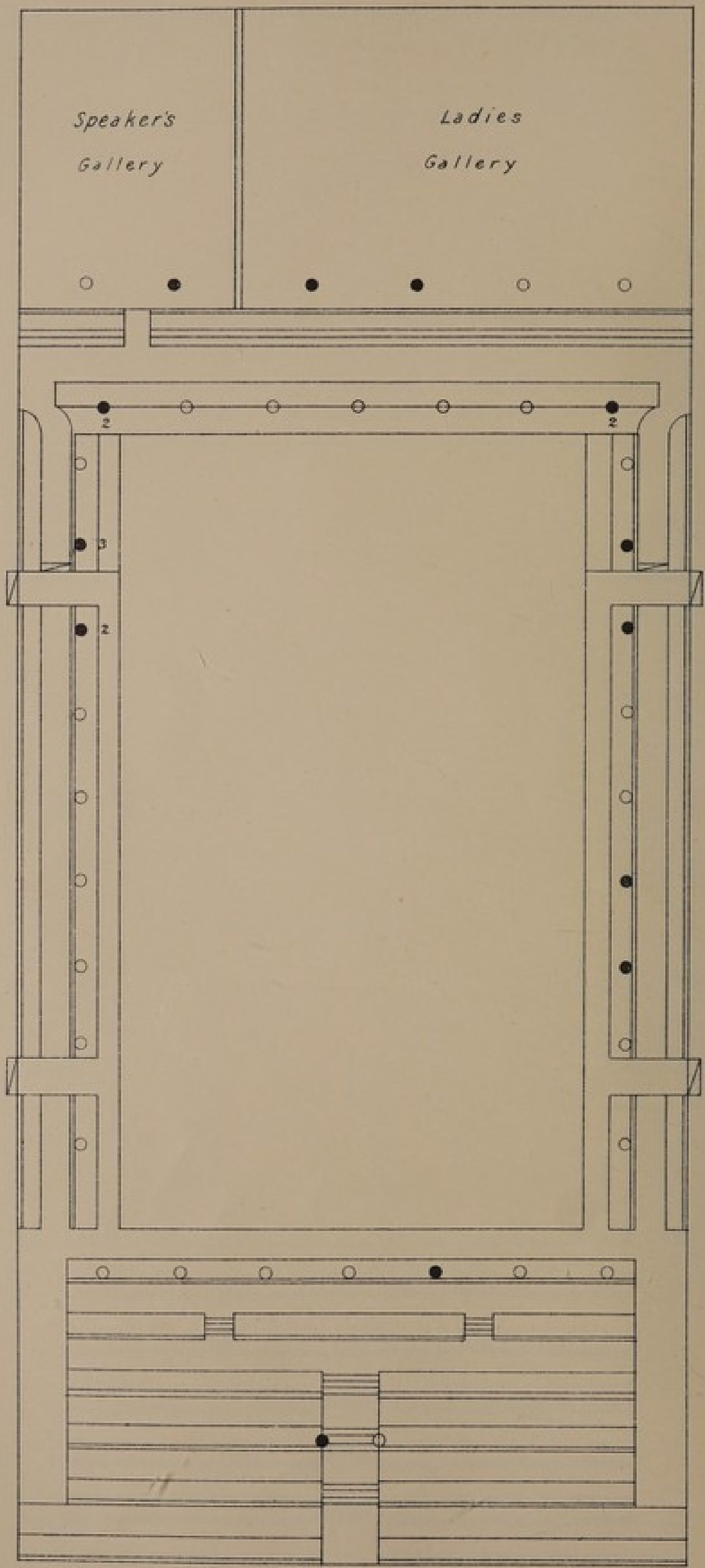
5598.1.06

• Plates affected
○ Plates unaffected

Weller & Graham. Ltd. Litho London.

Plan of Gallery

EXPERIMENT 2.

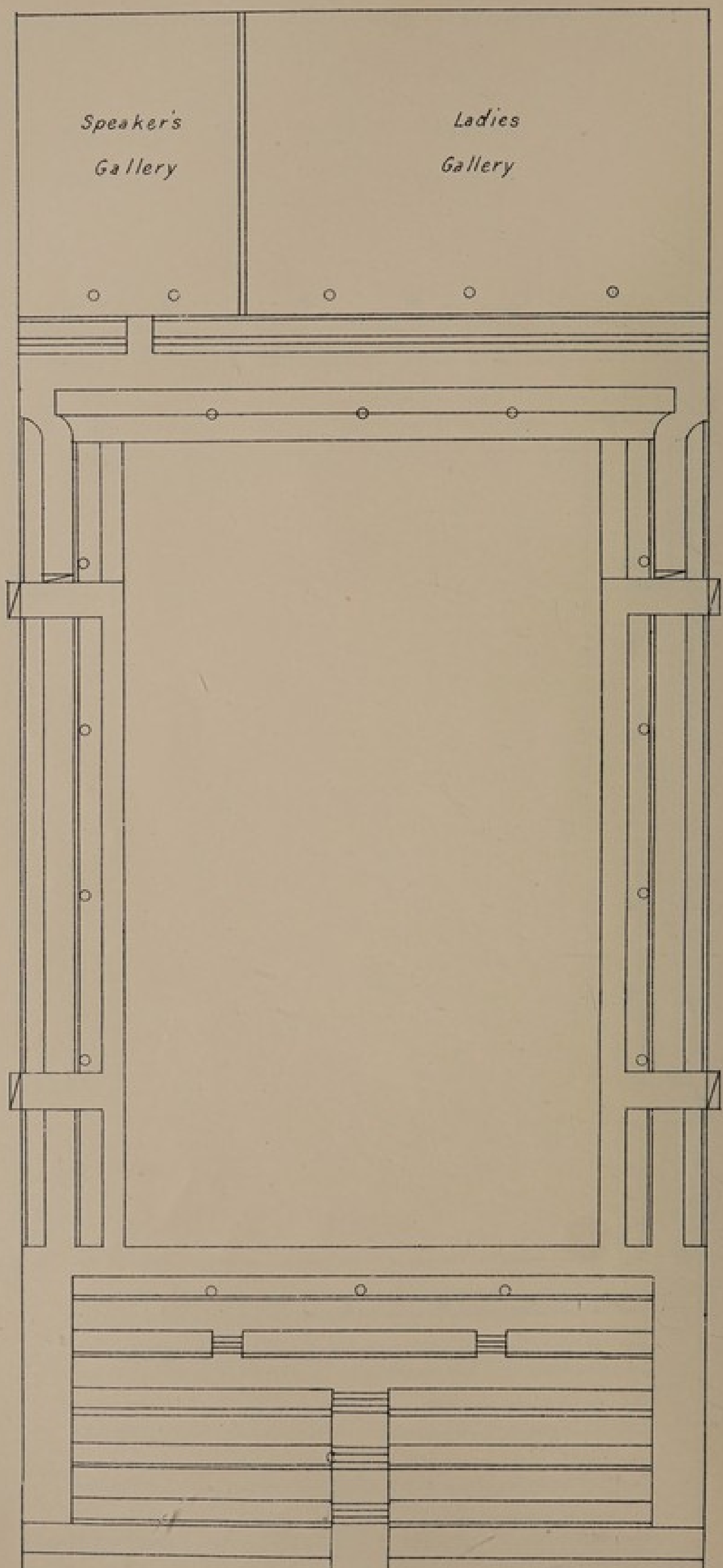


● PLATES AFFECTED
○ PLATES UNAFFECTED

5598. 1 0 + Weller & Graham. Ltd Litho. London

Plan of Gallery

EXPERIMENT 3



5598. 1. 06

● PLATES AFFECTED
○ PLATES UNAFFECTED

Weller & Graham, Ltd Litho. London.

PLATES I.-IV.

Speaking experiments in the Debating Chamber with B. prodigiosus as index of infection.

Isochromatic photographs of the plates after being incubated for three days at 22° C. The crimson colonies of B. prodigiosus show up blacker than the colonies of other micro-organisms present.

PLATE I.

SPEAKING EXPERIMENT.—VENTILATION OFF.

(*Experiment* 2, *pp.* 68-71.)

FIG. 1.—Of the 84 colonies present in the top plate, 83 were colonies of B. prodigiosus. This plate had been exposed on the Ministerial box. Of the lower pair of plates, one showing four colonies of B. prodigiosus had been exposed on the Table in front of the Clerk's seat; the other plate, showing one colony of the index micro-organism, had been exposed on an arm of the Speaker's Chair.

FIG. 2.—Plates exposed on the Government Benches above the Gangway, and infected with B. prodigiosus.

FIG. 3.—Ditto below the Gangway.

FIG. 4.—Infected plates, Opposition Benches above the Gangway.

FIG. 5.—Ditto below the Gangway.

Fig. 1.

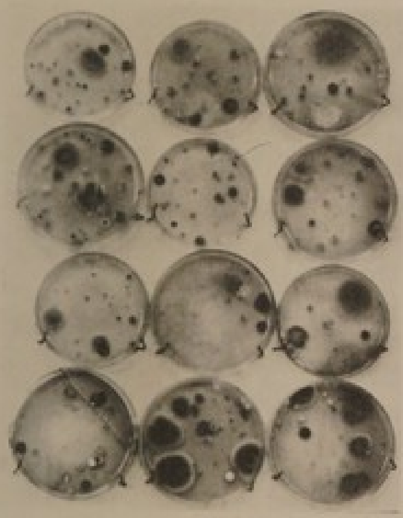


Fig. 2.

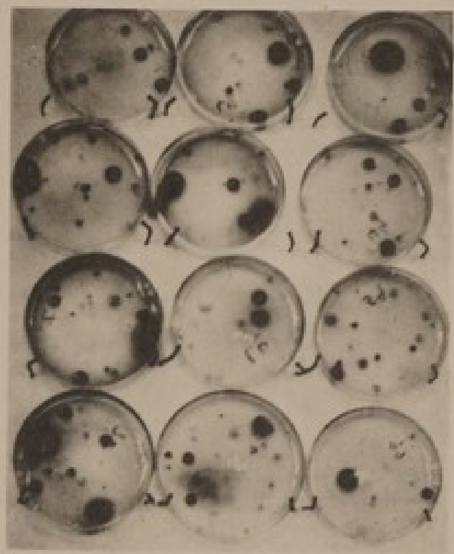


Fig. 4.

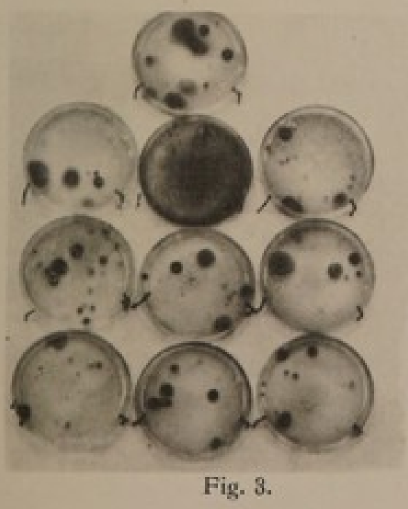


Fig. 3.

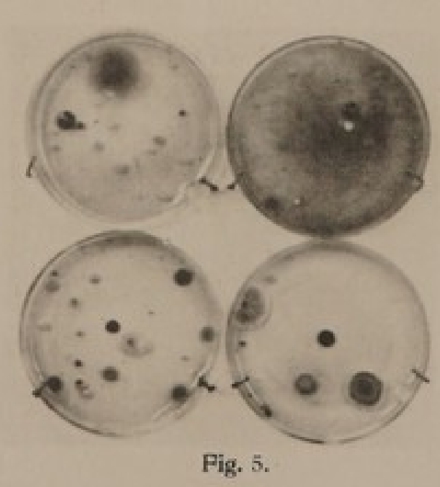


Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

PLATE II.

(*Same Experiment, Ventilation Off*—cont.)

Fig. 6.—Infected plates that had been exposed in the Members', Peers', and Strangers' Galleries during the speaking.

Fig. 7.—Infected plates exposed in the Ladies' and Speaker's Galleries.

Fig. 8.—Infected plates exposed in the roof above the ceiling.

PLATE III.

Speaking Experiment.—Ventilation On.

(*Experiment* 4, *pp.* 71-75.)

Fig. 9.—The plate in the upper left corner showed 1,384 colonies of B. prodigiosus. It had been exposed on the Ministerial box immediately in front of the person who spoke. The plate in the upper right corner had been exposed on the Table between the brackets for the Mace; it had 18 colonies of B. prodigiosus. The plate in the lower left corner had been exposed on the box on the Opposition side of the Table, and showed nine colonies of B. prodigiosus. The plate in the lower right-hand corner had been exposed on the front Opposition Bench facing the box, and showed three colonies of B. prodigiosus.

Fig. 10.—Infected plates from Government Benches above the Gangway.

Fig. 11.—Ditto below the Gangway.

Fig. 12.—Infected plates from Opposition Benches above the Gangway.

Fig. 13.—Ditto below the Gangway.

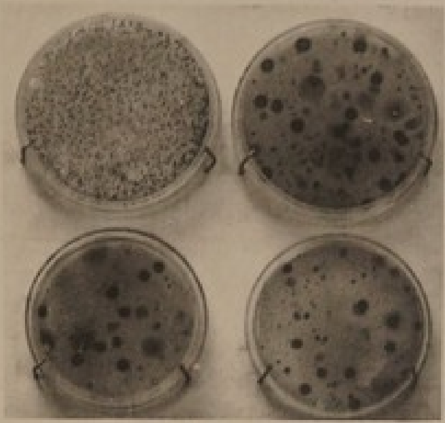


Fig. 9.

Fig. 10.

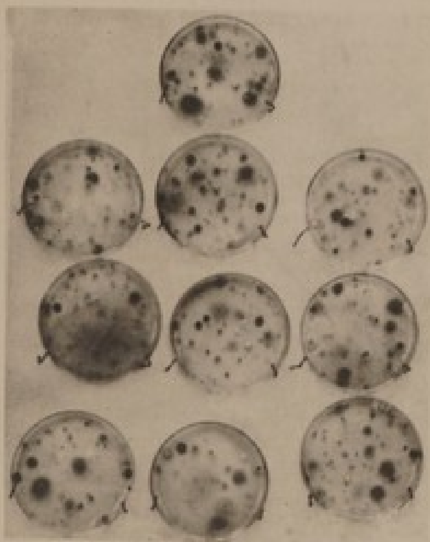


Fig. 12.

Fig. 11.

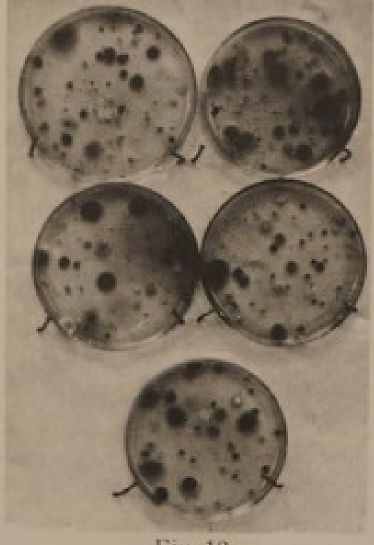


Fig. 13.

Plate IV.

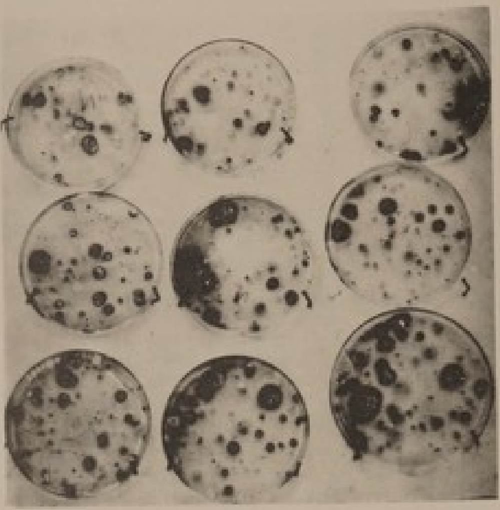


Fig. 14a.

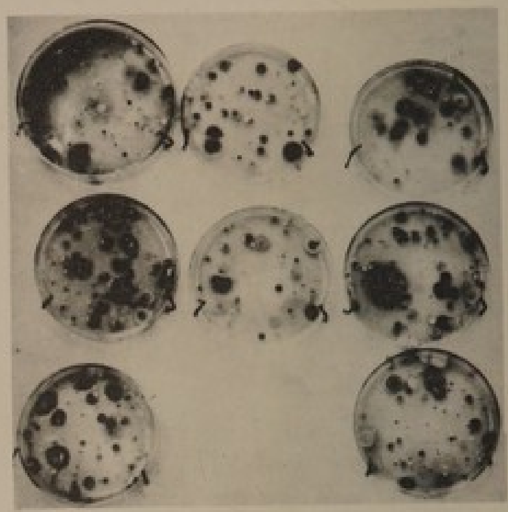


Fig. 14b.

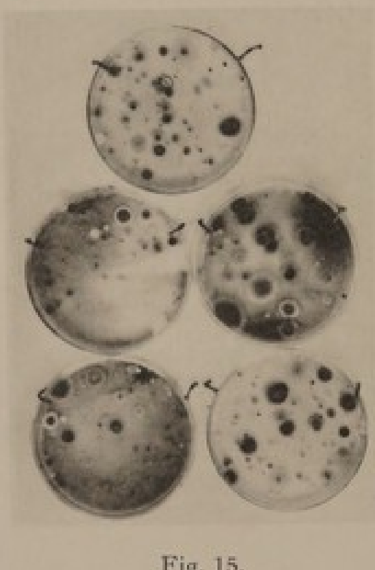


Fig. 15.

PLATE IV.

(*Same Experiment, Ventilation On*—cont.).

FIGS. 14*a* and 14*b* show the infected plates from the Members', Peers', Reporters', and Strangers' Galleries.

FIG. 15.—Shows the infected plates from the Ladies' Gallery and from above the ceiling.

PLATES V. AND VI.

PARTICULATE MATTER DISSEMINATED FROM MEMBERS' BOOTS.

Photographs of agar plates exposed in the airway between inlet on the Terrace and floor of the Debating Chamber on two occasions when the House was sitting. The plates were photographed after 48 hours' incubation at 22° C.

PLATE V.

FIG. 16.—Plates exposed on May 11, 1904, from 6.30 to 7.30 p.m.

The three plates in the top row were exposed respectively under the Bar, under the middle of the Centre Gangway, and under the portion of it behind the Speaker's Chair.

The second row was exposed in the Battery Chamber under these three points.

The third row, in the cotton-wool filter under the same points.

The fourth row of plates was exposed at the same time at the inlet.

The number of colonies is seen to be less in plates in the cotton-wool filter than in plates at the inlet.

The increased incidence on plates at each end of the Equalising Chamber is derived from Members' boots. This increase penetrates to 17 feet below the level of the floor of the Debating Chamber; to the Battery Chamber under the Bar.

Two colonies of B. mycoides are present in the plate in the Equalising Chamber under the Bar; one in the plate in the Battery Chamber under this point; and one in a plate at the inlet.

FIG. 17.—Plates exposed on similar spots, excluding the inlet plates, on May 10, from 3.40 to 4.40 p.m. The same increased bacterial incidence is seen under the Bar and under the Centre Gangway behind the Chair.

One colony of B. mycoides is seen in the plate exposed in the Equalising Chamber under the Bar.

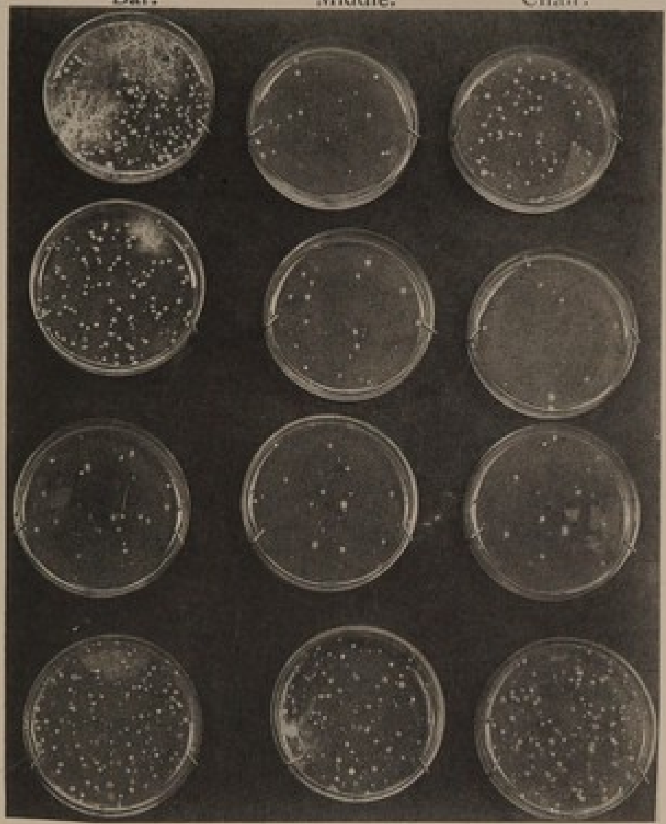

Bar.
Middle.
Chair.
Equalising Chamber.
Battery Chamber.
Cotton Wool Filter.
Inlet.

Fig. 16.

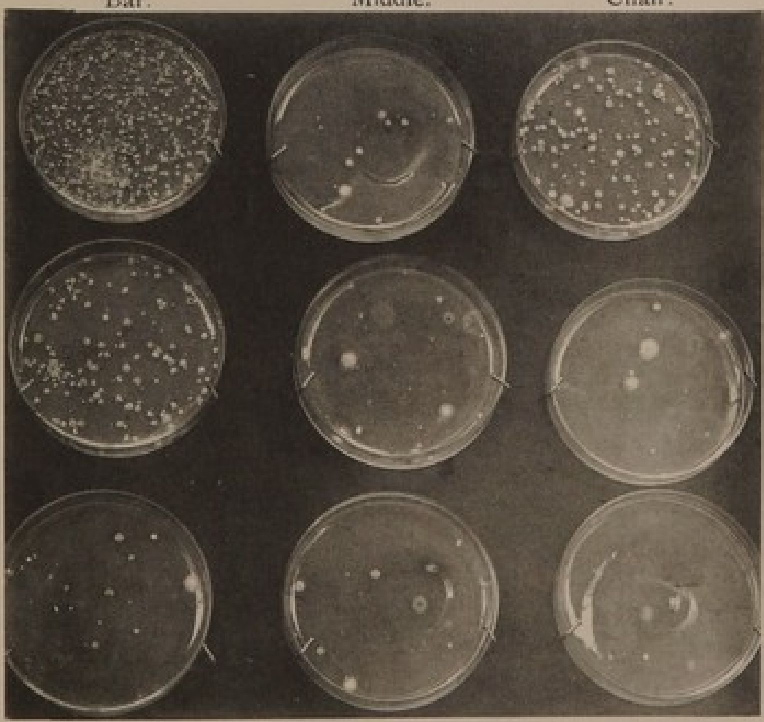

Bar.
Middle.
Chair.
Equalising Chamber.
Battery Chamber.
Cotton Wool Filter.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

PLATE VI.

The three plates shown in the top row of the last figure more highly magnified. They had been exposed in the Equalising Chamber.

Fig. 18.—Under the Bar. A total of 917 colonies was counted with the magnifying glass. The branching colony of B. mycoides is obvious.

Fig. 19.—Under the middle of the Centre Gangway—15 colonies counted.

Fig. 20.—Under the Centre Gangway behind the Speaker's Chair —154 colonies counted.

PLATE VII.

Salivary streptococci recovered from air passing out of the Debating Chamber during debates.

FIGS. 1, 2, and 3 show specimens of Streptococcus brevis, FIG. 4 of Streptococcus medius, and FIGS. 5 and 6 of Streptococcus longus.

The microphotographs represent subcultures of these micro-organisms after 48 hours growth in broth at 37° C., and the magnification in all cases is 500 diameters.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

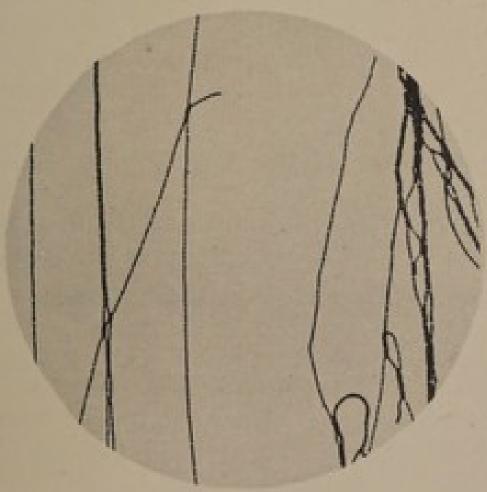


Fig. 5.

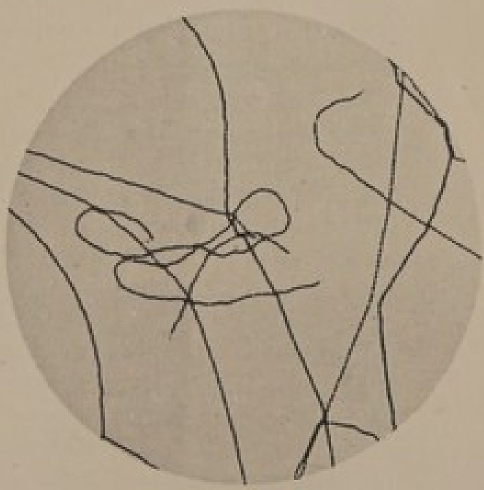


Fig. 6.

SECTION IV.

(B.) THE CHEMICAL REPORT.

RESULTS OF A CHEMICAL INVESTIGATION OF THE AIR SUPPLIED TO THE DEBATING CHAMBER OF THE HOUSE OF COMMONS, BY W. H. HURTLEY, D.Sc.

The observations herein described were made between May 2 and August 12, 1904, on occasions when the House was sitting. During this period an investigation was made in the first place of the air passing into and out of the Debating Chamber; secondly, some index experiments were carried out with the object of obtaining definite evidence for or against two particular sources suspected of contaminating the air supplied to the Debating Chamber; thirdly, some samples of dust and mud were examined.

I. THE RESULTS OF THE CHEMICAL INVESTIGATION OF THE AIR.

Air passing from the inlet on the Terrace to the Debating Chamber has been examined as regards the following constituents :—

1. Oxygen.
2. Ozone.
3. Carbon dioxide.
4. Ammonia.
5. Nitrogenous organic matter.
6. Nitric and nitrous acids.
7. Sulphuric acid.
8. Sulphuretted hydrogen.

Air passing out of the Debating Chamber during Debates has also been examined with regard to oxygen and carbon dioxide.

The results obtained were as follows :—

1. *Oxygen.*

In fresh air the oxygen only undergoes small variation in amount—from 20·9 to 21 per cent. by volume; in town air the variation is greater—it may fall to 20·8 per cent.; in inhabited rooms it has been observed to fall to 20·4 per cent.; and in very exceptional circumstances to 20·1 per cent. The former of these two values (20·4) was found by Angus Smith in the gallery of a theatre. In the present experiments the oxygen was determined by a Hempel burette and pipette, using phosphorus as the absorbent, and only those experiments were accepted in which the temperature of the water in the apparatus remained constant during the whole experiment.

Eleven Tests at the Inlet—all made on different days and at different hours, from 3 p.m. to 11 p.m.—never gave less than 21 per cent. by volume of oxygen, and on June 1st, at 11 p.m., the maximum value of 21·4 per cent. was obtained. This very high value was in all probability accounted for by the very heavy rain which had fallen in the earlier part of the day.

Eight Tests of the Mixed Downcast Air at the Level of the Basement—all made on different days, but at hours when the greatest diminution in oxygen was to be expected, namely, at the adjournment for dinner (7.30 p.m.), and immediately before leaving (11 to 11.15 p.m.)—gave the same minimum of 20·8 per cent. by volume of oxygen on five occasions, and 21 per cent. to 21·1 per cent. on the other three occasions. I do not think the whole of this diminution of oxygen (0·2 per cent.) is due to vitiation of the air, although no doubt a part of it is; a slight error would be introduced in the reading of the apparatus by the high temperature of the downcast, which was never below 19° C., and on one occasion as high as 23° C., while the apparatus was correct at 15° C. In any case the diminution in oxygen is quite insufficient to have any injurious effect, for no such effect was observed even in a prolonged stay in the downcast.

Three tests were made in the Equalising Chamber, and these gave the same results as experiments made as nearly at the same time as possible at the inlet.

Experiments were also made to determine whether the *scrim cloth* effected any change in the percentage of oxygen owing to the fact that nitrogen diffuses more rapidly than oxygen. Two similar pieces of apparatus were used, one on each side of the scrim cloth, and the determinations were made as nearly simultaneously as possible, but exactly the same percentage of oxygen was obtained on each side of the scrim cloth. The experiment was repeated on another day with the same result.

Finally, it was thought possible that the *spray*, which is used to increase the humidity of the air when the difference between the wet and dry-bulb hygrometers exceeds 10° F., might increase the oxygen on account of its smaller partial pressure in the air than the nitrogen. Accordingly, three determinations were made, one before the spray was started and two after the spray had been working for some time. All three experiments gave exactly the same result, namely, 21 per cent. by volume of oxygen.

In regard to oxygen, therefore, the air supplied to the House is quite normal, and even the downcast air is scarcely appreciably deficient in oxygen.

2. *Ozone.*

It is well known that the ordinary re-agents for ozone are acted upon by certain other compounds of which nitrous acid and hydrogen peroxide are, at any rate, occasional constituents of the atmosphere. Tests were made as follows :—

With strips of paper impregnated—

(1) With starch and potassium iodide.

(2) With neutral litmus and pure potassium iodide. This paper is coloured blue at once by air containing $\frac{1}{2610000}$ of its weight of ozone, and slightly blue by from ·0002 to ·0003 milligrams of ozone. (N.B.—·0002 mgm. = ·0000031 grains.)

(3) With Wurster's re-agent—tetramethyl paraphenylene diamine—which also gives a blue colour with ozone and is bleached by excess. This is a very delicate re-agent.

The complete series of results is given in the table. At the beginning of the experiment strips of the papers, precisely similar to those used in the test, were put in a tightly stoppered bottle for comparison after the experiment. The papers were never exposed for less than two hours, nor for more than three hours, and they were suspended from glass rods by platinum wires.

Table.

Date.	Time at beginning of Experiment.	1. Starch and Potassium Iodide.	2. Litmus and Potassium Iodide.	3. Wurster's re-agent.
	p.m.			
May 16	7.0	Blue	Blue	Bleached.
„ 17	4.20	No change	No change	Do.
„ 18	9.30	Do.	Blue	No change.
„ 24	3.15	Faintly blue	Red	Blue.
„ 31	6.15	No change	No change	No change.
June 1	9.15	Do.	Blue	Bleached.
„ 6	6.45	Do.	Red	Do.
„ 7	4.0	Do.	No change	No change.
„ 8	9.30	Blue	Red	Bleached.
„ 13	8.0	No change	Do.	Faintly blue.
„ 20	8.0	Do.	Do.	Bleached.

To understand the table it is necessary to bear in mind that—

Paper 1 is coloured blue by ozone, nitrous acid, or by hydrogen peroxide.

Paper 2 is coloured blue by ozone, or by hydrogen peroxide; also that the air supplied to the House is *always* acid. This was shown by suspending simultaneously with the other paper strips of blue litmus paper, which were reddened every time. Hence, if the amount of acid in the air was more than sufficient to neutralise the alkali liberated by the ozone or hydrogen peroxide, this paper would be reddened.

Paper 3 is coloured blue by ozone or by hydrogen peroxide and bleached by excess of either.

We must conclude, therefore, from these results, that *either* ozone *or* hydrogen peroxide was present on all but two occasions. To throw light on this question these further experiments were made:—

(1) Arnold and Mentzel have shown that a solution of tetramethyl-paradiamidodiphenylmethane in methyl alcohol gives a violet colouration with ozone, a yellow with nitrous acid, and no colour at all with hydrogen peroxide. This test was, therefore, employed to test for ozone, in addition to the previous re-agents, but it never gave any indication of ozone.

(2) Ozone was actually made in the inlet by passing a fairly rapid current of oxygen from a cylinder of compressed oxygen through a small Siemens ozone apparatus, worked by an induction coil. When the arrangement was working on the Terrace side of the steps in the inlet, ozone could be detected at the end of the inlet by the door which opens from the basement below the Central Hall, but it could not be detected beyond the scrim cloth, or at the entrance to the cotton-wool filter. When the apparatus was working by the door just mentioned, ozone could be detected in front of the fan and immediately behind the fan, and there was more ozone in the former place than in the latter. With the apparatus working immediately in front of the scrim cloth, ozone was detected with some difficulty beyond the scrim cloth. No smell of ozone ever reached the Equalising Chamber. For remarks on delicacy of sense of smell, see below.

These experiments show that it is unlikely that ozone ever enters the inlet, and that if it were to do so it would be destroyed before reaching the Equalising Chamber. That hydrogen peroxide is present was shown by the fact that water through which air has been aspirated in the inlet, and also rain-water which was collected at the House, each turned Wurster's re-agent strongly blue.

3. *Carbon Dioxide.*

The results have been summarised in the following table:—

No.	Locality.	Date.	Time.	Volumes of CO_2 per 10,000 Volumes of Air.	Excess of CO_2 over Outer Air (roughly).
1	Inlet	June 28	p.m. 3.50	4·2	—
2	Do.	July 27	5.50	3·5	—
3	Over ceiling of Debating Chamber, Bar end.	Aug. 8	7.10	4·2	·2
4	Over ceiling of Debating Chamber, Chair end.	July 26	10.15	5·6	1·6
5	Downcast Shaft 2, shutter level ...	June 27	10.0	6·7	2·7
6	Mixed air of downcasts at shutter level.	„ 29	10.0	5·4	1·4
7	Mixed air of downcasts at basement level.	July 27	7.15	5·0	1·0
8	A downcast shaft from Strangers' Gallery.	Aug. 4	5.15	3·9	—

Other determinations were made, but the above include the maximum and minimum values.

The figures show that the air admitted at the inlet had the normal value for town air (4 volumes), and that in no part of the Debating Chamber was there any accumulation of carbon dioxide that could be regarded as in the least serious—the highest value obtained being 6·7 volumes. These results are most satisfactory; but it should be added that being summer the windows were open in many of the tests.

4. *Ammonia and Nitrogenous Organic Matter.*

The method adopted was that of aspirating air through two narrow wash-bottles, one containing carefully prepared ammonia-free water (100 c.c.), and the other containing dilute sulphuric acid. The same amount of the same water and acid was put into a well-stoppered bottle at the beginning of the experiment, and the aërated water and the comparison water were always examined together on the day following the experiment. They were distilled with the addition of freshly-ignited sodium carbonate, and then with ammonia-free and freshly boiled alkaline permanganate in an apparatus in which ammonia-free water had been boiled till it was absolutely free from ammonia. The time occupied in aspirating the quantities of air given in the table was never less than two and a half hours nor more than four hours. In the first four determinations the air was aspirated by carefully graduated aspirators, in the remainder by a water-pump which we were able, through the kindness of Mr. Patey, to fix on the inner spray, and a meter which Dr. Gordon had had specially tested for these experiments. The results are given in the table.

Free and Albuminoid Ammonia collected from Air by passing the Air through Wash-bottles.

Date.	Hour of Starting.	Volume of Air.	Temperature.	Ammonia in 1,000 Litres.	
				Free.	Albuminoid.
	p.m.	Litres.	Degrees (C).	Grs.	Grs.
May 9* ...	6.45	63	—	0·	Trace
„ 16* ...	6.50	104	—	0·0096	0
„ 17* ...	4.50	103	17	0·0024	0
„ 18 ...	9.30	98	13	0·0051	0·0051
„ 31† ...	6.15	100	—	0·	0
June 7 ...	3.30	200	16	0·0025	0·0025
„ 8 ..	9.0	172·5	13	0·0034	0.0058
„ 20* ...	7.10	210	17·5	0·0033	0·0024
July 13 ...	7.20	180	21	0·0056	0
„ 14 ...	6.35	272·5	20·5	0·0066	0·0026

* On these days the outer spray was working.
† On this day heavy rain had fallen.

There are no results available for comparison, as there is no standard method of estimating atmospheric ammonia, and its amount appears to be very variable. These results are correct for the apparatus used; but in all probability some ammonia escaped absorption and some nitrogenous organic matter would not be decomposed by alkaline permanganate. Ammonia and its salts cannot be regarded as injurious, but the substances from which the albuminoid ammonia arises may be injurious; for instance, some bacteria would, no doubt, be arrested in the wash-bottles and if numerous would, on decomposition by boiling with alkaline permangate, yield albuminoid ammonia. Any process, therefore, which reduces the amount of these substances in the air supplied to the House would be well worth adopting. Such a process is found in the spray, which, however, is only at present used when the difference between the wet and dry bulb thermometers is 10° F. or more; it is then used to increase the humidity of the air—but it really purifies the air very considerably. To show this, two chemically clean bottles were washed out with the water from the spray pipes. One was filled at once with the unsprayed water, and the other was placed with a funnel in its neck on the floor to catch the spray. The two samples were examined on the next day for free and albuminoid ammonia exactly as described above. To test the effect of fineness of the spray the bottle was placed in such a position on June 20th, that it was filled in half the time it had taken to fill on June 13th.

Effect of Spray.

Outer Spray. Parts in 100,000 *Parts of Water.*

——	Free Ammonia.	Albuminoid Ammonia.
June 13th—		
Unsprayed water	0·0025	0·01025
Sprayed water	0·0140	0·01825
June 20th—		
Unsprayed water	0·0025	0·00750
Sprayed water	0·0050	0·01313
June 28th. Bottle placed half time in each position)—		
Unsprayed water	0·0006	0·00625
Sprayed water	0·0105	0·01200
Inner spray. (Bottle placed where finest spray appeared to fall)—		
Unsprayed water	0·0000	0·0056
Sprayed water	0·0220	0·01100

Over one-third of the air taken into the House enters the inlet by the middle chamber of the inlet, and in that chamber only is there a spray; so that when this spray alone is working, about a third of the air is purified. When the inner spray is working, on the other hand, all the air is washed; now this inner spray delivers on an average 1·66 litres of water per minute, that is, very nearly 100 litres per hour. The experiment on August 4th showed that 300 c.c. of sprayed water collected in 3 hours 0·000066 grs. of ammonia, or 100 litres would collect in 3 hours 0·022 grs. of ammonia when the bottle was placed where the spray appeared to be finest. Hence about three times as much water is used in the inner spray as is required for washing the air with a really fine spray.*

5. *Nitrous Acid.*

This was found in the water collected from the spray. On July 19th nitrous acid was found both in the sprayed and unsprayed water, but more in the former than in the latter; the amount was so small that it was not estimated. In August 4th the amount was so noticeable that it was estimated :—

1000,000 parts of sprayed water gave 0·03 parts of nitrogen as nitrite.

6. *Nitric Acid.*

This was only estimated in rain-water. On July 25th I arrived at the House soon after a heavy fall of rain had commenced. A bottle with a

* In the Recess, 1904–05, these sprays were replaced by a washing screen furnished with a battery of fine sprays. The screen in question was designed by Mr. Rivers, Chief Engineer to H.M. Office of Works. From tests to be described later, this screen would appear to remove some 60 per cent. of the bacteria from the incoming air.

large funnel in its neck was placed in the open and left about an hour, when the water collected was transferred to another bottle, and the original was placed at eight o'clock on the lawn at the south end of the Houses and left there till the adjournment. The first sample gave in 100,000 parts—

Free ammonia	0·35 parts.
Albuminoid ammonia	0·42 „
Nitric	Trace.
Sulphate	„

The second sample gave in 100,000 parts—

Nitrogen as nitric acid	0·825 parts.

This is a very high value for nitric acid, but the explanation is obvious. A fine lightning display accompanied the rain, and nitric acid is always formed during electric discharges in air.

7. *Sulphuric Acid and Sulphuretted Hydrogen.*

The aspirating arrangement used for ammonia was used for this determination. The wash-bottles were thoroughly cleaned with pure water and each bottle contained 100 c.c. of pure water for the experiment. The test was made on June 1st, again on the 6th, and again on the 13th. On all three occasions a trace only of sulphuric acid was obtained, no sulphuretted hydrogen, and no hydrochloric acid. The amounts of air taken were respectively 127·5 litres, 111 litres, 150 litres. Sulphuretted hydrogen was also tested for by means of lead acetate papers suspended at the same time as the ozone papers, with the following results:—

May 16th, May 17th, June 8th, slight darkening, showing a trace of sulphuretted hydrogen.

May 18th, May 24th, May 31st, June 1st, June 6th, June 7th, June 13th, June 20th, no change at all.

Summary.

By way of summarising the preceding results it may be said—

(*a*) That the essential constituent of the atmosphere—oxygen—was always present in normal amount.

(*b*) That the amount of air passing through the Debating Chamber was sufficient to prevent any noticeable accumulation of the gaseous products of respiration. This is proved by the results of the determinations of oxygen and carbon dioxide in air extracted from the Debating Chamber. But this statement is not to be taken as implying that the air is admitted in the best possible way.

(*c*) That certain substances are present which in appreciable amount would certainly be injurious, but they are present in such minute quantities that they probably produce no effect on any normal human being, with the exception only of the nitrogenous organic matter which may conceivably contain pathogenic micro-organisms.

(*d*) That evidence has been found to show that when the air passing to the Debating Chamber is subjected to the action of a *fine spray* of water injurious or potentially injurious constituents undergo considerable diminution. With an efficient system of spraying these constituents could no doubt be reduced still further.

(*e*) That these experiments were made at the most favourable time of the whole year, when there are no fogs, and the amount of coal and gas consumed is at its minimum.

II. Dust, Index Experiments, &c.

Dust from the Floor of the House and from the Scrim Cloth.

At the very beginning of these experiments papers were placed beneath the floor of the House to collect some of the dust which falls through into the Equalising Chamber; it was intended to ascertain what percentage of the dust was of organic origin, but owing to the large amount of fibre from the matting on the floor of the House which came through as dust, this intention had to be abandoned. Much of the dust collected must have been brought into the House on the boots of Members walking in from the streets. With the object of obtaining chemical evidence to establish this beyond all possibility of doubt, dust of a definite kind, namely, lithium carbonate, was put down in known positions outside the House, and papers were extended beneath the floor to catch the dust which fell through; the papers, two in number and overlapping were about six square feet in area, and they were placed at the Bar end of the Equalising Chamber. On August 8th the dust was put down in New Palace Yard at 1 o'clock, and the deposit upon the papers was collected till half-past 10. The next day dust was put a little nearer the House, and the papers were left till the adjournment of the House. On neither of these occasions could a trace of lithium be found; but it transpired that on the second occasion a scavenger had swept up the dust within an hour of its being put down. On August 10th the dust was put down in the Star Court and not swept up; or at all events not so promptly. The papers were again left till the adjournment of the House. Examination of the dust next day showed abundance of lithium. The experiment was repeated, and with the same result.

Through the kindness of Mr. Patey I received the dust which was extracted from the scrim cloth by the vacuum cleaner when the cloth was taken down first after the lithium carbonate experiments. Here again a quantitative determination of the organic matter was intended, but owing to the obvious presence of fibre from the cloth no meaning could be attached to such a determination. The dust was therefore submitted to a very careful qualitative analysis. It contained—

Water 4·93 per cent. (Loss of weight on drying for three hours at 110°.)

Organic matter 54·4 per cent. (Loss of weight on ignition after removal of water.)

Ammonia, aluminium, iron, silica, calcium, nickel, sodium, potassium, lithium.

Four of these constituents are particularly interesting.

The Organic Matter.—This is very large in amount, but unfortunately it is impossible to say how much of it arises from the material of the scrim cloth—some must come from the air.

Ammonia.—This must come from the air.

It has been shown that these constituents are present in the air, and we must conclude that the scrim cloth takes up some of them from the air. The scrim cloth is of service therefore.

Lithium.—This cannot have fallen on to the scrim cloth from the floor of the House. The only likely explanation of its presence is that the vacuum cleaner was employed to clean the matting from the floor of the House *before* it was put on to the scrim cloth and that dust from the former must have remained in the apparatus and have become mixed with the dust from the latter. This shows that although no lithium was put down after Thursday, August 11th, the *matting must have retained lithium* till it was taken up for cleaning on the Saturday morning.

Nickel.—The presence of this element shows that the dust extracted by the vacuum cleaner does not all come from the object cleaned, for there could be no nickel on the scrim cloth. The nickel must come from the vacuum cleaner, and also a part of the iron. It is safe to say that the vacuum cleaner is nickel-plated.

Leakage of Air into the Debating Chamber from Vaults in the Basement.

There is a passage known as the Commons pipe vault running parallel to the cotton-wool filter, and situated vertically below the Government side of the Debating Chamber. This passage conveys a number of steam pipes which pierce the vaulting of the passage to pass to part of the Battery Chamber immediately above. The passage also conveys air from the engine rooms and basement under the Central Hall to the Clock Tower furnace. The air in the Commons pipe vault has a high temperature, is very dry (42 per cent. humidity), and has a curious "stuffy" smell. It was thought that this smell could be recognised in the air of the Equalising Chamber, and that therefore a leak existed somewhere by means of which the air from the engine rooms and basement gained access to the air passing to the Debating Chamber. The ceiling of the Commons pipe vault showed leaks.

A determination of the oxygen and carbon dioxide, however, proved the air of the Commons' pipe vault to be quite normal in respect of these gases; and when applied to some cracks in the vaulting of the Commons pipe vault the anemometer showed a current from the Battery Chamber *downwards* into the vault below.

Under these circumstances it was decided to make use of the delicacy of the sense of smell to establish the existence or non-existence of a leakage of air into the airway to the Debating Chamber. Bertholot has shown that a quantity of iodoform so small as 0·000,000,000,000,01 gramme can be detected by the human sense of smell, while a quantity of musk so small as 0·000,000,000,000,000,01 gramme can be detected by the same subjective sense. The most delicate chemical tests are therefore very crude as compared with the delicacy of the sense of smell, since the most delicate test is that for sodium by the spectroscope, which will show less than 0·000,000,000,03 gramme, and next to this is the spectroscopic test for lithium, which will reveal 0·000,000,001 gramme.

The experiments were made immediately on the adjournment of the House for dinner. On August 8th an alcoholic solution of benzaldehyde, which has a very pleasant and easily detected odour of almonds, was sprayed in the Commons pipe vault at spots where it was thought the odour might reach the holes in the ceiling and pass into the Battery Chamber and be detected; but the result of this test was negative both in the Battery and Equalising Chambers.

On the following day the strongest ammonia was sprayed in the same place for half an hour during the adjournment; but no smell of it reached the Battery Chamber, nor were azolithmin papers, which were placed in the Battery Chamber, and left there the whole time, affected.

On the third day, sulphuretted hydrogen was generated in the Commons pipe vault at the same time; but no smell of it reached the Battery Chamber, nor were lead acetate papers which were placed there, and left the whole time during which the test was being made, affected.

Later on in the same evening, however, the flask in which the hydrogen sulphide had been generated was washed out by an attendant at a sink in a part of the basement nearer the input fan; and about the same time there was a complaint in the Debating Chamber of an offensive smell such as could well have been produced by inleakage of the gas into the airway. This accidental circumstance led to further investigation, with the result that inleakage of basement air into the airway was established at several points between the fan and the inlet. Subsequently measures were taken to reduce this inleakage as much as possible.

Mud of the River alongside the Terrace.

As the river mud is exposed at low tide in the river, it was thought advisable to examine this for organic matter. On two occasions some mud was taken up opposite the inlet. It was filtered and dried for a day at 100° to 110° C.; a weighed quantity was taken and ignited, when a gas was given off which re-acted strongly alkaline to azolithmin paper. The loss of weight showed the dried mud to contain 15.3 per cent. organic matter. The fresh mud had an odour of putrefying organic matter. No doubt on a hot day traces of ammonia and other gaseous products of decay of organic matter reach the House from this source.

SECTION IV.

(C.) PHYSICAL OBSERVATIONS OF THE AIR SUPPLIED TO THE DEBATING CHAMBER DURING 1904.

(1) Temperature of the air.

(2) Humidity of the air.

(3) An observation of the number of dust particles contained in air supplied to the Debating Chamber; the effect thereon of passing the air through the scrim-cloth screen; and some remarks about the present system of ventilation, by John Aitken, Esq., LL.D., F.R.S.

(1) Temperature of the Air.

In this country the temperature of the air in a room well ventilated and warmed should not fall below 59° F.; it should not be allowed to rise above 65° F., and the temperature aimed at should be 62° F.

When the House of Commons is sitting, the temperature of the air in the Debating Chamber is carefully observed and regulated by the ventilation staff; the readings of numerous thermometers distributed throughout the airway from the Terrace, over the gratings in the Equalising Chamber, and different parts of the Debating Chamber itself, being taken and recorded with commendable diligence and regularity.

Mr. Patey has furnished figures showing the mean temperature of the air in the Equalising Chamber on occasions when this inquiry was in progress. The mean of 31 daily observations shows that the temperature of the air passing into the Debating Chamber was 63° F. This figure corresponds with the observations occasionally made independently with a standardised thermometer in the Equalising Chamber, and it shows that the air supplied to the Debating Chamber is quite satisfactory as regards temperature.

(2) Humidity of the Air.

The most agreeable amount of humidity to most healthy people is when the relative humidity of the air is between 70 and 80 per cent.* In a room well ventilated and warmed, the humidity ought to range between 73 and 75 per cent.†

Observations of the relative humidity of the air supplied to the Debating Chamber have been made throughout the inquiry. While the House is sitting, readings are taken by the ventilation staff from a dry and wet bulb hygrometer fixed on the wall at the end of the Equalising Chamber under the Speaker's Chair. Mr. Patey supplied a copy of the mean of the readings from this instrument on occasions when the inquiry was in progress. In addition to these observations, it has been a routine practice, on occasions when the inquiry was in progress, to take observations of the humidity of the fresh air entering the airway from the inlet on the Terrace.

The readings shown by the hygrometers at each of these two portions of the airway, respectively, are seen in the accompanying tables, in which the relative humidity of the air implied by these readings is also given.‡

* Parke's Hygiene, 7th edition, edited by de Chaumont. p. 389.

† Wilson's Hygiene, 8th edition, p. 152.

‡ Glaisher's Tables.

Hygrometer Readings in the Airway near the Inlet.

Day.	Hour.	Hygrometer. Dry Bulb.	Hygrometer. Wet Bulb.	Humidity of the Air (Glaisher), Saturation=100.	—
	p.m.				
May 2	8.30	51	47	74	
„ 3	8.7	53	47	64	
„ 4	3.15	57	49	57	
„ 9	8.50	53	48	69	
„ 10	4.45	53	48	69	
„ 11	7.40	56	52	75	
„ 16	7.55	65	59	68	
„ 17*	7.35	60	49	46	
„ 18	10.30	55	49	65	
„ 26	4	66	59	64	
„ 31	4	60	56	76	
June 1	11	55	51	75	
„ 6	10	58	53	71	Mean of the 29 observations: Dry bulb, 59. Wet bulb, 54. = 71 per cent. humidity.
„ 7	9.30	53	48	69	
„ 8	10.30	54	48	64	
„ 13	11	60	58	88	
„ 14	11.15	60	56	88	
„ 15	11	62	59	82	
„ 20	11.15	61	55	67	
„ 22	10 to 11	61	54	62	
„ 27	10 to 11	61	56	72	
„ 28	10 to 11	66	57	56	
„ 29	10 to 11	64	54	51	
July 4	7.30	65	58	63	
„ 7	5	65	62	83	
„ 11	7	65	59	68	
„ 13	8.30	68	62	68	
„ 18	11	62	57	72	
„ 19	6	66	59	64	

Mean of Hygrometer Readings in the Equalising Chamber.

Day.	Hour.	Hygrometer. Dry Bulb.	Hygrometer. Wet Bulb.	Humidity of the Air (Glaisher), Saturation=100.	—
	p.m.				
May 2	2 to 8.50	62	57	72	
„ 3	2 to 4.19	61	54	62	
„ 4	2 to 3.50	61	53	58	
„ 9	2 to 10.30	62	53	54	
„ 10	2 to 4.40	62	56	67	
„ 11	2 to 7.50	62	54	58	
„ 16	2 to 8.30	62	54	58	
„ 17	2 to 6.50	62	56	67	
„ 18	2 to 11.15	60	52	58	Mean of the 31 observations: Dry bulb, 63. Wet bulb, 56. = 63 per cent. humidity.
„ 31	2 to 3.30	61	58	82	
June 1	2 to 11.12	62	58	77	
„ 6	2 to 9.15	62	55	62	
„ 7	2 to 10.30	61	54	62	
„ 8	2 to 11.10	61	55	67	
„ 13	2 to 11.15	61	57	77	
„ 14	2 to 11.10	63	59	77	
„ 15	2 to 10.30	62	57	72	
„ 20	2 to 11.0	63	57	67	
„ 21	2 to 11.30	62	55	62	
„ 22	2 to 10.0	63	57	67	
„ 27	2 to 11.30	62	55	62	
„ 28	2 to 11.0	62	55	62	
„ 29	2 to 11.0	64	57	63	
July 4	2 to 11.10	63	56	63	
„ 7	2 to 11.0	65	61	78	
„ 11	2 to 11.0	67	59	60	
„ 13	2 to 11.30	67	62	73	
„ 18	2 to 11.40	68	60	60	
„ 19	2 to 6.0	68	60	60	
„ 26	2 to 11.0	67	62	73	
„ 28	2 to 10.0	67	61	68	

* The Westminster Meteorological Station reading at 6 p.m. this day was:—Dry Bulb, 62; wet, 50 = humidity of 44 per cent.

The mean of the hygrometrical readings at the Inlet and Equalising Chamber respectively, the relative humidity of the air implied by these readings, and the capacity of the air at the two parts of the airway for absorbing moisture, are as follows:—

Position of the Air.	Number of Observations.	Hygrometer.		Relative Humidity.	Vapour required to saturate a Cubic Foot of the Air.
		Dry Bulb.	Wet Bulb.		
				Per cent.	Grains.
Near inlet	29	59	54	71	1·6
Entering the Debating Chamber	31	63	56	63	2·4

These figures prove that under the conditions existing in 1904 the raising of the temperature of the fresh air was effected at the expense of its relative humidity. The conclusion drawn from these data was that the air supplied to the Debating Chamber was too dry; its capacity for absorbing moisture being raised from 1·6 to 2·4, in fact, increased by 50 per cent.

Owing to the erection of a washing screen at the inlet during the following recess, the conditions under which these results were obtained have been considerably modified. It may be added that the observations made later by Mr. Lempfert were made after the erection of the washing screen.

Memorandum on the Ventilation of the House of Commons, by John Aitken, LL.D., F.R.S.

Being some remarks made after visiting and examining the ventilating arrangements in the House, and testing the number of dust particles in the air, and some criticisms of the evidence given before the Select Committee on House of Commons (Ventilation), and printed 25th June and 28th July 1903.

Dust Particles in the Atmosphere.
The Air Inlet.
Position of the Fan.
Airways.
Cotton-wool Filter.
Mr. Shone's Coke Tower.
Heating Arrangement.
Ventilation of Debating Chamber.
Purification of the Air.
Heating and Cooling the Air of the Chamber.

Dust Particles.

The inspection was made on the forenoon of the 25th August, 1904. As the House was not sitting at the time, a proper examination of the dust in the air could not be made, but the ventilating fan was put in action, and such tests as were possible under the conditions, were made.

The situation of the inlet on the Terrace was first examined, and the air in front of it tested for the number of dust particles it contained. The air here was found to be pure for city air; the numbers varying from 20,000 to 35,000 particles per cubic centimetre, with an average of 29,000 per c.c. The air in the passage to the fan was then tested, and found to have the same degree of impurity. After passing the fan and through the scrim cloth the air was again tested, but, so far as could be judged, the scrim cloth had little or no effect on the *number* of particles. At any rate, the improvement was not sufficient to show in tests made in a short time; the numbers varying so much and so rapidly at the entrance of the inlet, that a very large series of simultaneous observations would be necessary at the entrance and behind the screen, before any definite conclusion could be arrived at.

While the dust-counter showed hardly any purifying effect from the scrim cloth, yet it is not necessary to conclude that it had no effect. It seems highly probable that while the screen can have but little effect on the very minute particles, yet it will stop some of the larger ones; and as the number of large ones is very small compared with the microscopic ones, the detention of some of these large ones can hardly be expected to show in the total numbers.

I regret the cotton-wool had been removed from its screen; it was not, therefore, possible to test the effect of the cotton-wool in reducing the number of particles in the House.*

The test showed that the number of dust particles in the Debating Chamber was slightly greater than that observed in the air passage below it. But as the fan had not been long in action, and windows were open, the tests are of no value.

The air in the Commons' Court was next examined, and was found to be more dusty than the air on the Terrace, the average being 50,000 particles per c.c. The air in the Star Court gave a slightly higher number, being 55,000 per c.c

It would be rash to come to any general conclusion as to the amount of dust in the air in these places from these few tests, as they only show what the numbers were under the conditions existing on the day the tests were made. With other conditions they will certainly be different absolutely, and probably also relatively. I may here remark that the numbers here given are small for the air of London. From some observations I made in the beginning of June, 1889, on the air of London,† I find the number of particles in the air in Victoria Street was twice as great as any of the above numbers, and on the same date the air tested on the banks of the Thames, and coming from Battersea Park, with a strong westerly wind, was not as pure as that obtained on the Terrace, as the numbers in the air coming from Battersea Park varied from 48,000 to 84,000 per c.c. It will be as well to remember that the higher numbers recorded in 1889 were obtained at a season when more fires are likely to be burning, and also that the lower numbers obtained this year may in part be due to the observations having been made during a wet period, as we know that rain has a great influence in reducing the amount of dust in the air.

The Air Inlet.

A good many questions were asked by the Select Committee as to the suitability of the present position of the air inlet. Some seemed to be content with the present position; some recommended it should be 20 feet higher, whilst others wished the air to be drawn from the top of one of the towers. Taking the last recommendation first, anyone looking from a high

* The effect of the cotton wool filter was examined at a later date, when it was found to remove 83 per cent. of the dust particles from the air.

position in a town can easily see that smoke tends to rise from all elevations. The air over a town is necessarily hotter than that of the surrounding country, and this hot city air tends to rise, and so produces an indraught of air from all round, the indraught being modified by the wind blowing at the time. Now, as the incoming air is cooler, it comes towards the city at a lower level than the heated air which is passing upwards and away with the wind. There, therefore, does not seem to be much chance of getting the purest air high up.

I fear there are but few dust observations available for answering the question as to how far, and to what amount, the city air ascends, but there seems to be but little doubt that it will rise to very great heights. In some observations* made above the top platform of the Eiffel Tower in Paris in 1889, before the structure was completed, I found the city air very much in evidence at that elevation, which is nearly 1,000 feet. The observations were taken over a period of more than three hours, and the number of dust particles varied greatly from time to time, going as high as over 100,000 particles per c.c. Other readings gave over 50,000, and down to 3,000 per c.c.; while during a very heavy rainfall, which seems to have brought down the purer upper air, so very low a number as 226 per c.c. was observed. The average number was 34,000 per c.c. The observations previously referred to, made in Victoria Street, in 1889, were made outside a window very high up, and on that occasion all the readings gave over 100,000 per c.c.

There does not, therefore, seem to be much use in looking for pure air high up over towns, and we seem to be compelled to look for it in some convenient open space low down to which the cool air coming from the country has freest access with most directions of wind.

It way be as well to state that caution is necessary in drawing conclusions from dust readings. It must be remembered that these readings give the *number* of the particles, and have nothing to do with the *weight* of the dust, which is a very different thing. It seems probable that the higher we go in the atmosphere the fewer will be the *large* particles and *bacteria*, as these tend to settle through the lower atmosphere to the ground, if there be little or no wind. As, however, the very small particles are principally the result of combustion, their number may be taken as an index of the carbonic acid, and other impurities in the air.

The next question is, supposing the air is to be drawn in low down, how low ought the opening to be? Some of those examined wish the opening left as it is, while some would put it 20 or more feet higher. To my mind the present arrangement is not the best, and I think it would be an improvement if the opening were higher.†

Position of Fan.

The present position of the input fan is not ideally perfect. It is placed at some distance from the inlet, and as a result all the air-passage from the inlet to the fan is under a negative pressure. One effect of this will be that there will be a tendency to draw air into this part of the passage from any place from which it can get it, such as the substructures, &c., a result which evidently might lead to contamination. Further, there are doors in this passage on the suction side of the fan, which, unless quite tight, would allow air to be drawn in from other sub-passages which ought

* Proceedings, Royal Society, Edinburgh, 1890.

† The effect of raising the inlet a few feet was tried in 1905, but had to be abandoned for reasons described later (p. 143).

to be avoided. If possible the fan ought to be placed close to the inlet, so that all airways shall be under positive pressure.*

Airways.

At present a great deal of the energy of the fan is lost, owing to the unsuitability of the present airway. It has far too many corners and variations in its sectional area, and the result is the stream lines of the air will be very much broken by eddies, which cause a waste of power.

Cotton-wool Filter.

Some of those examined seemed to think there was a danger of the cotton-wool filter making the air more germ-laden than when it entered the filter, in the same way as some water filters do, by the filter becoming a breeding ground for the bacteria. This question does not come within my province, but any bacteriologist can tell whether bacteria can grow and multiply in *dry* cotton-wool. One would have thought that so long as the wool was dry, or covered with the greasy, tarry mess deposited from fogs, that the growth and multiplication would be impossible of any bacteria that could grow and multiply in the human body.

Mr. Shone's Coke Tower.

Mr. Shone proposes to get rid of the dust and impurities in the air entering the Debating Chamber by means of an arrangement similar to the "scrubber" used in gasworks. A little consideration will show that no argument can be drawn from the action of the "scrubber" to the application of the same apparatus to the purification of air. In the "scrubber" the ammonia is removed from the gas by the affinity which the ammonia has for water, which condenses it; while dust has no affinity for water, but rather the other way; it is repelled if any evaporation is taking place or if the water is hotter than the dusty air. It therefore does not seem probable that the "scrubber" would have much effect on dusty or foggy air.

Heating Arrangements.

Dr. Shaw, in his evidence regarding the heating apparatus, seems to imply that the disagreeable physiological effects of heating by steam radiators are due to something—infinitesimal, it may be—which is distilled from the dust in the air coming in contact with the heating surfaces. The disagreeable physiological effects of heated air is a very complex subject, and it will be as well, in considering this supposed action of the heat on the dust, that we keep in mind that no dust ever touches a hot surface. I have shown that hot surfaces repel the dust particles in the air,† and the hotter the surface the more violently they are repelled, so it does not seem likely that anything that can be distilled from the dust can cause much deterioration of the air. This may be a small point, but when we are looking for the cause of some infinitesimal change in the air of the Debating Chamber, it is well to keep in view all the facts of the case so far as they are known. A deposit of dust will no doubt fall on the radiators when they are not working, but any bad effect of that deposit will pass away soon after the heating is established.

The question of the responsibility of the radiators for the want of freshness in the air of the House can perhaps be answered by those acquainted with the House. If the radiators are the cause of the disagreeable physiological effects of the air, then this effect ought to be much more marked during cold weather, when the radiators are heated to their highest,

* The structure of the building does not permit of removal of the fan to the inlet. Recommendations for improvement of the inlet airway are included in the Committee's Report.

† Trans. Roy. Soc., Edin., Vol. XXXII., Part II.

than when only slightly heated, or not used at all. An examination of those familiar with the House might settle this point; if not, experiment would do so. So far as my own experience of similar heaters goes, though I cannot give them a clean bill, yet I have found that much of the bad effect is not directly due to the radiators themselves, but to the radiators being placed close to surfaces which, when heated, give off heavy odours. Paint, for instance, on a surface near a heater will for long give off a disagreeable odour, and many other substances act in a similar manner.

Dr. Shaw suggests earthenware pipes for the heater. At present there does not seem to be sufficient knowledge on the subject to enable us to say that hot metals have any deleterious effect on air passing over them, and that an earthenware surface would be better. If heated dust be the cause of the deterioration of the air, then the substitution of earthenware for metal will give no improvement. It would, however, be as well to bear in mind that an earthenware system would, in all probability, be very difficult to maintain tight. Its own expansions and contractions are very likely to bring about its own destruction, or at least cause leakage of joints. In connection with this subject, I would suggest that, whatever shape new radiators might take, if metal, they might be coated outside with black porcelain by the usual process.

The present heating apparatus does not seem to be satisfactory, for two reasons; first, because steam is used, and second, because the heating surface is far too limited. When using a steam heater, however little hot air may be required, some part of the heater will be raised to a temperature of 212°. Now whatever the cause may be, all seem to admit that the less highly the air has been heated the less objectionable it feels. Further, by using steam when only a little heating is required, a small amount of highly-heated air is introduced in a large amount of unheated air, and the mixture is imperfect; and this results in local air currents, the heated air tending to rise through the other air and up through the floor of the House, causing local disturbance of the general circulation. This objection also exists when the radiators are working full power. The very hot air cannot get mixed with the rest of the air, and these local currents are intensified. It is for this reason that I think the present radiators have not nearly enough surface. It is very much better, in every way, to heat a great deal of air only slightly, than to heat a little of it highly and then mix; that is to say, it is better to heat, say, one-half the air by 20 degrees, to get a general rise of 10 degrees, than to heat one-eighth of it 80 degrees to get the same effect. Not only do you get a better physiological result, but you also check the tendency of the heated air to form a separate circulation by rising quicker at one place than at another, and so interfering with the general circulation.

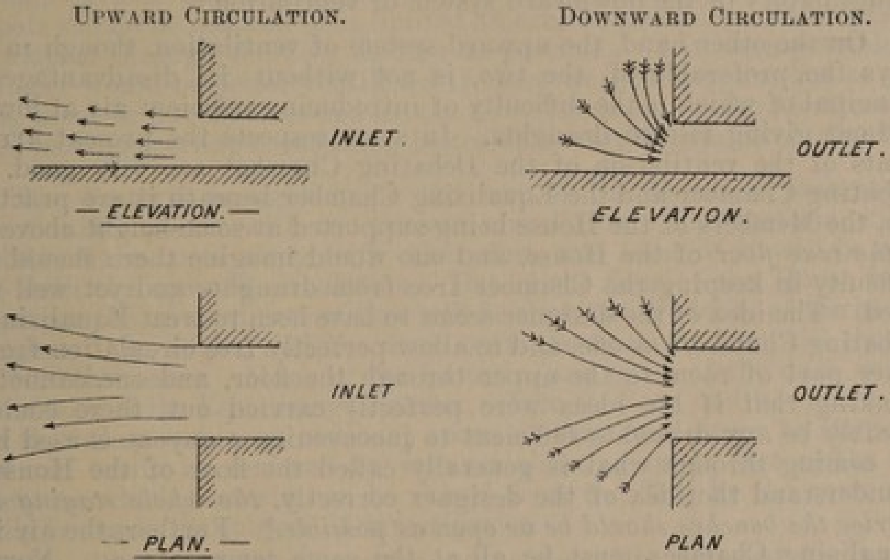
I do not, however, agree with the conclusion given by Mr. Keith in his summary at page 88, in which he states that the present arrangement makes the air dryer than any other heating arrangement. Whatever system of heating is adopted, so long as no vapour is added, the humidity will be determined by the final temperature alone. It does not matter whether a small proportion of the air be heated highly or a large proportion only slightly, the final humidity will be the same if they have the same final temperatures.

For the reasons above given, it appears to me that the present heaters ought to be replaced by others having a very much greater heating surface, and that water be used in them in place of steam. As suggested by Dr. Shaw, the water may be heated with steam, but this may not be necessary, as the usual boiler arrangement may perhaps be conveniently applied. The boiler arrangement has the advantage of having a large body of water which keeps the temperature steadier. On the other hand, if steam be used for heating the water, the temperature of the heaters is more under control, and more easily raised or lowered as required. Steadiness of temperature can also be attained by steam heating if a large body of water be connected with the heater.*

* The heating apparatus criticised by Dr Aitken has since been removed and replaced by a more modern type of radiator.

Debating Chamber.

Coming now to the ventilation of the Debating Chamber, there seem to be two quite distinct schools of ventilation—the one advocating a downward circulation with a plenum system, the other an upward circulation either with a plenum system or without it. Both of these schools are equally confident that their plan is the best, and there is doubtless much to be said for both of the systems. As regards draughts, there seems to be a consensus of opinion that the downward circulation is the best. At first sight, one might think it was all one whether the air circulated upwards or downwards, that there ought to be the same draughts whether the air went upwards or downwards, but on closer examination it will be seen that there are good grounds for the claim, because the draughts to which objections are made are worst in front of inlet openings than in front of outlets. In downward circulation the inlets are high up above the heads of the people in the room, while with upward circulation the inlets are near the feet of the occupants of the room. The reason why the inlets give rise to worse currents than outlets is easily seen when we draw the stream lines of the air in the two cases.



The inlet air rushes straight out from the opening and keeps in a fairly compact body till it loses its velocity, as it spreads over the room. That is, the inlet air moves in a narrow channel and carries its velocity well into the room. Now look at the outlet current. It approaches the opening from both sides, from front and from above. The sectional area of the current increases very rapidly, and the velocity therefore diminishes very rapidly with the distance from the opening, and at a very short distance from it no draught is felt. The inlet should thus be at some distance from the occupants of the room.

If we examine the downward system of circulation further, we find it very unsatisfactory in many respects. If we were cold-blooded animals it would suit us very well as our breath would be cool, and the upward tendency of the vapour added to our breath would just about be compensated for by the downward tendency of the carbonic acid added to it, and bacteria would be readily carried away by the downward current. But for hot-blooded beings the downward circulation system acts in direct opposition to the natural circulation produced by the warm, moist breath and hot air rising from our bodies. These all tend upwards, and are fighting with a downward circulation, and, as a result, we cannot hope for anything but a mixed circulation under the conditions.

Mr. Key, who is one of the advocates of the downward circulation, examined by the Select Committee, says, at page 67, that he does not ventilate smoking-rooms or kitchens by downward, but by upward circulation. One can easily see that downward circulation would be useless in a kitchen, where the badly-smelling airs come from the highly-heated range, and their upward tendency would be too strong for the downward circulation. But a smoking-room is just as favourably circumstanced as an ordinary room for the downward circulation. The little increase in the temperature due to the burning of the tobacco is too small to have any appreciable effect on the temperature of the air from the lungs of the smokers. One cannot help thinking why Mr. Key applies the system to ordinary rooms, but not to smoking-rooms, is that in the one case there is nothing to show that the system is not working, while in the other the smoke persists in showing an absence of general downward circulation. Mr. Key's explanation of the failure of the system in smoking-rooms is difficult to understand; it looks like an attempt to obscure vision. He says: "In smoke every particle is a heat unit, and inclined to rise." Now, if that means anything, then each smoke particle contains enough heat to raise the temperature of a certain quantity of water through one degree. If this be so, even though it be only the smaller unit, then a smoking-room is a vast untapped source of energy, capable of driving a good-sized mill or ship. So far as one can see, this smoking-room evidence is very condemnatory of the downward system of ventilation.

On the other hand, the upward system of ventilation, though in many ways the preferable of the two, is not without its disadvantages, the principal of which is the difficulty of introducing sufficient air at low level without giving rise to draughts. In some respects the present arrangements of the ventilation of the Debating Chamber are very good. The Debating Chamber and the Equalising Chamber beneath it are practically one, the Members of the House being supported at some height above what is *the true floor* of the House, and one would imagine there should be no difficulty in keeping the Chamber free from draughts and yet well ventilated. The idea of the designer seems to have been to treat Equalising and Debating Chambers as one, and to allow perfectly free circulation from the lower part of room to the upper through the floor, and one cannot help thinking that if his ideas were perfectly carried out, there could not possibly be any draughts sufficient to inconvenience anyone caused by the air coming through what is generally called the floor of the House. If I understand the idea of the designer correctly, *the whole staging which carries the benches should be as open as possible.** Further, the air in the Equalising Chamber must be all at the same temperature. Now, one cannot help thinking that it is here that will be found the cause of some of the draughts in the House.

I think the designer's idea would be more perfectly carried out if the airs, that is, the hot and cold airs, were mixed before arriving at the Equalising Chamber, and by doing so a better result would be attained. It is very evident the hot and cold airs cannot be mixed in the Equalising Chamber without giving rise to draughts in the House. We must keep in mind that by the construction of the building the Debating Chamber and the Equalising Chamber are practically one. Remove, in imagination, the open screen which supports the benches in the House, and which really obstructs the vision more than it obstructs the passage of the air, and think of the two chambers which, without the screen, will be seen to form one which is badly arranged for ventilation. The air coming from the radiators into the Equalising Chamber, that is, into the space below the seats, tends to rush upwards and do little to heat the Chamber. The screen forming the floor checks this upward rush, but cannot entirely effect proper mixing, nor check the local up-currents which will penetrate the openings in the floor.

The introduction of much larger heating apparatus will do a great deal to check the formation and velocity of these rising currents by making

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* Dr. Reid's book on Ventilation shows that Dr. Aitken's view is quite correct in this matter. Dr Reid had a "Mixing Chamber" also.

the air in the Equalising Chamber more nearly of one temperature. But I think an effort should be made to get the air well mixed, and all of one temperature, *before* it arrives at the Equalising Chamber, and admit it there with as *low a velocity* as possible. In fact, treat the Equalising Chamber as part of the Debating Chamber, which it really is.

This may seem to be a departure from the original idea of the designer of the building, but it is easy to see that if the floor of the Chamber is to be kept open as designed by him, that the mixing of hot and cold air cannot be done underneath it without causing local currents. It seems desirable that the whole floor of the House be kept as open as possible. Any closing up of one part only increases draughts at another.

Another objection which may be made to the present system of ventilation is that part of the incoming air comes in over the feet of the Members, and part through carpets. These certainly are not ideal conditions. Air coming through woollen material is apt to have a stuffy odour communicated to it. To correct this, two ideas suggest themselves. Try effect of carpets made of some material which does not give a disagreeable odour. If this cannot be obtained, then place under the carpets some material which will check all flow of air through them. As very little air comes through carpets this would have very little effect on the ventilation. All carpets should be reduced to as limited an area as possible, so as to leave the circulation through the floor as free as possible. If it were possible, the Chamber would be better ventilated if there were no carpets, but as something must be put down to reduce the noise produced by the Members' feet when moving, perhaps something better than carpets can be obtained.

The bacteria brought in on the feet of the Members present some objectionable points with the present circulation. The bacteria will get rubbed off the boots along with other dust, and some of it will be apt to rise with the upward circulation. But if the floor of the House is kept very open the upward rate of flow will be slow, the tendency of the bacteria to rise will be slight, and the more open the floor the less will the risks be from this cause. Many of the bacteria, and much of the dust, will fall to the floor of the Equalising Chamber, where they can do little harm, much less than they can in an ordinary room, as they need never be stirred up, and can easily be removed by vacuum cleaning or by wet cloths. The extent to which bacteria can be raised from the floor by the current can easily be made the subject of investigation.

Dr. Shaw suggests that some means should be adopted for carrying away the air coming down from the windows during cold weather, as it will interfere with the general circulation, and bring the upper air down again to the breathing level. This seems to be a very desirable object, because though this down current over the cold glass does little or no harm in an ordinary room, yet in one ventilated like the Debating Chamber, and, indeed, in all large halls, its effects are bad. I have shown that cold currents flowing down the inside of windows in ordinary rooms falls to the floor, flows towards the fireplaces, and goes up the chimney.* In ordinary rooms this cold current may have a beneficial effect, as it draws away the impure air from near the ceiling and takes it out of the room, so reducing the depth of the impure stratum of air near the ceiling, thus preventing it coming down to the breathing level, which it is apt to do when gas or lamps are used for lighting.

There are two ways of treating this down current in the Debating Chamber. One is the plan suggested by Dr. Shaw, to place air openings below the windows connected with an airway through which the air could be extracted. The other way of treating it would be to prevent the current forming. This can be done by placing a heating apparatus just below the window, which would set up an up-current of hot air sufficient to check the cooling effect of the window. Which of these plans should be adopted will depend on whether the structure admits most easily of the construction of an air passage sufficiently large, and with convenient

* Proceedings Royal Society, Vol. 50.

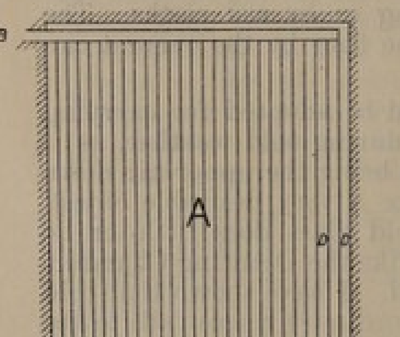
means of connecting with outflow, or of the admission of a pipe to bring in either steam or hot water, the latter by preference, as steam heaters are apt to be noisy if not carefully constructed.

Purification of the Air.

It might be as well, when testing different ways of purifying air, that some electrical methods be tried for general purification, and especially for fogs. Electricity at a high potential might be discharged into the air to electrify the particles, and the air afterwards passed through screens of wire cloth, to which the dust would be attracted and adhere. These screens might either be electrified oppositely to the electrification of the dust, or they might be simply connected to earth. Provision would require to be made for removing the dust from the screens, either by removing the screens and brushing, them, or by keeping jets of water playing on them.

Heating and Cooling the Air in the Debating Chamber.

On a previous page I have pointed out some objections to the present method of heating the air in the House; and the advantages to be derived from having the hot and cold airs mixed before they arrive at the Equalising Chamber. On further consideration of this subject, I think this can be easily accomplished by heating and mixing the airs in one operation. To accomplish this some such plan as the following could be adopted. Pass the whole air through an air passage fitted with hot water pipes, that is, with pipes extending from floor to ceiling, and from side to side. In this way the air passing through the screen of pipes would be only heated slightly above the required temperature, and it would be thoroughly mixed with the air that had not come in contact with the pipes by the eddies formed behind the pipes. In this manner the whole incoming air would have one temperature before it arrived at the Equalising Chamber, which I have shown would in all probability be a great improvement over the present plan of mixing the hot and cold airs in that Chamber, where they give rise to the formation of local currents which rise through the floor of the Debating Chamber.



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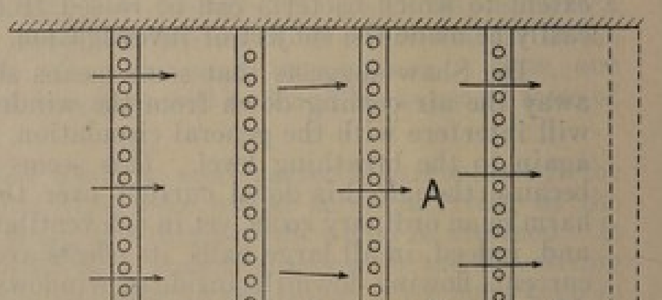

Plan.

The above sketch roughly indicates the idea I propose. A is a section of the air in passage. B is the inlet for hot water, and C outlet. DDD are the vertical heating pipes extending from top to bottom and from side to side of the airway. The air would be made to pass through a series of these screens as shown in plan. The hot water pipes might be placed vertically or horizontally, and might be sloped towards the incoming air to check any tendency of the hot air to rise. One objection to this arrangement of heating is that it would slightly retard the flow of the air, but a little increase in fan power would overcome this. When heating is being done, this energy would be well spent, but would be lost if no heating were going on. This loss might be avoided by having a bye-passage to be used when pipes were not in use, but that hardly seems necessary.

An arrangement of pipes, such as above described, might be used in summer for cooling the air by supplying it with iced water in place of hot water.

As it would be necessary to get into the spaces between the screens of piping for cleaning and for repairs, a door between each set of pipes would require to be provided as indicated by EE on plan, or if the airway was wide enough, some of the pipes could be removed from the end of each set, and in their place doors fitted as shown by dotted lines FFF in plan. This would give a straight passage through the heating chamber when the doors were open. The construction of the substructures of the House will determine which of these plans is the best under the circumstances.

(Signed) John Aitken.

SECTION V.

SUMMARY OF THE MAIN RESULTS OF THE INQUIRY UP TO THIS POINT.

The results of observations of the quality of the air described in the preceding pages may be condensed as follows.

(A).—*Air entering the inlet.*

Bacteriologically. A series of bacteriological observations of air entering the inlet showed that rainfall had a distinct influence on the abundance, or otherwise, of bacteria of all sorts to be obtained from it; the number of bacteria deposited by the incoming air being diminished in wet weather. No evidence was obtained of the presence in air entering the inlet of particulate matter derived from the human mouth. It was found, however, that air entering at the north inlet was liable to be polluted by material of intestinal origin—probably horse-manure—derived from the boots of persons walking over the grating on the Terrace fixed above the inlet in question. With this exception, the air at the inlet showed exceedingly little evidence of being charged with particulate impurity of a kind at present recognised as liable to be associated with matter that can convey disease.

Chemically. Dr. Hurtley made a very thorough chemical examination of the air entering the inlet and has fully dealt with the results obtained by him. He found the air to be normal for town air as regards oxygen and carbon dioxide. Ozone was absent, and tests led him to conclude that even were small quantities of ozone present in the air at the inlet they would not reach the Debating Chamber. For the rest, he found traces of substances that in appreciable amount would certainly be injurious, though they were present in such small quantities as to be probably harmless to a normal human being. The single exception he makes to this statement is with regard to organic matter, and he does so on the ground that it may contain pathogenic micro-organisms. The bacteriological results here recorded supply the requisite information upon this matter. An important observation was made by Dr. Hurtley with regard to the purifying action upon the air exercised by the fine rainlike spray in occasional use at the inlet for moistening the air.

Physically. Dr. Aitken's observation with regard to the number of dust particles in the air at the inlet led him to infer that its quality in this respect was good, for the air of a town.

(B).—*Air entering the Debating Chamber.*

Bacteriologically. During debates, the number of bacteria deposited from the air of the Equalising Chamber showed a marked increase at certain points corresponding to gratings in the roof thereof which constitutes the floor of the Debating Chamber. The excess of bacteria at these points was due to showers of debris falling through the gratings from Members' boots. The increase in the bacterial deposit from this cause was most marked below the portion of the centre gangway between the Bar and the Lobby door at that end of the Debating Chamber, and, to a less extent, behind the Speaker's Chair and below the side gangways. No evidence was forthcoming that the air of the Equalising Chamber below the Debating Chamber was contaminated by particulate material from the human mouth. On the other hand, the chief pollution found to be brought in on Members' boots and imparted to the air below the floor of the Debating Chamber was particulate material of intestinal origin—derived in all probability from horse-manure.

Air supplied to inhabited rooms in this country should have a temperature of between 60° and 65° F. The average temperature of the air of the Equalising Chamber was 63° F., and, therefore, in this respect, the air was found to be entirely satisfactory. Physically.

The difference observed between air at the Inlet and Equalising Chamber respectively as regards capacity for absorbing moisture has been advanced elsewhere as a possible explanation of the peculiar difference in quality perceived subjectively by Members between fresh air and the air of the Debating Chamber.

(C.)—*Air passing out of the Debating Chamber.*

It has been found that when the Debating Chamber is in use, the number of bacteria deposited from air leaving the Debating Chamber was increased as compared with the number obtained from corresponding air when the Chamber was empty. The chief bacterial contamination detected in air leaving the Debating Chamber during debates was due to the presence therein of micro-organisms disseminated from the mouth and upper respiratory passages of persons speaking, coughing, sneezing, &c., within the Debating Chamber. Bacteriologically.

In the course of the examination of air leaving the Debating Chamber bacteriological evidence was also occasionally obtained of the presence therein of particulate material of the same class as that brought in from the outside upon Members' boots.

The chemical evidence showed that, as regards carbon dioxide, air passing out of the Debating Chamber during debates was remarkably pure for air coming from an inhabited room. The proportion of oxygen was also satisfactory. As regards these two gases therefore the air of the Debating Chamber was entirely satisfactory. Chemically.

(D.)—*The result of Index-experiments.*

Index-experiments with the harmless but readily recognised micro-organism B. prodigiosus were carried out in order to determine the extent to which the air of the Debating Chamber is liable to be polluted respectively by material brought in from the outside on boots, and by material sprayed from the human mouth in performance of the act of loud speaking. Earth infected with B. prodigiosus and deposited outside the Debating Chamber at a point 576 feet from the Bar was found to have been brought in upon Members' boots; it was recovered from air below the Bar. In the speaking experiments which were made with the ventilation off and on respectively, it was found that so far from removing the particulate contaminating matter sprayed from the mouth in performance of the act of loud speaking, the effect of the ventilation at the time the experiments were made was merely to permit distribution of such material over a larger area in the Chamber than had been the case in a previous experiment when the ventilation was off. The importance of this form of contamination, of the presence of which evidence was also constantly obtained when examining the air leaving the Debating Chamber during debates, lies in the fact that certain infectious diseases are liable to be transmitted as a result of dissemination of their infection in air, notable instances being influenza and infectious colds.

PART II.

OBSERVATIONS MADE DURING 1905.

CONTENTS.

PART II.

SECTION I.

PRINCIPAL POINTS STILL REQUIRING INVESTIGATION.

Three main features of the ventilation remained open for investigation during 1905. In the first place, owing to alterations made during the Recess of 1904-05, some further observations of the quality of the air were necessary. The most important features of the ventilation, however, still to be investigated were the quantity of air passed through the system under the new conditions; and especially the area within the Debating Chamber over which the fresh air brought from the Terrace was being distributed.

The places ventilated by the Debating Chamber system are as follows:—

1. The Debating Chamber, both floor and galleries.
2. The Division Lobbies.
3. The Commons Lobby, including the Post Office and Whips' Rooms.
4. The Press Rooms.

In forming an opinion as to the quantitative efficiency of the present system of ventilation, the first point to be known is the nature of the air-requirements to be met by it. The maximum air-requirement may be arrived at roughly by estimating the maximum number of persons present in each part of the system under working conditions, and by then allowing per head per minute a minimum supply of 50 cubic feet of air. According to figures supplied to the Committee, the maximum number of persons present in various parts of the system during the most crowded debate may be stated as follows:—

1. Debating Chamber and Galleries	900
2. Division Lobbies during most crowded division	650
3. Commons Lobby, Whips' Room, &c.	50
4. Press Rooms	50

As the Division Lobbies are not in use for a division at the same time that a debate is in progress, the maximum number of persons present in various parts of the system under working conditions may be put at 1,000. The maximum air-requirements, therefore, of the whole system would be, according to the estimate, 50,000 cubic feet of air per minute. Of this amount 45,000 is required for the Debating Chamber alone during the most crowded debate.

In point of fact, however, the number of persons present in various parts of the system under ordinary conditions when the House is sitting is usually about half this maximum number.

Now, the present standard allowance of 50 cubic feet of air per head per minute is by no means a final one; the quantity of air to be provided having continually increased with progress in the art of providing it. At one time an allowance of 10 cubic feet of air per head per minute and even less was deemed sufficient. It is noteworthy, however, that so long ago as 1838, when low standards of ventilation prevailed, Dr. Reid, in a paper read before the British Association, protested against them, and stated that he never supplied the House of Commons with less than 30 *cubic feet of air per head per minute, and that on occasion he had given* 60 *cubic feet.* As Dr. Reid had evidently arrived at these figures from practical experience, they are worthy of the greatest respect.

The present 50 cubic feet standard was the result of simultaneous investigation of the air of inhabited rooms by both the subjective sense of smell and the objective carbon dioxide test; and this standard of de Chaumont was based on the fact previously related that a limit of two parts excess of exhaled carbon dioxide per 10,000 of air was the usual point at which its pollution from human exhalations was found to become perceptible to the unfatigued subjective sensation.* In some cases—for instance hospitals—an allowance of 50 cubic feet of air per head per minute has been found insufficient to conceal such pollution from the subjective sensation. Having regard, therefore, both to the history of ventilation, and also to the nature of the basis on which the 50 cubic feet standard rests, it is clear that this standard can only be regarded as a provisional one.

As the real origin of the present 50 cubic feet standard was the subjective sense of smell, so also the sole limit to the amount of air that it is desirable to supply is the subjective sensation of draught. This limit has been experimentally defined, and it has been found that the movement of air at a temperature of 55°-65° F. :—

(1.) At 1½ feet per second is felt by none.

(2.) At 2-2½ „ „ „ „ by only a few very sensitive persons.

(3.) At 3 - „ „ „ „ by most.

(4.) At 3½ - „ „ „ „ by all.

(5.) At 4 - „ „ „ „ a distinct draught.†

Since a velocity of 1½ feet per second therefore is felt by none, the quantity of air that can be supplied without producing complaint of draught is limited chiefly by the sectional area of the available inlet. With an inlet area of 1 square foot per head, 90 cubic feet of air could be supplied per minute without producing draught; and 120-180 cubic feet could be supplied without the movement of the air being perceptible to more than a few very sensitive persons.

It is clear from the above that the 50 cubic feet standard is by no means an extravagant test of quantitative efficiency to apply at the present day to what is perhaps the most important system of ventilation in the United Kingdom.

But in determining how far the present system is capable of fulfilling its requirements, information concerning the quantity of air passed through alone is not sufficient. Of equal importance is the question of the distribution of this air; in other words the effective area of inlet and outlet within the system.

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* The standard was calculated according to the formula $d = \frac{e}{r}$ where d is the quantity of air required, e the amount of CO_2 exhaled, and r the limit within which the CO_2 is to be kept. As the value of e is 0·6 cubic feet per hour, and of r 0·0002, it follows that d = 3,000 cubic feet per hour, or 50 cubic feet per minute.

† Parkes' Hygiene, 7th edit., p. 183.

SECTION II.

RECENT ALTERATIONS IN THE SYSTEM.

During the Recess 1904-5 some important alterations were effected in the system by which the Debating Chamber is ventilated. These alterations are as follows :—

1. The old engine-driven input fan with 6-ft. propeller has been discarded and replaced by an electrically-driven fan of the centrifugal or enclosed type. This new input fan has been fixed in an adjoining vault (as shown on the plan), whereby considerable simplification of the airway on the discharge side of the fan has been effected. The wheel of this fan is 8 ft. in diameter, and is belt-driven by an electric motor of 25 Brake Horse Power. The control is carried to the Equalising Chamber so as to come under the ventilator in charge, and the regulation is so delicate that the fan speed can be raised or lowered by less than one revolution per minute; this variation representing an alteration of volume of 300 cubic feet of air indrawn per minute by the fan.

The volume of air moved by the fan at various speeds is fully dealt with in the quantity section (Section III). The following table, however, illustrates the terms minimum, medium and maximum there used when referring to the speed of this input fan :—

Speed.	Revolutions of the Fan.	Cubic Feet of Air impelled by Fan per Minute.	Electrical Horse Power.
Minimum	120	36,000	8·5
Medium	150	47,000	16
Maximum	190	58,000	25

It is important to bear in mind that the air impelled by this input fan has to supply the Commons Lobby and Division Lobbies as well as the Debating Chamber.

2. Previously, the extraction of vitiated air through the ceiling of the Debating Chamber was chiefly brought about by a coke furnace in the Commons Tower, but partly by a coke furnace in the Clock Tower, and partly also by gas lights in the ceiling. The gas-light extraction has been retained, but the extraction by the two coke furnaces has been done away with, and at the present time the vitiated air is chiefly extracted from the Debating Chamber by an electrically-driven fan placed above the ceiling of the Commons Lobby. In size and structure the extract fan in question is a duplicate of the new input fan in the basement, but owing to the resistance on the suction and discharge sides of this extract fan being so much less than in the case of the input fan, a far greater volume of air is moved by it at the same consumption of energy. The following figures if compared with those given in the table for the input fan bring out this difference* :—

Speed.	Revolutions of the Fan.	Cubic Feet of Air extracted by Fan per Minute.	Electrical Horse Power.
Minimum	115	53,500	8·5
Medium	140	64,700	16
Maximum	165	75,000	25

* The minimum of the extract fan has recently been lowered so as to bring it into harmony with the input fan.

Here also it must be borne in mind that the total volume withdrawn by the extract fan includes the air extracted from the Ways and Means Corridor and Commons Lobby. The quantity withdrawn by the fan from the Debating Chamber alone at these speeds is seen on page 151.

The speed of the extract fan is controlled by a regulator in the Equalising Chamber, as in the case of the input fan.

3. A washing screen, designed by Mr. Rivers, has been placed at the inlet from the Terrace. The principle and particulars of this screen are described by Mr. Rivers in a Memorandum addressed to the First Commissioner of Works, and published in Appendix No. 4 of the Report of the Select Committee on the House of Commons Ventilation, dated July 28th, 1903. The screen in question consists of a sheet of copper gauze supported on framework and fixed vertically across the whole sectional area of each of the three inlet Chambers. When the screen is in action the copper gauze is kept continually moist by a water spray derived from jets which play in front of its outer surface. The mesh of the copper gauze is 20 to the linear inch. The area of the screen is altogether 222·7 square feet, and when in operation 615 gallons of water are used by it per hour. By an automatic arrangement this water passing from the screen is used for boiler feed purposes.

4. At one of its most tortuous parts, the airway in the basement has been straightened, as explained in paragraph 1.

5. Two of the three inlets to the airway from the Terrace have been raised by surrounding them with a temporary wooden wall or "surround."

6. Mr. Patey has made some alterations in the floor of the Debating Chamber under the seats, by means of which the benches, especially the back benches, obtain an increased supply of air from the Equalising Chamber. These alterations and their effect will be dealt with in detail later.

7. The old gill-pattern radiators in the Battery Chamber have been replaced by radiators of a more modern type.

8. The system of retaining the ventilator (or person in charge of the ventilation) continually in the airway has been discontinued, and a position found for him behind the cross doors leading to the West Division Lobby. By this arrangement he is able to make frequent periodical visits to the parts of the system underneath, and also to observe the number of Members present in the Chamber, and so to make alterations with view to meeting, so far as is at present possible, the varying requirements. Another advantage of this arrangement is that the whole of the system now comes under one control, instead of the responsibility being divided, as was formerly the case.

9. A compressed-air main has been run into the Equalising Chamber and the compressed air applied for the purpose of blowing out dust lodged in the perforated risers under the Benches of the Debating Chamber. This compressed air has proved to be most valuable for the purpose of removing dust from crevices hitherto inaccessible.

10. The four downcast shafts have been cut off from the ceiling of the House, the present extraction of which has been described in No. 2.

11. For the efficient cleansing of the whole air-course and Chambers below the Debating Chamber, a cold-water supply has been installed together with a system of drains.

SECTION III.

FURTHER OBSERVATIONS RELATING TO THE QUALITY OF THE AIR.

QUALITY SECTION.

CONTENTS. Page.

The quality of the air from the chemical and bacteriological standpoints having been examined previously at considerable length, attention has, in the present instance, been confined chiefly to the temperature and humidity of the air which have been kept under continual observation by means of thermographs and hygrographs. The recording instruments in question were stationed in the air-courses during May, June, July and August of 1905, and were under the constant care of Mr. Lempfert, of the Meteorological Office.

(A.) REPORT ON THE TEMPERATURE AND HUMIDITY OF THE AIR, BY MR. LEMPFERT.

This branch of the inquiry had for its objects:— *Objects of the Inquiry.*

1. To investigate the distribution of temperature in the Equalising Chamber.

2. To determine the effect of the washing screen at the Terrace inlet on the temperature and humidity of the air supplied to the Debating Chamber.

3. To examine the changes of temperature and humidity which take place in the air during its passage through the Debating Chamber.

The Instruments used, and the manner of controlling their indications.

The instruments used consisted of five thermographs by Richard Frères, of Paris, lent by Dr. W. N. Shaw, and five self-recording hair hygrometers also by Richard Frères.

The thermographs were controlled by means of maximum and minimum thermometers placed beside them, and read and set once a day. Corrections were, when necessary, applied to the readings deduced from the curves in order to make them agree with those obtained from the eye observations. The readings finally adopted may be regarded as correct to within 1° F.; in most cases the uncertainty of the reading does not exceed 0·5° F.

The hygrographs were, in the first instance, standardized by painting the hairs with water, and setting to 95 per cent. Their readings were regularly compared with the values of the humidity determined from readings of dry and wet bulb thermometers, and found to agree very closely. By applying a suitable correction for each week, it was generally possible to make the curve readings agree with the values deduced from the dry and wet bulb observations made during that week to within 1 or 2 per cent., if only those readings were used for the comparison which were taken while the ventilation was "on." To further guard against errors arising from changes of zero, &c., the comparison of the humidity at two places was always carried out by means of three hygrographs. Two of these were maintained permanently at the two places being compared, while the third was placed alternately beside one or other of the two stationary instruments, its position being changed every day or every other day. If the readings of the "traveller" agree with those of the instrument next to which it is placed, it seems justifiable to regard the simultaneous readings of the two stationary instruments as comparable. In practice the method was found to give satisfactory results.

It is probable that the values of the humidity finally adopted do not differ from those which would have been obtained from efficiently managed dry and wet bulb thermometers by, at most, 3 or 4 per cent.

All the thermometers used for checking the readings of the self-recording instruments had either been verified at Kew Observatory or were compared with instruments so verified by immersion in a water bath.

Exposure of the Instruments.

The instruments were exposed in the following positions:—

1. To examine the air before it reached the sprays, a shelf was fixed just outside the central air inlet on the Terrace and on this were placed a thermograph and a hygrograph with their controlling thermometers. These instruments were thus in the main current of air from the Terrace; they were protected from rain by a sloping wooden roof fixed over them which protruded a few inches beyond the edge of the shelf.

2. To determine the change in the temperature of the air produced by the spray, a thermograph was placed on a shelf fixed to the wall of the air-way at the point where the old, now disused, fan is. By this means the temperature of the air was determined immediately before it passed through the fan now in use.

3. The conditions within the Equalising Chamber were examined by means of:—

(*a*) A thermograph and a hygrograph placed on a shelf in the central passage of the Equalising Chamber.

(*b*) A thermograph placed on a bracket fixed to the floor of the House vertically over the large circular grating at the Bar end of the Equalising Chamber.

(*c*) A thermograph placed on a shelf similarly fixed over the corresponding grating at the Chair end of the Equalising Chamber.

A third hygrograph was used as a "traveller," and was placed alternately beside the hygrograph at the inlet and the hygrograph in the centre of the Equalising Chamber.

4. To examine the state of the air leaving the Debating Chamber, the thermograph from the Chair end of the Equalising Chamber was, on June 26th, transferred to a position over the ceiling of the Debating Chamber immediately over one of the openings in the sloping part of the ceiling, over the Strangers' Gallery.

On July 17th, the thermograph from the Bar end of the Equalising Chamber was transferred to a corresponding position at the other end of the ceiling of the Debating Chamber, over the Press Gallery.

The fourth hygrograph was placed beside this thermograph, and the fifth hygrograph was used as a "traveller" between this position and the hygrograph in the Equalising Chamber.

In selecting the positions above the ceiling of the House, care was taken to avoid the proximity of local sources of heat such as lamps. The instruments were so placed that they were not affected by the gas lights above the ceiling, a fact which was established by ascertaining that on those occasions when artificial light was required before the adjournment for dinner, the records of the instruments betrayed no trace of the turning on of the gas.

An anemometer, held beside the instruments, gave a reading of about 100 feet per minute when the fans were working, thus showing that the ventilation was amply sufficient to secure satisfactory results.

Method of dealing with the observations.

The records of all the instruments were tabulated for every second hour for the times during which the House was sitting. From the values of temperature and percentage humidity thus tabulated, the pressure of the aqueous vapour present in the air, and the corresponding wet bulb readings were computed by means of Glaisher's Hygrometric Tables for (1) the Terrace air, (2) the air in the Equalising Chamber, and (3) the air extracted through the ceiling of the House.

The Distribution of Temperature in the Equalising Chamber.

Little need be said on this subject. The Equalising Chamber, even on the days at the commencement of the Session when artificial heating was still required, fulfils its purpose as far as temperature is concerned, as the occasions on which the differences of temperature, shown by the three thermographs placed in it, reached a whole degree were the exception rather than the rule, and only on one occasion do the tabulations show a difference of more than 2° between the two ends of the Chamber. We may, therefore, say that the temperature was, as a rule, uniform throughout the Equalising Chamber within the limits of accuracy of the instrumental method.

When differences of temperature of more than 1° were shown, the thermograph at the Chair end generally read higher than either of the other two. This is probably due to local heating by the steam pipe under the Treasury Bench.

The ventilating staff succeed in maintaining an exceedingly even temperature in the Equalising Chamber during the portion of the year when artificial heating is required. Thus, during the week from Monday, May 22nd, to Friday, May 26th, the readings within the Equalising Chamber all lay between the limits 60° to 64°, whereas the external temperature varied between 44° and 64°.

When no artificial heating is required, this result is less easily attained, but even then, by regulating the speed of the fans, the fluctuations of temperature are confined within much narrower limits within doors than without.

The effect of the Sprays playing on the Wire Gauze Screens at the Inlet.

Before proceeding to discuss the effect of this screen, it will be advisable to consider briefly the readings obtained on days when the sprays were not in use. The instruction to the ventilating staff is to turn off the sprays when the difference between the dry and wet bulb readings in the Equalising Chamber falls below 5° F. Confining our attention to days on which this was the case throughout the day, we find that the values for the pressure of aqueous vapour at the inlet and in the Equalising Chamber are the same within the limits of accuracy which the method of observation admits of; from which it follows that loss or gain of water, due to absorption by the walls of the airway or to the converse process of evaporation, is too small to be taken into account. It was, therefore, unnecessary to determine the humidity at other points than at the inlet, and in the Equalising Chamber, as the humidity or wet bulb reading could be calculated at any intermediate point for which the temperature was known.

On looking through the tabulations, it was found that one effect of the sprays was to keep the humidity within the Equalising Chamber up to or above 60 per cent., even on occasions when the humidity of the outer air was as low as 40 per cent.

When the humidity without rose to above 70 per cent., the difference between the dry and wet bulbs in the Equalising Chamber became less than 5° at all temperatures, and the sprays were accordingly turned off. A few occasions can, however, be found when they were kept on for a short time beyond this limit.

Under conditions of high external humidity, the humidity within the Equalising Chamber rose to close on, or slightly above, 80 per cent., and even with external humidities between 60 per cent. and 70 per cent., the values within doors were generally above 75 per cent. It is a question for consideration whether a difference of 5° between the dry and wet bulb readings in the Equalising Chamber is the most suitable value to select as a limiting one.

To determine the effect of the sprays under different conditions of humidity and temperature of the external air, the tabulated value of the temperature, humidity, vapour pressure and wet bulb readings were grouped according to the temperature of the external air, the divisions selected being from 60° to 64·9°, from 65° to 69·9°, from 70° to 74·9° and from 75° to 80°. The values in each group were further subdivided according to the humidity of the external air, the divisions adopted being from 40 per cent. to 50 per cent., from 50 per cent. to 60 per cent., from 60 per cent. to 70 per cent. and above 70 per cent. The mean was then taken of all the readings in each sub-group. The results so obtained are given in Table A.

The supplementary Table B. has been prepared from Table A. to show the changes in the various elements in a rather more direct manner:

TABLE A.

Changes produced by the Water Sprays playing on the Wire Gauze Screens at the Air Inlet.

Temperature Range.	Humidity Range.	No. of Cases.	Outer Air (Terrace).				In Airway by Fan.	Equalising Chamber.			
			Dry Bulb.	Wet Bulb.	Vapour Pressure.	Humidity.	Dry Bulb.	Dry Bulb.	Wet Bulb.	Vapour Pressure.	Humidity.
	p.c.		°	°	in.	p.c.	°	°	°	in.	p.c.
75°–80	60-63	2	75·6	67·9	·572	62	71·0	70·8	67·2	·612	80
,,	50–60	9	76·5	66·3	·502	55	71·4	71·6	65·7	·548	70
,,	46-50	2	75·6	63·0	·420	47	69·7	68·7	63·7	·519	73
70°–74·9°	70–75	4	70·9	65·9	·559	73	68·6	70·5	66·6	·595	79
,,	60–70	10	72·3	64·9	·511	64	68·4	69·6	65·3	·558	77
,,	50–60	24	71·6	62·1	·436	55	67·2	68·3	63·5	·505	73
,,	40–50	5	70·5	58·2	·345	46	65·6	66·5	59·9	·434	65
65°69·9°	70–75	6	65·6	60·5	·457	73	64·1	65·9	62·4	·522	80
,,	60–70	17	67·6	60·7	·443	65	64·8	66·3	61·6	·487	75
,,	50–60	15	68·0	58·0	·371	54	63·3	64·9	59·2	·434	70
,,	40–50	14	67·6	55·5	·312	46	63·7	64·6	57·5	·386	63
60°–64·9°	60–70	8	62·2	55·3	·357	63	60·7	63·1	57·9	·417	72
,,	50–60	4	63·6	55·1	·335	57	61·7	63·5	57·4	·403	69

TABLE B.

Changes in the Various Elements produced by the Water Sprays at the Inlets under varying conditions.

Temperature Range.	Humidity Range.	No. of cases.	Reduction of Temp.		Depression of wet bulb.		Change in wet bulb Chamber minus Inlet.	Change in humidity.	Change in vapour pressure.
			At Fan.	In Equ. Chamber.	At Inlet.	In Equ. Chamber.			
	p.c.		°	°	°	°	°	p.c.	in.
75°–80°	60–63	2	4·6	4·8	7·7	3·6	−0·7*	18	·040
"	50–60	9	5·1	4·9	10·2	5·9	−0·6*	15	·046
"	46–50	2	5·9	6·9	12·6	5·0	+0·7	26	·099
70°–74·9°	70–75	4	2·3	0·4	5·0	3·9	+0·7	6	·036
"	60–70	10	3·9	2·7	7·4	4·3	+0·4	13	·047
"	50–60	24	4·4	3·3	9·5	4·8	+1·4	18	·069
"	40–50	5	4·9	4·0	12·3	6·6	+1·7	19	·089
65°–65·9°	70–75	6	1·5	−0·3	5·1	3·5	+1·9	7	·065
"	60–70	17	2·8	1·3	6·9	4·7	+0·9	10	·044
"	50–60	15	4·7	3·1	10·0	5·7	+1·2	16	·063
"	40–50	14	3·9	3·0	12·1	7·1	+2·0	17	·074
60°–64·9°	60–70	8	+1·5	−0·9	6·9	5·2	+2·6	9	·060
"	50–60	4	1·0	0·1	8·5	6·1	+2·3	12	·068

* The negative sign signifies that the wet bulb reading was lower in the equalizing chamber than in the outer air.

The variations within the same temperature group of these tables suggest that other factors besides the temperature and humidity of the outer air must be taken into account when considering the effect of the sprays. Variations in the temperature of the watèr probably play their part, but a much more important factor is the rate at which the air is passing through the screens.

The water is detached from the screen in the form of a fine spray which is carried down the air-way in sufficient quantity to appreciably damp the clothing of an observer stationed in it, even if he take up his position near the old fan. Some of the small droplets of spray evaporate, others fall to the floor of the air-way, and are there either absorbed or drained away. As the speed of the fans is accelerated, the velocity of the air is increased, and not only is the total amount of water detached as spray increased thereby, but the drops are also carried through a greater distance before they settle. An observer standing in the air-way for any length of time when the fans are running at a high speed finds a coat or mackintosh desirable.

At high velocities more air is drawn through the air-way, and hence more water is required to produce a given effect on the temperature and humidity of the air, but, *ceteris paribus*, it is probable that the effectiveness of the screen, considered as a humidifying agent, increases with the speed of the fans.

The speed of the fans is regulated according to the number of Members present, and according to the temperature prevailing; but the latter factor is the more important of the two.

As we should expect, the effect of the sprays is greatest under conditions of high temperature and low humidity, when the fans are probably working at high speed. With humidities of between 40 per cent. and 50 per cent., and temperatures of from 75° to 80° the temperature of the air was found to be reduced by 6° by the time it reached the thermograph by the old fan, and by 7° in the Equalising Chamber. Under similar conditions of humidity, but with temperatures between 60° and 65°, the corresponding changes were only 3·9° and 3·0°, respectively, but it must be borne in mind that under these conditions the fans would be working at only a moderate speed.

At higher humidities the reduction of temperature is, as we should expect, less, and as before, it is conspicuously smaller at low temperatures than at high ones. With humidities between 60 per cent. and 70 per cent., the reduction at the fan is 4·6° for the temperature group 75° to 80°, and only 1·5° for the group from 60° to 65°. With the highest humidities experienced (70 per cent. to 75 per cent.) the reduction of temperature at the fan was only 2·3° for the temperature group 70° to 75°, and 1·5° for the group 65° to 70°. We have no case of humidity of over 70 per cent. in the highest and lowest temperature groups.

It will be noticed that, in almost all cases, the temperature in the Equalising Chamber is slightly higher than in the air-way at the fan. This is probably due to the communication of heat to the air, partly from the walls of the Equalising and Battery Chambers, but mainly from a steam pipe which runs through the centre of the cotton-wool filter, and was always maintained at a very high temperature. The difference between the readings becomes very conspicuous at low temperatures when the fans were running at a minimum, and the air was consequently moving slowly. At high temperatures, on the other hand, when the fans were running at their maximum, the differences were slight, and in some cases the readings in the Equalising Chamber were even lower than those at the fan, suggesting that under these circumstances the evaporation of the spray was not complete by the time the air reached the fan. It was, in fact, noticed on several occasions that drops of water were deposited on the face of the watch used when timing the rate of revolution of the fan.

The changes in the values of the wet bulb readings produced by the sprays are not without interest. At high temperatures, the wet bulb reading in the Equalising Chamber is practically the same as that at the inlet, in spite of the fact that the dry bulb reading is considerably reduced. At low temperatures, on the other hand, the wet bulb reading is raised, sometimes by as much as 2·5°, while the dry bulb is affected to a much smaller extent,—in some cases it is even higher than the temperature of the outer air in consequence of the heating effects mentioned above.

The columns of Table B. showing the change in the relative humidity and in the vapour pressure of the air call for no special comment. The latter figures may be taken as approximately proportional to the mass of water added to each cubic foot of air; to obtain truly proportional values a small correction would have to be applied to allow for changes of temperature.

An interesting side-light on the effects of the sprays was thrown by the traces of the instruments on two occasions when the water was turned off to enable some bacteriological experiments to be carried out in the air-way.

On July 13th the spray was turned off from about 4.15 p.m. to 5.30 p.m. and the following results were obtained :—

Time.	Values abstracted from instrumental traces.					Values deduced from these.				—
	Outer Air.		At Fan.	In Equalising Chamber.		Outer Air.		In Equalising Chamber.		
	Dry Bulb.	Humidity.	Dry Bulb.	Dry Bulb.	Humidity.	Wet Bulb.	Vapour Pressure.	Wet Bulb.	Vapour Pressure.	
	°	p.c.	°	°	p.c.	°	in.	°	in.	
4 p.m. ...	75·0	53	70·0	75·5	70	64·4	·462	64·7	·531	Spray on.
5.30 p.m. ...	76·0	52	74·5	72·5	60	65·0	·468	64·2	·489	Spray off.
6 p.m. ...	76·0	54	71·0	71·5	68	65·5	·483	65·2	·533	Spray on.

Again, on July 26th, the sprays were turned off from about 3.30 p.m. till 4.30 p.m., and we have the following values:—

Time.	Values abstracted from instrumental traces.					Values deduced from these.				—
	Outer Air.		At Fan.	In Equalising Chamber.		Outer Air.		In Equalising Chamber.		
	Dry Bulb.	Humidity.	Dry Bulb.	Dry Bulb.	Humidity.	Wet Bulb.	Vapour Pressure.	Wet Bulb.	Vapour Pressure.	
	°	p.c.	°	°	p.c.	°	in.	°	in.	
3.30 p.m. ...	79·5	52	73	73·5	75	68·2	·532	68·5	·623	Spray on.
4.30 p.m. ...	79·5	52	78	76·0	63	68·2	·532	68·0	·561	Spray off.
5.30 p.m. ...	78·5	57	74	75·0	74	68·9	·568	69·9	·646	Spray on.

On both these occasions the humidity in the Equalising Chamber fell in the course of a few minutes from the "spray on" to the "spray off" value, and then varied but slightly, but the changes shown by the thermograph were much slower, owing, presumably, to the loss of heat by the air to the walls, &c., of the air passages which had been previously cooled by the passage of the air cooled by the sprays. The temperature was still rising slowly in the Equalising Chamber when the sprays were turned on again.

On both occasions also the pressure of the aqueous vapour in the Equalising Chamber remained above that of the outer air, indicating a certain amount of evaporation from the damp walls and floor of the airway. On occasions when the spray was "off" all day the values agreed much more closely.

Summary.

Before dismissing the question of the water screen, it may be useful to summarize its effects on the temperature and humidity of the air. From Table B. (p. 133) we find that the maximum reduction in the temperature of the air which the screen can bring about amounts to close on 7°. As might be expected, this maximum effect occurs when the outer air is both warm and dry (temperatures 75° to 80°, humidities 46 to 50 per cent.). As temperature falls or humidity increases, the amount of reduction becomes less, and under the conditions of lowest temperature (60° to 64°) and highest humidity (60 to 70 per cent.) with which we have to deal in this report, the temperature in the Equalizing Chamber may be higher than that of the outer air by as much as a whole degree. This increase of temperature, as we have seen above, must be due to the communication of heat to the air during its passage from the fan to the Equalising Chamber. At the fan the reduction of temperature was always greater than one degree. If we regard external temperatures of from 65° to 75° and humidities of from 50 to 60 per cent. as typical of average summer conditions, we may say that the air is in general cooled through slightly more than 3° in its passage from the Terrace to the Equalising Chamber.

As regards the question of humidity, we may note in the first instance that the screen had the effect of maintaining the relative humidity in the Equalising Chamber above 60 per cent. throughout the session. The greatest increase in the humidity of the air occurred under the same conditions as the maximum reduction of temperature. Corresponding to a change of temperature of 7°, we find an increase in humidity of 26 per cent. Under the average summer conditions referred to above the increase in the humidity amounted to about 17 per cent., while, under the least favourable conditions met with, it was only 6 per cent.

It is interesting to note that at temperatures above 70° and corresponding humidities above 60 per cent., the wet bulb reading is the same in the Equalising Chamber as in the outer air to within a fraction of a degree, that is to say, the rise in the wet bulb reading which would be produced by the addition of the same amount of water per cubic foot at constant temperature is counter-balanced by the fall which would be brought about by cooling the air by the amount stated without the addition of water. At lower temperatures and greater humidities the wet bulb reading may be raised by more than 2·5°.

The Air above the Ceiling of the House.

The efficiency of the ventilation, considered from the point of view of temperature, can be best estimated from the readings obtained on the afternoon of Monday, July 24th, when every part of the Chamber, both floor and galleries, was crowded to its utmost capacity. The day was a moderately warm summer day, the external temperature varying from 70·5° at 2 p.m. to 72° at 6 p.m. As a very large attendance was anticipated, the ventilation was set going early, with the result that when the House met at 2 p.m. the normal excess of temperature, which was always shown by the thermograph on the ceiling over that in the Equalising Chamber was reduced to a minimum. The fans were maintained at a high speed up to the hour of adjournment.

Here are the readings:—

Hour.	Outer Air (Terrace).	Air-way. At Fan.	In Equalising chamber.	Above Ceiling.		No. of revolutions of Fans per minute.	
				Over Strangers' Gallery.	Over Press Gallery.	Intake.	Output.
	°	°	°	°	°		
2 p.m. ...	70·5	67·0	68·5	*69·5	69·5	152	155
4 p.m. ...	71·0	67·5	69·0	73·0	71·5	177	155
6 p.m. ...	72·0	68·0	69·0	73·0	72·0	177	155
7.30 p.m. ...	71·5	68 0	69·0	73·5	72·5	177	155

* Reading somewhat doubtful, as the thermograph was only started a few minutes before 2 p.m.

It appears that at the hour of adjournment (7.30 p.m.) the temperature of the escaping air was higher than that of the air supplied to the House by 4·5° at the outlet over the Strangers' Gallery, and by 3·5° at the outlet over the Press Gallery. We also see that the temperature rose rather more rapidly in the former place than in the latter. Throughout the period during which thermographs were maintained at both ends of the ceiling, this tendency for the readings over the Strangers' Gallery to be higher than those over the Press Gallery was discernible. The smoke tests carried out after the end of the Session showed that the air at the back of the Strangers' Gallery was comparatively stagnant, and hence liable to become unduly contaminated when the gallery is well filled, and this may account for the differences observed.

The amount by which the temperature of the air is raised during its passage through the Chamber, naturally depends both on the number of

Members present and on the rate at which the air is passed through the Chamber. In this connexion it is interesting to compare the readings obtained on July 25th and 26th with those obtained on August 1st and 2nd.

Date and Hour.	Temperature of Outer Air (Terrace).	Temperature of Equalizing Chamber.	Temperature above Ceiling over		No. of Members present.	No. of Revolutions of Fans per minute.	
			Press Gallery.	Strangers' Gallery.		Input.	Extract.
	°	°	°	°			
July 25th, 2 p.m. ...	75·5	72·0	72	72	80	152	155
4 p.m. ...	75·7	72·0	73	74	120	152	155
6 p.m. ...	75·0	72·0	74	74	100	152	155
7.30 p.m. ...	73·5	72·0	73	74	100	152	155
9 p.m. ...	71·5	72·0	72·5	72·5	40	Varied for experiments.	
11 p.m. ...	69·5*	70·0*	72	73·0	200	152	155
1 a.m. ...	66·5	69·0	72·2	72	400	152	155
July 26th, 2 p.m. ...	78	72·5	73·5	73	120	160	155
4 p.m. ...	79·5	76	76	77·5	415	160	155
6 p.m. ...	78	74·5	76·5	77	420	160	155
7.30 p.m. ...	75·5	73·5	75	76	150	160	155
9 p.m. ...	75·5	72	74	74	100	Varied for experiments.	
11 p.m. ...	70·5	71·5	73·5	75	120	160	155
August 1st, 2 p.m. ...	68	65	66·5	67	340	152	147
4 p.m. ...	68·5	65	67·5	68	140	152	147
6 p.m. ...	68·5	65	67·5	69	190	152	147
7.30 p.m. ...	65·0	64	68·0	68·5	—	152	147
9 p.m. ...	62·5	63	66	67·5	40	—	—
11 p.m. ...	61*	62*	67·8	68·8	120	152	147
Midnight...	60	62	68·5	68·5	470	152	147
August 2nd, 2 p.m. ...	69	64·5	66·5	66·5	70	152	147
4 p.m. ...	68·5	65	67·5	68	120	152	147
6 p.m. ...	66·5	64·5	67·0	68	100	152	147
7.30 p.m. ...	64·5*	63·5*	66·5	67	130	152	147
9 p.m. ...	62	62·5	65 5	66	90	120	115
11 p m. ...	61·5	61·5	68·0	68·5	316	120	115
1 a.m. ...	59·5	61	67·5	67	140	120	115

* Spray turned off as humidity was getting excessive, hence fall of temperature in equalising chamber checked.

On July 25th the temperature of the air supplied to the Chamber remained high enough to enable the fans to be run at a moderately high speed throughout, and on July 26th it was possible to still further increase the speed of the input fan. On August 1st and 2nd, on the other hand, the readings were considerably lower, and, moreover, a rapid fall of temperature occurred during the evening, so that the speed of the fans, particularly that of the extract fan, had to be reduced. The effect of this is clearly shown in the readings of the thermographs over the ceiling, for the temperature of the air was raised no less than 7° during its passage through the Debating Chamber towards the close of the evening, whereas on the warm days the increase never exceeded 3·5°. It is true that the number of Members present in the House between 11 p.m. and 1 a.m. was considerably greater on August 1st and 2nd than on the July days, and that the differences is partly due to this cause, but on the afternoon of July 26th the attendance was still larger, and yet the increase of temperature was only 2·5°. Moreover, when compared with the results quoted above for July 24th, when all parts of the House were crowded to their utmost capacity, the results for August 1st and 2nd must be pronounced unsatisfactory.

It may be that the method of keeping up the temperature by reducing the rate of flow of the air causes little inconvenience to Members on the floor of the House, where a supply of fresh air from the Equalising Chamber is being constantly received, but its effect must be deleterious to the occupants of the galleries who have to draw their entire air supply from the partially vitiated air from the floor of the House. A method by which a small portion of the heating apparatus could be rapidly brought into action when required on cool summer nights would be much more satisfactory.

It may be pointed out that all the experiments described above were carried out during the summer when the heating apparatus was not in use. It remains to be seen whether the new heating apparatus can give off a sufficiently large quantity of heat to maintain an adequate supply of air at a sufficiently high temperature on really cold winter days. That the old apparatus was insufficient under the conditions which prevail now that the new fan has been put in was shown by the fact that it was necessary on the cold days at the end of May to reduce the velocity of the air by passing it through the cotton-wool filter in order to maintain the required temperature within the House.

No results have been obtained from the records of the hygrographs placed above the ceiling of the Debating Chamber. The changes in the amount of moisture present in the air produced by respiration and transpiration were, in all cases, so small that the experimental methods employed to detect them were not sufficiently sensitive. Thus, on July 24th, the values of the pressure of water vapour in the air in the Equalising Chamber and over the ceiling of the House were, respectively:—

—	Equalising Chamber.	Over Ceiling.
At 2 p.m.	·514 in.	·514 in.
4 p.m.	·501	·505
6 p.m.	·486	·493

The probable experimental error is greater than the differences between the simultaneous values, showing that the ordinary hygrometric methods are not applicable to the study of this question.

R. G. K. Lempfert.

September, 1905.

(B.) THE VALUE OF THE WASHING SCREEN AT THE INLET FOR REMOVING BACTERIA FROM THE INDRAWN AIR.

The value of this screen has been investigated from two points of view. In the first place its value for humidifying, and also for cooling the incoming air is seen from the data supplied by Mr. Lempfert's recording instruments and dealt with in his lucid report just given. It was desirable, however, to also ascertain the extent to which the screen removed particulate matter from the incoming air. Tests have, therefore, been carried out to determine its effect from this point of view, both as regards bacteria contained by the air, and also as regards dust particles. The value of the screen in the former sense is seen from the following observations.

(1.) The Purity of the Water used.

The first matter to be examined was the purity of the water supplied to the screen for the purpose of purifying the air. An examination made on July 18th, 1905, of a sample of water drawn from one of the sprays playing on the screen showed that it contained 45 micro-organisms per cubic centimetre capable of developing on gelatine at 22° C., and 15 per c.c., capable of developing on agar at blood-heat. This result indicates that the water was fairly pure from the bacteriological point of view.

(2.) The Value of the Screen for Reducing the Number of Micro-organisms suspended in the Air.

The number of micro-organisms contained in a definite volume of the air before and after passage through the screen was determined on three occasions, and on each by a different method. In all cases the air before and after the screen was examined simultaneously.

The first method used was that of Frankland; the second that of Straus and Wurtz; and the third a modification of Hesse's method. In the case of the first two methods, the air was aspirated by means of a water-pump, the amount drawn through the apparatus being measured by means of an air-meter. In both instances the air was aspirated at the rate of about one litre per minute. The micro-organisms were estimated by cultivating a measured dilution of the filtrate of the air on gelatine at 22° C. With regard to the third or modified Hesse method, I use a piece of glass tubing about four feet in length, and half inch in internal diameter. The glass tube is shortened by being bent into a series of convolutions, and its two extremities are turned upwards. The end of the tube which is to act as inlet for the air besides being bent upwards may also be bent forwards at a right angle on its neck. Before use, sterile nutrient gelatine is poured into the tube at its outlet end, and after replacing the plug of wool, the apparatus is steamed for twenty minutes. A series of these tubes may be prepared at the same time, and if securely plugged and preserved in a dark cupboard will keep for months. When in use the outlet end of the tube, with the wool plug left *in situ*, is connected by rubber tubing to the top of an aspirator bottle previously calibrated and filled with water, and the tube is clamped in such a position that its inlet is turned away from the direction in which the air is flowing. The wool plug is now removed from the inlet, and the tap of the aspirator bottle at once turned to a point previously determined. The point to which the tap is turned is such that water flows out of the aspirator bottle (and air, therefore, into it) at a rate not exceeding 500 c.c. per minute. When 5 litres of air have in this way been drawn slowly over the gelatine, the aspirator tap is turned off, and the inlet of the tube at once replugged. The tube is then disconnected and either incubated at 22° C. or kept in a dark cupboard until the micro-organisms deposited from the air upon the gelatine have developed into colonies. I generally count the latter on the fourth day.

The results obtained when examining the air before and after the screen by these three methods are seen in the following table:—

Test.	Method.	Date.	Amount of air sampled.	Total number of Micro-organisms per litre of air. Before Screen.	After Screen.	Reduction per cent.	Speed of Inlet Fan.
1	Frankland ...	July 18th	50 litres	5·2	1·8	66	160 revs.
2	Strauss and Wurtz.	Aug. 8th	75 litres	5·8	2·5	62	150 revs.
3	Modified Hesse	Aug. 4th	10 litres	6·7	2·6	62	150 revs.

It would appear from these results that the washing screen is of considerable value for freeing the incoming air of micro-organisms. The average reduction found in the three tests, which were all made whilst the House was sitting, was about 63 per cent. How much of this reduction was due to the sprays, and how much to the wet gauze, has not yet been determined.

The great majority of the micro-organisms that developed were moulds. As the significant kinds of bacteria present in the air entering the inlet had been previously determined in much detail, and by more suitable methods, it was considered unnecessary to go into this matter again in the present instance.

(3.) The Influence of the Screen in Reducing the Number of Micro-organisms Deposited from the Air.

On July 4th this matter was determined in the following way:—

A small table 3 feet 6 inches in height was placed in the middle of the airway at a point about 50 yards past the washing screen. The water was now turned off the screen, and when the copper gauze had become quite dry—which took about ten minutes—I marked two spots on the table and exposed an agar plate on each for thirty minutes. The water was then turned on at the screen, and after ten minutes pause, in order to allow the sprays to thoroughly wet the entire surface of the gauze, another pair of agar plates were exposed on the same spots on the table for thirty minutes. The water was then turned off at the screen, and after ten minutes another pair of agar plates were exposed on the same spots on the table for thirty minutes.

Water off.

Water on.

Water off.

The six agar plates were incubated for forty-eight hours at 22° C., and at the end of that time the colonies that had developed upon them were counted. The results were as follows:—

Test.	Washing Screen.	Number of Micro-organisms developing upon the Plates.	Mean.
1	Off	425 497	461
2	On	153 106	129
3	Off	457 506	481

When the water screen was in action, therefore, the number of micro-organisms deposited from the air was reduced by about two-thirds.

It should be added that in this test, which was also made while the House was sitting, the speed of the fan was kept uniform throughout, viz., at 130 revolutions per minute.

It was observed during these experiments that the copper gauze was very effective in the way of straining off flies from the incoming air.

(C.) THE VALUE OF THE WASHING SCREEN AND COTTON-WOOL FILTER, RESPECTIVELY, FOR REMOVING DUST PARTICLES FROM THE INCOMING AIR, Etc., by J. AITKEN, LL.D., F.R.S.

On the forenoon of the 31st of May, 1905, an inspection was made by Dr. Gordon and myself of the alterations recently introduced in the ventilating arrangements of the House of Commons, and tests were made of the effect of the water screen, and the cotton-wool filter, on the number of particles of dust in the air.

A number of tests were first made of the air on the Terrace by Dr. Gordon and myself. The result given by both instruments was about 40,000 particles per cubic centimetre. The number varied from time to time, from a little under to a little over that number. We then proceeded to test the effect of the water screen. Dr. Gordon remained on the Terrace while I proceeded to the inside of the air passage, to the far side of the water screen to test the effect of the screen in reducing the number of dust particles. The screen was in full working order, water flowing copiously over it. While I was testing the air after its passage through the screen Dr. Gordon was at the same time counting the number in the air before it entered the air passage on the Terrace. A number of tests were made, but we could detect no difference in the number of particles in the air before entering the screen and after passing through it. The numbers on both sides of the screen remained a little over or a little under 40,000 per c.c.

This result is much what might have been anticipated from what we know of the action of any such piece of apparatus. In the investigation published in the Trans. Roy. Soc., Edinburgh, Vol. xxxii, Part 2, I have shown that the dust particles in the atmosphere are attracted by any dry surface colder than the air, but repelled by surfaces hotter than the air, and also repelled by moist evaporating surfaces. During the summer months the wire screen will generally be colder than the air, but during these months the evaporation will be sufficiently strong to counteract the attraction produced by the cold, and thus prevent the dust particles coming in contact with the wet surface. The efficiency of such a screen can at best be but slight, and its powers may vary from practically nil to something very small; its best working conditions being a hot, saturated air and cold water. Under these conditions, as there will be no evaporation to counteract the attraction of the cold surfaces, some dust will settle on the screen.

But while the tests made with the dust counter show no appreciable effect of the water screen in reducing the number of dust particles, we must not therefore conclude it had no effect on the character of the dust. It is quite possible, and very probable, that it will have some effect in stopping some of the larger particles, as these by their inertia will be driven against the wet surface, the evaporation effect not being strong enough to keep them off. Now, as a hundred or so of these large particles per cubic centimetre might be trapped by the screen without their loss having any appreciable effect on the 40,000 per c.c. counted by the dust counter, it may still be claimed that the screen has a beneficial effect. This claim can, however, be best settled by bacteriological tests, as bacteria are much larger than most of the dust particles.

After the water screen tests were completed Dr. Gordon and myself proceeded to test the effect of the cotton-wool screen. These tests were made in the Equalising Chamber over the inlets. The result of our tests was to show that the number of dust particles was reduced from 40,000 to 7,000 per c.c., or less than one-fifth of the number in the air before entering the screen. This result may be looked on as fairly satisfactory, though at first sight it may not appear so. But we must remember that no special precautions had been taken to make the wooden and other divisions air-tight in the passages between the filtered and unfiltered air, and much dusty air no doubt gets to the filtered side without passing through the cotton-wool; then there is the difficulty of making the whole surface of the filter such that no air escapes passing through the wool; and in considering the result we must remember that the filter will necessarily be most effective on the larger particles, so that those which have escaped will be mostly the very fine ones and therefore less harmful; so I think we are justified in considering the effect of the filter to be fairly good, though no doubt it might be made better.

JOHN AITKEN.

June 16th, 1905.

It may be added that on December 11th, 1905, when a dense fog prevailed, the opportunity was taken of testing the value of the washing screen at the inlet for removing fog from the air, and that its effect was found to be negative in this respect. The cotton-wool filter, on the other hand, efficiently removed the fog from the air on the same occasion. It was found that the best results as regards freshness and clearness of the atmosphere in the Debating Chamber were obtained when the input fan was alone in action, and at maximum. Under this condition there was found to be a distinct outward pressure of air through the doors of the Debating Chamber. But when the extract fan was now put on, even though its speed was at minimum, the air in the Debating Chamber became less clear owing to its being contaminated by foggy air drawn in from outside the building, and the pressure at the doors of the Debating Chamber was found to be inwards.

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4. THE QUESTION OF LEAKAGE OF UNDESIRABLE AIR INTO THE SYSTEM.

(1.) *The effect of raising the Terrace Inlet in the fashion adopted during last session.*

In order to meet—so far as present architectural and structural considerations allow—a suggestion that the Terrace Inlet should be raised, wooden surrounds 4 feet 2 inches high were placed round two of the three openings by which air is indrawn at this point. It was not practicable to raise the third or north opening in the same way because the grating over it forms the approach to a doorway giving access to the Terrace, and much used.

The height of the two surrounds was determined by the fact that they could not be raised higher without obstructing the windows of Members' private dining-room D. At the height to which these two inlets were raised, the top of the surrounds were on a level with the sills of the windows of this dining-room.

It was frequently noticed during last session that towards evening a strong smell of dinner found its way into the airway from the Terrace, and this raised the suspicion that the smell was due to leakage of air into the inlet from refreshment-room D.

The following tests were made to decide this matter:—

Experiment 1.

Conditions.

Surrounds enclosing the two inlets as during the last session. A strong south wind blowing. The two windows of the dining-room were opened to a height of 2 feet, and the average of three one-minute readings taken with the anemometer at each.

Results.

Fan off.—2,050 cubic feet of air passes into the room per minute.

Fan medium speed.—520 cubic feet of air passes out through the windows into the airway per minute.

The test was repeated on another occasion when there was no wind.

Results.

Fan off.—No reading obtained with the anemometer at the windows.

Fan medium speed.—760 cubic feet of air passes out of the windows into the airway per minute.

On generating smoke in the refreshment-room, the smoke was found to rapidly pass out through the windows into the airway, and the Debating Chamber became clouded with this smoke. The smoke was observed to pass out of the refreshment-room chiefly through the lower part of the windows.

Experiment 2.

(A.) The surround enclosing the centre inlet was lowered to a height of 3 feet.

Result.

Fan off.—No reading.

Fan medium speed.—500 cubic feet of air passed into the room through the south inlet window, and 490 passed out of it through the centre window.

Fan maximum speed.—200 cubic feet passed into the room through the south inlet window, and 520 out through the centre window.

(B.) The height of the surround enclosing the south inlet was now also diminished to 3 feet.

Result.

Fan off.—No readings.

Fan medium speed.—Very slight movement into room through upper half of windows and out through lower half.

Fan maximum speed.—300 cubic feet of air passed out of room into the airway.

Experiment 3.

Surrounds taken away entirely and inlets left at ground level as before last session.

Slight wind; temperature of room 58° F.; outside temperature 48° F.

Result.

Fan off.—330 cubic feet of air passing through windows into the room.

Fan medium speed.—350 cubic feet of air passing through windows into the room.

Fan maximum speed.—300 cubic feet of air passing through windows into the room.

Inferences.

These experiments prove that the effect of raising the inlet in the fashion adopted is to aspirate air out of the windows of the refreshment-room D and to forward this air to the Debating Chamber when the input fan is working.

On the other hand, when the inlets are at the ground level as formerly, no evidence of this transfer of refreshment-room air to the Debating Chamber was found.

It is clear, therefore, that the mode of raising the inlets here adopted is undesirable.*

(2.) *The question of air leakage from the engine rooms and basement into the airway between the Terrace Inlet and the Input Fan.*

When the input fan is in action, the minus pressure at this part of the airway varies from 0·3 to 0·7 inch water gauge. This minus pressure is not appreciably increased by turning the water on at the washing screen at the inlet.

Evidence was previously found of air from the basement being drawn into the airway and forwarded to the Debating Chamber, and accordingly this matter has been re-examined. The indicator used was as before, H_2S, gas generated outside the airway. The whole of the parts of the airway between input fan and inlet were systematically examined, and places where the gas came through marked for stopping.

* The surrounds have now been removed.

A good deal of thought has been given to the problem of preventing leakage into the system of air from the basement corridors. Short of removing the input fan to the inlet as suggested by Dr. Aitken—an alteration which unfortunately is at present impracticable because of structural considerations—the desideratum is to form at each of the three doors into the airway at this part an air lock by means of two doors separated from each other by a distance of a few feet. By recent tests the present form of door and frame has been found unsuitable to stand the strong minus pressure of the fan (0·3 to 0·7 inch water gauge). Experiments are now being made with a door having a cast iron frame with a slightly rounded knife edge making airtight contact with the rubber face of the door.* The door is held in tight contact with the frame by means of a handle at its centre which operates four metal bolts, each of which is tapered and slides into a slot fixed in the frame.

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* The rubber is dovetailed into the woodwork of the door.

SECTION IV.

OBSERVATIONS DURING 1905 OF THE QUANTITY OF AIR PASSED THROUGH THE DEBATING CHAMBER SYSTEM.

QUANTITY SECTION.

CONTENTS.

1. DESCRIPTION OF THE AIR-COURSE OF THE DEBATING CHAMBER SYSTEM. (See plan.)

(A.) INFLOW.

Air, drawn down from the Terrace through the windows of the three chambers which comprise the Terrace Inlet, passes at once through the washing screen stretched across each chamber, and then travels for a distance of about 100 feet along a somewhat narrow and irregular passage past the "ice racks" to the input fan.

The first branch out of the system is given off from the ceiling of the air-way soon after the input fan. This branch, which is provided at its base with a coil of steam pipes, goes up to the floor of the Commons Lobby. This first branch of the System therefore is given off before the cotton-wool filter is reached.

The bulk of air goes past this branch to the Commons Lobby and, except in time of fog, passes through open doors in the sides and end of the cotton-wool filter direct to the Battery Chamber above. When a fog is on, however, the doors into the cotton-wool filter are closed, and the air then enters the filter through the six inches of cotton-wool with which its sides are filled. When it has gained the interior of the cotton-wool filter, the direction of the air-stream is changed into an upward direction.

In order to understand some of the results which will shortly be described, it is important to bear in mind that the space in which the cotton-wool filter lies is of the same sectional area as the passage from the input fan. On the other hand, the two chambers to which the air passes after leaving the cotton-wool filter are much larger, being, in fact, of the same length and breadth as the Debating Chamber, of which they form the two lower stories.

The gratings in the ceiling of the cotton-wool filter form the floor of the middle portion of the Battery or Heating Chamber to which the air next passes, and the gratings in the ceiling of the Heating Chamber are the inlets in the floor of the Equalising Chamber.

When the air has reached the Equalising Chamber it can take one of two directions. It can pass on directly upwards through the roof of the Equalising Chamber which constitutes the floor of the Debating Chamber, or it can pass laterally through five openings or "port holes" in the side walls of the Equalising Chamber into the space beneath the floor of the Division Lobbies. The Equalising Chamber is thus an "air junction" for the Debating Chamber and Division Lobbies.

In addition to the ceiling of the Equalising Chamber, which almost wholly consists of cast-iron gratings, there are some special shafts by which air can be conveyed to the galleries of the Debating Chamber. The chief of these shafts at present operative open laterally in the walls of the Equalising Chamber between the "port holes" conveying air to the Division Lobbies. These shafts, which are four in number on each side, convey air in part to the space under the gallery, but chiefly to the Members' gallery on each side of the Debating Chamber. For the latter reason they will be referred to as the "Members' Gallery shafts."

Besides these Members' Gallery shafts there are a number of shafts which rise in the wall upon each side of the Debating Chamber and convey air from the upper side of the "port holes" cut in the walls of the Equalising Chamber (*see* section). These shafts go to the Members' Gallery and also to the Retiring Rooms. They convey at present comparatively little air owing to the position of their origin in the Equalising Chamber, and also to their small size and consequently great resistance. Accordingly they have not been systematically examined in the present investigation.

Besides the shafts mentioned there are no channels at present operative by which air is conveyed directly from the Equalising Chamber to the Strangers', Press or Ladies' Galleries, or to the Press rooms. These parts of the House at present depend entirely upon the body of the Debating Chamber for their air supply. Accordingly, in summer, when the Debating Chamber windows are open, the occupants of these places benefit considerably thereby.

(B.) Outflow.

The new extract fan over the Commons Lobby extracts air through three openings. One of these is an outlet from the Ways and Means corridor and adjoining rooms and will not be further considered, because the inlet to that district is outside the Debating Chamber system. The second opening delivers air from the Commons Lobby. The third, largest, and most important opening of all is the hydraulically operated "shutter-valve" through which all air extracted from the Debating Chamber by the extract fan must pass.

The collecting area from which is gathered the air that passes through the shutter-valve in question is formed chiefly by the raised panels of the ceiling of the Debating Chamber. The spaces between these panels and their supporting framework, however, do not constitute the sole channels by which air passes from the Debating Chamber to the extract fan. Over the Ladies' and Speaker's Galleries is an arch in the wall, and through this arch all air extracted from the Ladies' and Speaker's Galleries passes to join the air extracted through the ceiling by the fan.

The central part of the ceiling is free to deliver air either to the gaslights or to the main extraction.

Division Lobby Extract.

The extract from the Division Lobbies is cut off from the ceiling area of the extract fan and is at present still actuated by the coke furnace in the Clock Tower. Owing to the air-course connection between the perforated panels of the ceiling of the Division Lobbies and the Clock Tower furnace being so long and tortuous, the pull which the furnace exerts upon these Lobbies is but feeble, as will be seen later.

The Lavatories in the Division Lobbies are also joined for extract purposes to the Clock Tower furnace.

The Retiring Room extract and lavatories are joined to the Division Lobby extract, and are therefore also actuated by the Clock Tower furnace.

The Press Rooms extract, which is also joined to the Clock Tower furnace, is connected to that system at a point nearer the Clock Tower.

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2. STATIONS AT WHICH OBSERVATIONS OF THE AIR-FLOW HAVE BEEN CHIEFLY TAKEN.

(A.)—Inflow.

Inflow.

The general inflow was always observed at the ice racks in the airway before the input fan.

The Common Lobby inflow was observed at the base of the shaft to the Commons Lobby. On two occasions the air-flow was observed in other parts of this system.

The air-flow through the *Battery Chamber* was investigated at the gratings in the floor of this chamber, but owing to a strong down current of air at the end under the Bar, no quantitative estimate was here made of the air-flow.

The air-flow into the Equalising Chamber was frequently observed by anemometer at all of the 17 gratings by which air is at present admitted through the floor of this chamber.

The flow into the Division Lobbies was measured at the "port holes" by which air passes into these Lobbies. It was also measured at two openings, by which, at either end of the Equalising Chamber, air is conveyed to some perforated panels in the sides of the Division Lobbies.

The flow of the Members' Gallery shafts was observed by exposing the anemometer in the rising part of each shaft.

The quantity of air passing into the Debating Chamber was deduced by subtracting the air-flow to the Division Lobbies from the air-flow into the Equalising Chamber through its floor on the same occasion.

Inside the Debating Chamber, the air-flow to the Benches was measured by anemometer observations at the inlets to them. The inlets in question consist of a slit behind each Bench, and a space left between the valance of the seat and the floor.

The air-flow through the remaining part of the Debating Chamber floor, which chiefly consists of gangways, was arrived at by subtracting the total air-flow to the Benches from the quantity of air deduced from observations in the Equalising Chamber, as the amount flowing through the floor of the Debating Chamber on the same occasion.

(B.) Outflow.

Outflow.

The air extracted from the Debating Chamber by the extract fan was observed at the shutter-valve above the ceiling; at the arch to the Ladies' and Speaker's Gallery; and at the ceiling panels.

The air extracted from the Commons Lobby was observed at the outlet therefrom near the extract fan.

The air extracted from the Division Lobbies was observed at a doorway at the base of a large perpendicular shaft, by which, on either side of the Debating Chamber, air from each of these Lobbies respectively passes to the top of the Debating Chamber to join the openings of four downcast shafts by which it descends again towards the Clock Tower furnace.

The air extracted from the Lavatories and Retiring Rooms on each side was observed on the same occasion at a smaller doorway at the base of each of the two perpendicular shafts.

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3. METHOD BY WHICH THE AIR-FLOW HAS BEEN DETERMINED.

The quantity of air propelled along the air-courses of the Debating Chamber system at various speeds of the input and extract fans has been determined by anemometer. The sole instrument employed was the anemometer made by Casella. Before beginning the present investigation, the error of this instrument at air velocities of from 50 to 500 feet per minute was ascertained by submitting it to Kew Observatory, and throughout the inquiry the readings have been corrected according to the figures then supplied.

When measuring the velocity of the air, the anemometer was held on a stick 3-4 feet in length, and was moved slowly but continuously and as far as possible at an equal rate either in a perpendicular or in a horizontal direction through each quarter section in turn, until the whole of the sectional area of the air-course at the point where the reading was being taken had been covered. At the beginning of the investigation the question arose as to whether an appreciable increase of accuracy in the method would be obtained by increasing the length of the stick on which the anemometer was held, but on being put to the test of experiment this question was found to be answered in the negative. Later on, a further question arose, viz., whether, in case of readings obtained by passing the anemometer close to, but not touching, the face of a grating, the air-flow through the said grating should be calculated by multiplying the velocity by the whole sectional area of the grating, or whether the velocity should be multiplied only by that portion of the area of the grating that was actually patent. This question was also solved by experiment and in the following way: One of the gratings in the floor of the Equalising Chamber was selected and readings taken by passing the anemometer over the face of it in the usual way. The readings so obtained were then compared with readings taken on the same occasion at the top of a "cuff" which had been erected round the circumference of the grating to a height of 3 feet. In this way it was possible to compare readings obtained at the actual face of the grating with readings obtained when the air-currents passing through the grating had become "equalised," and as a result it was found that to estimate the air-flow correctly, the air velocity ascertained by passing the anemometer over the face of the grating in the usual way should be multiplied only by the sectional area of that part of the grating which was actually patent.

The question of readings at gratings.

At an early stage of the enquiry Mr. Patey made some alterations in the floor of the Debating Chamber, as the result of which good anemometer readings were found to be obtainable at the inlets to all the benches. As has been stated previously, advantage has been taken of this fact to measure the inflow of air to the Benches. The effect on the air supply to the Benches of blocking the gangways with carpet, and of lifting the valances entirely has also been observed in the same way.

Readings at slits.

Anemometer observations of the air-flow to the Benches by the slits were not found to present much difficulty, as the sectional area of these inlets was large enough to admit of the whole of the vaned wheel of the anemometer being inserted. On the other hand, observations of the air-flow by the space under the valance—a space averaging $1\frac{1}{4}$ inches in height—caused considerable perplexity in regard to the extra correction

Reading at valances.

needed for the instrumental error under these circumstances. The correction which has been adopted was arrived at by the following experiments, designed and executed by Mr. Patey :—

1. Two Casella anemometers were taken and compared under the same conditions of air-flow. Three one-minute readings taken simultaneously in a 4-feet tube having a constant air-flow showed that the readings given by the two instruments agreed to within 2 per cent.

2. The two anemometers were then compared at the valance inlet by taking readings in the ordinary way, and again the variation between the two instruments was less than 2 per cent.

3. Each of the two anemometers was now placed in a small frame of the same size and pattern, with the exception that one of these frames was fitted with a sliding shutter by means of which the wheel of the anemometer could be screened to any degree desired.

4. On comparing the two anemometers in their frames at the valance inlet, with the shutter of anemometer A raised, the results were as follows. The figures quoted in this and the following experiments are in all cases the average of four one-minute readings :—

Anemometer A.—Shutter raised, 140.

Anemometer B.—146.

5. The shutter of anemometer A was now lowered until the part of the anemometer wheel exposed to the air-current measured only $1\frac{1}{4}$ inch in height, that is to say, until the upper limit of the part of the wheel exposed exactly corresponded with the lower level of the fringe of the valance. The results now were as follows :—

Anemometer A.—Only $1\frac{1}{4}$ inches of wheel exposed, 124.

Anemometer B.—Whole of wheel exposed, 143.

6. On raising the shutter of anemometer A until $1\frac{3}{4}$ inches of the anemometer wheel was exposed, *i.e.*, until the part exposed was of the same height as the valance inlet, including fringe, the following results were obtained :—

Anemometer A.—$1\frac{3}{4}$ inches of wheel exposed, 141.

Anemometer B.—Whole of wheel exposed, 144.

7. Experiment 5 was now repeated, but with the frames containing the anemometers in a current of uniform velocity as in experiment 1, the results were as follows :—

Anemometer A.—$1\frac{3}{4}$ inches of wheel exposed, 140.

Anemometer B.—Whole of wheel exposed, 220.

Inferences.

1. When the whole surface of their respective wheels was exposed to the air-current, the two anemometers gave readings that, for practical purposes, may be regarded as identical.

2. The velocity reading obtained at the valance inlet in the ordinary way is equivalent to a reading obtained by exposing $1\frac{3}{4}$ inches only of the wheel of the anemometer to the air-current.

3. The velocity reading obtained when $1\frac{3}{4}$ inches of the anemometer wheel is exposed to the air-current is only about 63 per cent. of the reading obtained at the same air velocity but with the *whole* of the wheel of the anemometer exposed.

4. It is therefore necessary to add some 37 per cent. to the reading obtained at the valance in the ordinary way. This has been followed

throughout the tests of the air-flow at the valances by adding one-third to the reading before adding the Kew correction for the velocity thus arrived at.

When examining the finer distribution within the Debating Chamber of air supplied from the Terrace inlet, and especially when endeavouring to ascertain the extent to which the galleries benefit from this air, exceedingly useful evidence has been obtained by adding smoke to the air at the Terrace inlet, and by then observing the path of this smoke-tinged air through the Debating Chamber. On many occasions also we have employed smoke to check the validity of conclusions arrived at by the anemometer.

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4. OBSERVATIONS OF THE GROSS QUANTITY OF AIR PASSED INTO THE SYSTEM THROUGH THE TERRACE INLET AND OUT OF THE DEBATING CHAMBER AT VARIOUS SPEEDS OF THE TWO FANS.

Except when expressly stated otherwise, all windows and doors in the Debating Chamber were closed when determining the air-flow. The Division Lobby windows, however, were kept open, and the small extraction fans in them were kept going. Airflow at Terrace inlet and Debating Chamber outlet.

At the same time that the inflow was being taken at the ice-racks, the outflow from the Debating Chamber was taken at the shutter valve above the ceiling.

Throughout the records of anemometer observations, the figures for the flow of air signify cubic feet of air passing per minute.

It will be convenient to consider the results obtained:—

1. When both fans were working.
2. When the input fan alone was working.
3. When the extract fan alone was working.

The inflow and outflow when both fans were working simultaneously is seen from the following table, which should be read quite across from left to right :—

	Input System.			Extract System.		
No.	Input Fan Speed.	Revolutions.	Inflow at Terrace Inlet.	Extract Fan Speed.	Revolutions.	Outflow at Debating Chamber Shutter.
1	Minimum	120	36,045	Minimum	128	42,400
2	Do.	120	36,000	Do.	115	40,400
3	Maximum	190	58,005	Maximum	177	55,600
4	Do.	190	58,000	Do.	165	57,000
5	Near Maximum	176	54,765	Minimum	113	38,500
6	Minimum	118	36,405	Maximum	177	56,880

NOTE.—In considering these results it must be borne in mind that air entering the Terrace Inlet supplies the Commons Lobby and Division Lobbies as well as the Debating Chamber. It is, therefore, wrong to assume that all air entering the Terrace Inlet passes to the Debating Chamber.

Inferences.

(A) *The amount of Terrace Air passed into the system.*

It appears from these observations that when both fans were put at their minimum speed, about 36,000 cubic feet of Terrace air passed into the Debating Chamber *system* per minute; and that when the speed of both fans was increased to maximum, the amount of Terrace air indrawn increased to 58,000 cubic feet per minute.

(B) *The Air-flow when both Fans were put at the same Speed.*

When both fans were at their minimum speed, the amount of air extracted from the Debating Chamber was slightly in excess of the amount propelled from the Terrace Inlet; but when both were at maximum speed, the input fan propelled slightly more air into the *system* than the extract fan withdrew from the Debating Chamber. It will be noticed, however, that under maximum conditions the input fan is run at a higher speed than the extract. The reason of this has been previously explained, viz., resistance.

(C) *The Air-flow when the Fans are run at Unequal Speeds.*

The first of the two tests that in the table come under this heading, namely, test 5, goes to show that the input's maximum is well in advance of the extract's minimum. The result of the second test, however, shows that the extract fan can get a good proportion of its air complement independently of the Terrace Inlet.

(2.) THE AIR-FLOW WHEN THE INPUT FAN ALONE IS WORKING.

When the extract fan was stopped, and the input fan put at minimum speed and then increased to maximum, the results were as follows:—

Input System.			Extract System.		
Input Fan Speed.	Revolutions.	Inflow at Terrace Inlet.	Extract Fan Speed.	Revolutions.	Outflow at Debating Chamber Shutter.
Minimum	117	35,500	Zero	0	9,100
Maximum	182	54,500	Zero	0	12,500

Inference.

Only about a quarter of the air impelled into the system by the input fan, therefore, was expelled through the ceiling of the Debating Chamber under these conditions.

When the input of air was increased by 53 per cent., the outflow from the Debating Chamber increased by 37 per cent.

(3.) THE AIR-FLOW WHEN THE EXTRACT FAN ALONE IS WORKING.

When the conditions of the last test were reversed, the input fan being stopped altogether and the extract put at its minimum, and then increased up to its maximum, the flow of air is seen from the following table:—

Input System.			Extract System.		
Input Fan Speed.	Revolutions.	Inflow at Terrace Inlet.	Extract Fan Speed.	Revolutions.	Outflow at Debating Chamber Shutter.
Zero	0	1,035	Minimum	125	39,320
Zero	0	2,160	Maximum	177	55,960

Inference.

Although the input fan was stopped, the extract fan obtained its complement of air from the Debating Chamber; but only an insignificant proportion of this air came from the Terrace Inlet.

When the air extracted was increased by 43 per cent., the inflow from the Terrace Inlet was increased by 108 per cent.

In view of the result of the last test it was desirable to define at once, so far as possible, the sources within the Debating Chamber from which the extract fan drew its air when the input fan was stopped.

(4.) The Field of the Extract Fan.

It was discovered that during the last test mentioned a door at the back of the Strangers' Gallery had been opened, and left open. The Division Lobby windows also had, as usual, been open throughout.

In the next test, therefore, which was carried out on July 24th, the previous test was repeated in the following manner. As before, the input fan was stopped and the extract put at its maximum. Three series of observations of the air-flow were then made in different parts of the Debating Chamber under the following conditions respectively.

1. Door to Strangers' Gallery and Division Lobby windows open.
2. Door to Strangers' Gallery shut. Division Lobby windows open.
3. Both door to Strangers' Gallery and Division Lobby windows shut.

The points at which observations were taken, and the flow of air observed at each, are seen from the following table:—

Input Fan Stopped. Extract Fan Maximum.

—	1 Door Strangers' Gallery open. Division Lobby windows open.	2 Door Strangers' Gallery shut. Division Lobby windows open.	3 Door Strangers' Gallery shut. Division Lobby windows shut.
Air-flow into Terrace inlet.	3,420	4,815	6,480
Down-flow of air *from* Division Lobbies into Equalising Chamber.	12,744	14,903 (19,000 in a later test).	11,491
Door behind Strangers' Gallery.	Air-flow to Debating Chamber: Velocity 207 ft. per minute.	Shut	Shut
Door behind Ladies' Gallery.	Not observed	Velocity 142 ft. towards Grille.	Velocity 197 ft. towards Grille.
Out-flow from Ladies' and Speaker's Gallery to Ceiling.	3,990	4,199	4,180
Out-flow from Debating Chamber Shutter.	54,320	56,360	56,560

Inferences.

The result of this test goes to show that under the circumstances examined, the extract fan drew its air into the Debating Chamber in great part through the windows of the Division Lobbies (whence it passed down into the Equalising Chamber, and thence up through the floor of the Debating Chamber), but also through the various doors and windows in the sides of the Debating Chamber. Amongst the doors through which the extract fan was drawing air into the Debating Chamber, were the doors at the backs of the Strangers' and Ladies' Galleries.

When the Debating Chamber and Division Lobbies were made as air-tight as possible by shutting all the doors and windows, the extract fan nevertheless obtained its full complement of air through the sides of the Chamber and Division Lobbies rather than from the Terrace Inlet.

The cause of this result is clearly a structural one, viz., that the airway by which air passes from the Terrace Inlet to the Debating Chamber is so long, narrow, and winding that the resistance which it offers to the inflow of air is greater than the resistance offered by the sides of the Debating Chamber and Division Lobbies when all doors and windows are shut, and the extract fan alone is working.* For this reason the extract fan, when not fed by the input fan, draws air from foreign sources rather than from the legitimate Terrace Inlet.

A further important point was discerned in this test, and afterwards confirmed in many and various tests, namely, that the lateral outflow of air from the Equalising Chamber to the Division Lobbies is a sensitive index by which the degree of the over-balancing of the input by the extract fan may be gauged. When the supply of Terrace air to the Equalising Chamber is below the demands of the extract fan, not only is the normal lateral outflow to the Division Lobbies stopped, but as the overbalancing progresses a current of air develops in the opposite direction, that is to say, from the Lobbies to the Equalising Chamber.

The effect of a later test in particular, in which it was found that the opening of windows in the Debating Chamber caused more air to flow out of the Equalising Chamber into the Division Lobbies, is an instance of the effect of lessening the pull of the extract fan on the inlets to the Division Lobbies.

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5. OBSERVATIONS OF THE QUANTITY OF AIR PASSED THROUGH EACH PART OF THE SYSTEM WITH VARIOUS SPEEDS OF THE TWO FANS, &c.

The parts of the system at which the air-flow has been determined are:—

(1.) The Commons Lobby.

(2.) The Equalising Chamber.

(3.) The Division Lobbies.

(4.) The Debating Chamber.

(1.) The Commons Lobby.

The results of two surveys of the air-flow through the Commons Lobby are contained in the following tables. The observations were made

* The resistance of the washing screen has also to be taken into account.

during August, 1905. The windows of the Lobby were all shut while they were proceeding :— Commons Lobby.

Test I.

Commons Lobby Air-flow.

Observation.	1	2	3	4
Input Fan	Zero.	Minimum.	Medium.	Maximum.
Extract Fan	Zero.	Minimum.	Medium.	Maximum
Air-flow up Commons Lobby Shaft	2,013	6,593	7,277	9,354
Portion of this air going into Commons Lobby.	1,497	6,097	5,918	7,491
Portion going to Whips' Rooms and Post Office.	516	496	1,359	1,963
Air extracted at ceiling of Commons Lobby.	1,102	4,833	5,574	6,365

Test II.

Commons Lobby Air-flow.

Observation.	1	2	3	4
Input Fan	Zero.	Minimum.	Medium.	Maximum.
Extract Fan	Zero.	Minimum.	Medium.	Maximum.
Air-flow up Commons Lobby supply shaft.	499	6,201	7,450	8,151
Portion of this air going to the Lobby.	−108	4,824	6,663	7,393
Portion going to Whips' Rooms and Post Office.	?499	1,377	787	758
Air extracted from Commons Lobby	1,137	4,662	5,745	7,257

Inferences.

(1.) *Supply* v. *Exhaust.*

The figures for the extraction show that in these tests the exhaust from the Lobby well balanced the supply.

(2.) *Efficiency of the Ventilation.*

The average number of persons present in the Commons Lobby during debates is estimated at 120, and the maximum at 180. According to these estimates the volume of air supplied by the ventilation per head in the Commons Lobby would be as follows :—

Cubic feet of Air supplied per head per minute in the Commons Lobby.

Input Fan		Zero.	Minimum.	Medium.	Maximum.
Extract Fan		Zero.	Minimum.	Medium.	Maximum.
120 persons present	Test 1 ...	12	50	49	62
	„ 2 ...	0	40	55	61
180 persons present	„ 1 ...	8	33	32	41
	„ 2 ...	0	26	37	41

These results indicate that the ventilation of the Commons Lobby, independently of the windows, is satisfactory under ordinary circumstances; and by no means bad when it is relatively full, and both fans going at their maximum speed.

(2.) THE GRATINGS IN THE FLOOR OF THE EQUALISING CHAMBER.

Equalising Chamber.

The quantity of air passed into the Equalising Chamber under various fan speeds is of cardinal importance because of the Equalising Chamber being the air junction for both Debating Chamber and Division Lobbies.

The air-flow at this point under various fan speeds is shown in the following table :—

I.—Air-flow through floor of Equalising Chamber.

No.	1	2	3	4	5	6	7
Input Fan	0	0	Max.	Max.	Max.	Max.	Med.
Extract Fan	0	Max.	0	Max.	Max	Min.	Med.
Air-flow through floor of Equalising Chamber.	2,561	9,005	44,801	43,509	42,271	40,725	35,445

It appears from these results (1) that the essential condition for obtaining the maximum delivery of air at the floor of the Equalising Chamber is to have the input fan at its maximum speed, and (2) that the extract fan exerts comparatively small influence on the air-flow at this point. In experiment 2, in which the extract alone was acting, and at maximum, there was a downflow of air (919 cubic feet per minute) through the Commons Lobby shaft to the air-way.

II.—Experiments showing effect of closing down Commons Lobby Shaft.

Experiment	1	2	3
Commons Lobby Shaft	Open.	Shut.	Shut.
Input Fan	Maximum.	Maximum.	Maximum.
Extract Fan	Minimum.	Minimum.	Minimum.
Air-flow through floor of Equalising Chamber ...	40,725	52,030	53,963

By closing the Commons Lobby shaft, therefore, a gain of some twelve thousand cubic feet of air per minute was obtained at the Equalising Chamber.

III.—Same conditions as in Tests 2 and 3 of Table II., but in addition the Cotton-Wool Filter thrown into action.

Experiment	1	2
Input Fan	Maximum	Maximum
Extract Fan	Minimum	Minimum
Air-flow through floor of Equalising Chamber ...	40,362	41,476

The effect of passing the air through the cotton-wool therefore was to neutralise the gain obtained by closing down the Commons Lobby shaft. By closing that shaft 12,000 cubic feet of air was gained at the Equalising Chamber; by then throwing the cotton-wool filter into action, a loss occurred of 12,000 cubic feet of air. Equalising Chamber.

These experiments show that during fog, 40,000 to 42,000 cubic feet of filtered Terrace air may be obtained at the Equalising Chamber per minute; provided that the Commons Lobby shaft is closed. The closure of the Commons Lobby shaft was not, however, complete in these tests, as the wooden flaps by which it is closed were not absolutely air-tight.

IV.—Showing effect of altering inlet area at floor of Debating Chamber, i.e., *at ceiling of Equalising Chamber.*

Date	October 12.	Do.	October 13.	Do.	November 14.	Do.
Input Fan ...	Medium	Medium	Medium	Medium	Medium	Medium
Extract Fan ...	Medium	Medium	Medium	Medium	Medium	Medium
Condition of floor of Debating Chamber.	Usual (string matting).	Gangways partially carpeted.	Usual	Gangways thoroughly carpeted.	Usual	All valances lifted up.
Air-flow through Floor of Equalising Chamber.	39,042	39,286	37,531	39,313	35,812	33,414

The alterations referred to do not seem to have produced much effect upon the air-flow through the floor of the Equalising Chamber.

Summary.

It appears from these observations that when the input fan alone is acting and at maximum, or when both fans are at maximum, a volume of about 44,000 cubic feet of air per minute is delivered at the floor of the Equalising Chamber from the Terrace inlet.

If the Commons Lobby shaft be shut, and the input fan at maximum and the extract at minimum speed, a volume of 52,000 to 53,000 cubic feet of Terrace air per minute is then delivered at the Equalising Chamber.

By now throwing the cotton-wool filter into action, the Commons Lobby shaft remaining shut, the air delivery at the floor of the Equalising Chamber is reduced to 40,000 cubic feet per minute.

Inferences.

The maximum supply of Terrace air to the Equalising Chamber under ordinary conditions suffices for 880 persons.

The closing of the Commons Lobby shaft raises this amount until it is sufficient for 1,050 persons.

When the cotton-wool filter is thrown into action and the Commons Lobby shaft closed, enough filtered Terrace air can be supplied at the Equalising Chamber to suffice for 800 persons.

Conclusion.

Unless the Commons Lobby shaft is shut, the maximum quantity of Terrace air delivered at the floor of the Equalising Chamber by the ventilation at present is insufficient to meet the demands of the Debating Chamber alone when crowded to the full.

Quantity.

During a fog, enough filtered Terrace air can be supplied at the floor of the Equalising Chamber to suffice for 800 persons. Though ample for ordinary requirements, this quantity is insufficient for maximum requirements that might arise in time of fog; and it is obtained by sacrificing the ventilation of the Commons Lobby.

(3.) The Division Lobbies.

Division Lobbies.

1. Observations of the Inflow of Air to the Division Lobbies from the Equalising Chamber.

I.—Air-flow from Equalising Chamber into Division Lobbies.

—	1	2	3	4	5	6
Input Fan ...	Maximum	0	Maximum	Maximum	Maximum	Medium
Extract Fan ...	0	Maximum	Maximum	Maximum	Maximum	Medium
Aye Lobby ...	9,923	−10,330	2,803	1,633	1,840	3,148
No Lobby ...	10,812	− 9,560	3,871	1,945	3,400	763
Both	20,735	−19,890	6,674	3,578	5,240	3,911

It is seen from the figures in this table that the maximum air-flow to the lobbies occurs when the input fan alone is working and at its maximum. The effect of the extract fan is to actively diminish the air-flow to these lobbies from the Equalising Chamber.

II.—The effect of closing the Commons Lobby Shaft, and of putting on the Cotton-Wool Filter, respectively.

Experiment	1	2	3	4
Input Fan	Maximum	Maximum	Maximum	Maximum
Extract Fan...	Minimum	Minimum	Minimum	Minimum
Commons Lobby Shaft	Open	Shut	Shut	Shut
Cotton Wool Filter	Off	Off	On	On
Aye Lobby	1,840	9,541	7,019	7,152
No Lobby	3,400	9,230	7,008	7,423
Both	5,240	18,771	14,027	14,575

The effect of closing the Commons Lobby shaft therefore was to very largely increase the amount of air going to the Division Lobbies. This relative increase is maintained, even though the cotton-wool filter is thrown into action. The effect of the cotton-wool filter upon the supply to the Division Lobbies and Debating Chamber respectively in the same test, will be dealt with later when considering the effect of the cotton-wool filter on the distribution of Terrace air within the Debating Chamber.

III.—The result of tests to determine (1) *the effect of lifting up the valances in the Debating Chamber, and* (2) *the value of the small fans in the Division Lobby windows.*

Both input and extract fans were at the same "medium" speed during the five tests here referred to.

Division Lobbies.

No. ...	1	2	3	4	5
Date ...	Aug. 14	Aug. 14	Aug. 14	Nov. 14	Nov. 14
Valances in Debating Chamber	Up	Up	Down	Down	Up
Fans in Division Lobbies ...	Off	On	On	On	On
Aye Lobby Inflow ...	1,642	3,104	5,013	3,229	1,634
No Lobby Inflow ...	570	2,209	2,940	1,007	100
Both ...	2,212	5,313	7,953	4,236	1,734

The lowering of the valances in the Debating Chamber is seen from comparison of tests 2 and 3 to have increased the inflow to the lobbies by 2,640 cubic feet per minute. Similarly, by comparison of tests 4 and 5, it is seen that the effect of lifting the valances was to diminish the flow to the lobbies by 2,502 cubic feet per minute. This parallel result is strong testimony to accuracy of the method.

The effect here shown of the Lobby window fans will be considered later. The combined effort of these fans increased the air-flow to the lobbies by 3,101 cubic feet per minute in experiment 2.

IV.—The effect of Carpeting the Gangways in the Debating Chamber.

Experiment ...	1	2	3	4	5
Date ...	Oct. 12	Do.	Oct. 13	Do.	Do.
Gangways of Debating Chamber.	Partially Carpeted.	String Matting.	Thoroughly Carpeted.	String Matting.	String Matting.
Input Fan ...	Medium	Do.	Do.	Do.	Do.
Extract Fan...	Medium	Do.	Do.	Do.	Do.*
Aye Lobby ...	Nil	Nil	2,686	1,457	3,033
No Lobby ...	1,444	1,078	4,059	1,932	3,460
Both ..	1,444	1,078	6,745	3,389	6,493

* In this test the Ways and Means Outlet door above the ceiling, shut in the preceding four tests, was opened and the extraction from the Debating Chamber thereby lessened from 53,000 to 45,000 cubic feet per minute.

The effect of partially carpeting the gangways in the Debating Chamber was small, therefore, the lobbies only profiting by 366 cubic feet of air per minute thereby. In the partial carpeting referred to, all the gangways were carpeted except the Centre Gangway behind the Chair. On the other hand, when the gangways were entirely carpeted the lobbies profited to the extent of 3,356 cubic feet per minute. On diminishing the extract (test 5) this amount became approximately doubled.

V.—The effect of opening the windows in the Debating Chamber.

It has been repeatedly observed that when both input and extract fans are working, the effect of opening the windows in the Debating Chamber is to lessen the pull of the extract fan on the Equalising Chamber, and hence to allow more air to flow into the Division Lobbies.

Thus on July 31st, when the House was sitting, the windows on the Opposition side of the Debating Chamber were open. The input and extract fans were at their medium speed. On examination it was found

Division Lobbies.

that in the Equalising Chamber 3,696 cubic feet of air were flowing into the Aye Lobby and 3,817 into the No Lobby, a total of 7,513 for both per minute.

On August 2nd both fans were at approximately the same speed as on July 31st, but the windows of the Debating Chamber were closed. On the present occasion 3,148 cubic feet of air were flowing into the Aye Lobby, but only 763 into the No Lobby, a total of 3,911 for both lobbies.

The following experiment was now made. The fans were kept at the same speed, and the amount of air passing out from the Equalising Chamber to the Division Lobbies was examined at four of the openings to the Aye Lobby, first with the windows of the Debating Chamber shut, then with them open.

Result.

—	Windows shut.	Windows open.
Opening 1	621	799
„ 2	742	1,197
„ 3	455	1,068
„ 4	508	795
	2,326	3,859

The effect of opening the Debating Chamber windows, therefore, was to increase the air passing to the Aye Lobby through these openings by approximately one-third.

(2.) Observations of the Extraction from the Division Lobbies.

(a.) *The Lobby Window Fans.*

The test previously quoted, made on August 14th, with both chief fans at medium speed, showed the following air-flows from the Equalising Chamber to the Division Lobbies :—

—	Lobby Fans off.	Lobby Fans on.
Aye Lobby	1,642	3,104
No Lobby	570	2,209
Total	2,212	5,313

The effect of the window fans, therefore, in these tests was to increase the air-flow to the Aye Lobby by 1,642 cubic feet per minute, and to the No Lobby by 1,639, or an increase altogether to both lobbies of 3,281 cubic feet per minute.

From direct measurements made at the windows by Mr. Patey, it appears that when working at maximum speed these window fans extract altogether 4,000 cubic feet of air per minute from the Division Lobbies. Their efficiency is, therefore, rather greater than the above observations in the Equalising Chamber imply.

But these window fans are only a makeshift device. Their very presence in the windows of the lobbies at all is a confession of the incompetence of the proper extract through the ceiling of the lobbies. The fans, moreover, have been a frequent cause of complaint on the part of Members using the lobbies. They cannot be run at full speed because of the noise they make; and in cold weather they cannot be used because of cold air blowing in through the centre of the fans. Division Lobbies.

(b.) The Ceiling extract of the Division Lobbies.

It has been previously stated that the panels of the ceiling of the Division Lobbies have a perforated border, and that the Clock Tower furnace is still connected to the air space over these panels.

On August 8th, and again on August 11th, the air-flow through the shaft on each side, by which the air gathered up from all the ceiling panels of each Division Lobby passes to the Clock Tower furnace, was examined. The results were as follows:—

Date	August 8th.	August 11th.
Input Fan	Medium	Minimum.
Extract Fan	Minimum	Minimum.
Aye Lobby Shaft to Clock Tower.	1,524	1,155
No Lobby Shaft to Clock Tower.	1,501	1,270
Total	3,025	3,425

Summary.

The largest quantity of Terrace air flows into the Division Lobbies from the Equalising Chamber when the input fan is at maximum, and the main extract fan is stopped. Under these circumstances, some 20,000 cubic feet of Terrace air is supplied to the lobbies per minute. Inflow.

The extract fan actively diminishes the air supply to the Division Lobbies from the Equalising Chamber; and when not balanced by the input fan, it even converts the Equalising Chamber inlets to the Division Lobbies into vigorous outlets from the lobbies.

The fans in the Division Lobby windows when at maximum speed extract some 2,000 cubic feet of air per minute from the Equalising Chamber to each lobby, and the ceiling extract in its present state extracts a total of about 3,000 cubic feet from both lobbies. Thus, altogether, from both lobbies, some 7,000 cubic feet of air is extracted per minute under present conditions. Outflow.

Inferences.

As the maximum amount of Terrace air that can be supplied to the Division Lobbies is only sufficient for 400 persons, the supply is inadequate. Moreover, this amount of air can only be supplied to the Division Lobbies by either stopping the extract fan, or by closing the Commons Lobby shaft. Inflow.

As the maximum amount of air found to be extracted from both lobbies is only sufficient if no more than 140 persons are present, it is clear that the extract is even more unsatisfactory than the supply to the Division Lobbies. Outflow.

In summer, when the windows of the Division Lobbies are opened, the results of this inadequate ventilation are not perceived. In the winter and spring, however, the insufficiency of the supply of fresh air must be more obvious to Members. Fortunately there are fewer divisions at that time of year.

Division Lobbies.

There can be no doubt that the first remedy indicated is to join the ceiling of the Division Lobbies to the extract fan over the Commons Lobby. By this means not only will the Division Lobby extract become more powerful and far more under control, but the inhibitory action of this extract fan on the Division Lobby inlets in the Equalising Chamber will be diminished.

It may be added that the cubic space of each Division Lobby is 27,670 cubic feet. The present extract, therefore, changes the air of each lobby about every 9·2 minutes. But if 325 Members were in each lobby, and a supply of 50 cubic feet of fresh air per head per minute given, the air of each lobby would require to be changed every 1·7 minutes. Unless the inlet and outlet area operative within the lobbies were to be made more extensive than at present, this degree of ventilation would most probably lead to complaint of draught. It should be remembered, in this connection, that air having a temperature between 55° and 65° F. when moving at a velocity of 1 to 1½ feet per second is felt by none, and when moving at a velocity of 2 feet is felt by only a few very sensitive persons. It is therefore quite possible to change the air of the Division Lobbies every 1·7 minutes without producing the sensation of draught, provided that the area of inlet and outlet within these lobbies is sufficiently diffuse.

Addendum.

The subsidiary supply to the Division Lobbies from the Commons and Star Courts.

At one period of the ventilation of the Debating Chamber, the whole air supply was drawn from the Commons and Star Courtyards. This supply was unassisted by mechanical means, and was dependent entirely on the exhaust created by the two coke furnaces situated at the Commons Tower and the Clock Tower, respectively. It is not to be wondered at that the air indrawn from this source proved inadequate to meet the requirements of the Debating Chamber.

On the abandonment of this supply for the Debating Chamber, it was still used for the Division Lobbies—chiefly during Divisions—and also for the Commons Lobby.

The value of this supply for the Division Lobbies has been investigated on two occasions, once when the temperature of the outside air was less than that of air in the Equalising Chamber, and once when the reverse conditions held.

Test I. July 26th, 1905.

The temperature of the Equalising Chamber, 73·5° F.
" " " Commons Court, 77·5° F.
Air passing by inlets *from* No Division Lobby, 550 cubic feet.

Temperature of Equalising Chamber, 73° F.
" " Star Court, 79° F.
Air passing by inlets *from* Aye Division Lobby, 620 cubic feet.

Total air by inlets *from* both lobbies, 1,170 cubic feet.

Test II. August 1*st*, 1905.

Temperature of Equalising Chamber, 63·75° F.
" " Commons Court, 59·5° F.
Air passing by inlets to No Division Lobby, 2,020 cubic feet.

Temperature of Equalising Chamber, 64° F.
" " Star Court, 60° F.
Air passing by inlets to Aye Division Lobby, 2,360 cubic feet.

Total air passing by inlets to both lobbies, 4,380 cubic feet.

Summary.

On July 26th, when the temperature was higher outside than inside by 4° F., 1,170 cubic feet of air passed *out* of the lobbies per minute through these so-called inlets; and on August 1st, when the temperature was lower outside by 4° F. than inside, 4,380 cubic feet of air passed into the lobbies through these inlets per minute.

Inference.

The supply from the Courtyard to the Division Lobbies through these inlets is entirely a question of difference of temperature, and, accordingly, at times the inlets at this point are apt to become outlets. Although in the second observation (August 1st) enough air passed in through these openings to the Division Lobbies to suffice for 87 persons, the introduction of air at a temperature considerably below that of the lobbies cannot be recommended. It is advisable, therefore, that this supply should be abolished. It is merely a remnant of a previous system, and if the Division Lobby Ceiling extract is connected to the extract fan as suggested, and the input of Terrace air at the Equalising Chamber increased to the requisite degree, there will be no need for this somewhat crude and uncertain supply from the Commons and Star Courts.*

(4.) The Debating Chamber.

Debating Chamber.

In the present section attention will be confined to observations of the amount of air passing through the Debating Chamber under various conditions. The relative activity of the inlets and outlets within the Debating Chamber itself will be considered later when dealing with the distribution within that chamber of air supplied from the Terrace inlet.

The amount of air passing into the Debating Chamber from the Equalising Chamber has been arrived at by deducting the air-flow to the Division Lobbies from the air-flow through the Equalising Chamber floor on the same occasion. The outflow from the Debating Chamber was observed directly at the shutter above the ceiling, through which air passes from the Debating Chamber to the extract fan.

The results of various tests of the air-flow through the Debating Chamber are seen in the following table:—

I.—*Quantity of Air supplied from the Equalising Chamber to the Debating Chamber and withdrawn from the latter at various Speeds of the two Fans.*

Test	1	2	3	4	5	6
Input Fan	0	Max.	Max.	Max.	Max.	Med.
Extract Fan...	Max.	0	Max.	Max.	Min.	Med.
Air entering Debating Chamber from Equalising Chamber.	28,901	24,066	36,829	38,691	35,485	31,534
Air withdrawn from Ceiling of Debating Chamber by Fan.	55,960	12,500	56,920	54,000	38,500	48,320
Difference between Supply and Exhaust.	27,059	11,566	20,091	15,309	3,015	16,786
Approximate percentage of Terrace Air in Debating Chamber.	...	100 (?)	64	71	92	65

* This supply has now been abandoned.

Debating Chamber.

The percentage of Terrace air in the Debating Chamber in the various tests has been arrived at by finding the percentage of the exhaust supplied from the Equalising Chamber. A careful examination of the sides of the vitiated air chamber over the ceiling of the Debating Chamber showed that the inleakage of outside air at this point may be neglected.

In Test 1 of the above table it should be stated that of the 28,901 cubic feet of air entering the Debating Chamber from the Equalising Chamber, no less than 19,896 came from the Division Lobbies.

It is seen from Test 2 of the table that the smallest quantity of air entered the Debating Chamber from the Equalising Chamber when the input fan alone was in action; a result due to the fact that in this condition, almost half of the air entering the Equalising Chamber from the Terrace inlet passed into the Division Lobbies. Owing to the extract fan being stopped, it is probable that the percentage of Terrace air in the Debating Chamber gradually reached its maximum point in this test.

The largest quantity of air was forwarded to the Debating Chamber from the Equalising Chamber when both fans were at maximum speed (Tests 3 and 4). The quantity provided under these conditions was sufficient for about 750 persons. Owing, however, to the demands of the extract fan being in excess of the air supplied to the Equalising Chamber by the input fan, Terrace air only appeared to form some 67 per cent. of the atmosphere of the Debating Chamber when both fans were at maximum speed.

Under working conditions, the speed at which the highest percentage of Terrace air appeared to obtain in the Debating Chamber was when the input fan was at maximum speed, and the extract at minimum. The quantity of air impelled into the Debating Chamber with this fan combination nearly approached the maximum, but the chief advantage of it was that under these circumstances the proportion of Terrace air in the atmosphere of the Debating Chamber rose as high as 92 per cent.

II.—*Quantity of Air supplied to and withdrawn from the Debating Chamber when the Cotton-wool Filter is in Action.*

Date	August 7th.	August 7th.	August 8th.
Commons Lobby Shaft	Shut	Shut	Shut
Cotton Wool Filter	Off	On	On
Input Fan	Maximum	Maximum	Maximum
Extract Fan	Minimum	Minimum	Minimum
Air entering Debating Chamber from Equalising Chamber.	33,259	26,335	26,901
Air withdrawn from Ceiling of Debating Chamber by Fan.	40,000	40,000	40,400
Difference between Supply and Exhaust.	6,741	13,665	13,499
Approximate percentage of Terrace air in Debating Chamber.	83	65	66

It appears from these results that when the filter was on, the quantity of filtered Terrace air supplied to the Debating Chamber was sufficient for some 530 persons. The effect of the cotton-wool filter on the atmosphere of the Debating Chamber was to substitute 65 per cent. of filtered Terrace air therein for 85 per cent. of the same air unfiltered.

III.—*The Effect on the Air-flow to the Debating Chamber of lifting up the Valances under the Seats.* Debating Chamber.

Condition	Valances all down.	Valances all up.
Input Fan	Medium	Medium
Extract Fan	Medium	Medium
Air entering Debating Chamber from Equalising Chamber.	31,576	31,680

The raising of the valances, therefore, appeared to have exceedingly little effect upon the gross air-flow from the Equalising Chamber into the Debating Chamber.

IV.—*The Effect on the Air-flow to the Debating Chamber of Carpeting the Gangways.*

Date	October 12th.	October 12th.	October 13th.	October 13th.
Gangways	Partially carpeted.	String matting.	Entirely carpeted.	String matting.
Input Fan	Medium	Medium	Medium	Medium
Extract Fan	Medium	Medium	Medium	Medium
Air entering Debating Chamber from Equalising Chamber.	37,842	37,964	30,786	35,924

The incomplete carpeting of October 12th had no effect, therefore, on the total air entry from the Equalising to the Debating Chamber. When, however, the gangways were more thoroughly covered with carpet, the air supply to the Debating Chamber became reduced by some 5,000 cubic feet per minute.

Summary.

The smallest flow of air from the Equalising Chamber into the Debating Chamber occurred when the input fan alone was in action, and the largest flow occurred when both input and extract fans were at their maximum speed. Under the latter circumstance, enough Terrace air was impelled into the Debating Chamber for 750 persons, but, owing to the excess of extraction, the Terrace air supplied by the input fan only formed some 67 per cent. of the atmosphere of the Debating Chamber. Inflow.

The largest proportion of Terrace air obtained in the atmosphere of the Debating Chamber when the input fan was at maximum and the extract fan at minimum speed. With this fan combination, enough Terrace air was supplied for about 700 persons, and its proportion in the atmosphere of the Debating Chamber rose to 92 per cent.

The effect of throwing the cotton-wool filter into action was to diminish the proportion of Terrace air in the atmosphere of the Debating Chamber by 18 per cent. Under this condition, however, enough filtered Terrace air was supplied for about 520 persons.

The raising of the valances in the Debating Chamber appeared to have little effect upon the quantity of air supplied to the Debating Chamber from the Equalising Chamber. Partial carpeting of the gangways also had no effect in this respect; but when the gangways were wholly carpeted the inflow of air from the Equalising Chamber was reduced by some 5,000 cubic feet per minute.

Outflow.

The quantity of air extracted from the Debating Chamber when the extract fan was put at its lowest speed, was slightly in excess of the quantity supplied by the input fan acting at its highest speed. When the speed of the extract fan was increased, this difference, of course, became larger.

When the extract fan was at minimum speed, the whole of the air of the Debating Chamber (165,000 cubic feet) was found to be extracted about every 4 minutes; an extraction sufficient for an assembly of about 750 persons. When the extract fan was put at maximum speed, the air of the Debating Chamber was found to be changed a little under every 3 minutes; an extraction sufficient for an assembly of 1,120 persons.

Inference.

Though ample for ordinary requirements, the input fan when working at its maximum does not supply enough air to the Debating Chamber for 900 persons—the maximum requirement. The minimum of the extract fan is more powerful than is necessary under the average conditions of occupancy of the Chamber, and the maximum extract of this fan is higher than the maximum requirements of the Debating Chamber demand.

The first remedy indicated is to decrease the resistance of the Terrace airway, and if, as is possible, this is not found to be sufficient, it may be necessary to have a more powerful input fan.

Should the extraction from the Division Lobbies be joined to the extract fan, as advocated when discussing the ventilation of these Lobbies, the at present too strong full of that fan on the Debating Chamber would thereby be diminished. If the reduction affected by this measure is not found to be sufficient, it may be possible to further reduce the at present minimum speed of the extract fan by electrical means.

Summary showing the Air-flow through various parts of the Debating Chamber System at the same time.

Test	1	2	3	4	5	6	7	8
Input Fan ...	Zero	Zero	Max.	Max.	Max.	Med.	Max.	Max.
Extract Fan ...	Zero	Max.	Zero	Max.	Max.	Med.	Min.	Min.
Inflow at Terrace Inlet.	2,490	5,010	56,385	55,370	56,025	47,745	54,000	56,070
Air-flow to Commons Lobby.	—	−919	10,711	6,957	9,903	7,700	6,787	Shut
To Equalising Chamber.	2,561	9,005	44,801	42,271	43,509	35,445	40,725	52,030
To Division Lobbies.	—	−19,890	20,735	3,580	6,680	3,911	5,240	18,771
To Debating Chamber.	—	28,895	24,066	38,691	36,829	31,534	35,485	33,259
Ceiling Outlet of Debating Chamber.	—	(56,000)	(12,500)	54,000	56,920	48,320	38,500	(40,400)

The prefix indicates that the inlet referred to was acting as an outlet to the extent indicated. The figures in brackets represent an approximate estimate.

ADDENDUM TO THE QUANTITY SECTION.

COMPARISON BETWEEN THE QUANTITY OF AIR SUPPLIED TO THE DEBATING CHAMBER BY THE VENTILATION ON TWO OCCASIONS WHEN THE HOUSE WAS SITTING IN 1904 AND 1905 RESPECTIVELY.

The improvement in the ventilation effected by the alterations made between 1904 and 1905 can be seen from comparison of the following observations of the air-flow made on August 3rd, 1904, and on July 31st, 1905, respectively, during the progress of a debate:— Debating Chamber 1904 v. 1905

Date.	Air Flow into the System from the Terrace Inlet.	Air extracted from the Debating Chamber.
August 3rd, 1904	21,900	15,653
July 31st, 1905	41,175	46,000

As the gas extraction was acting on both occasions, it has been ignored in comparing the extraction from the Debating Chamber on the two dates.

As the cubic capacity of the Debating Chamber is 165,000 cubic feet, it follows that on August 3rd, 1904, the air of the Debating Chamber was changed by the coke fire extraction every 10·5 minutes, whereas, on July 31st, 1905, it was changed by the extract fan every 3·5 minutes, that is to say, three times as fast as before.

The air-flow through the intermediate parts of the system was not fully observed on the 1904 date, so that full comparison in this respect cannot be made. But the velocity of the air passing up through the circular gratings in the floor of the Equalising Chamber was observed on August 3rd, 1904, and as both the velocity and the air-flow at this point were fully observed on July 31st, 1905, comparison can here be made.

The velocity of the air passing up on August 3rd, 1904, through the 9 circular gratings referred to happens to have been recorded in the accompanying diagram in red figures at each grating. The velocities found at the same gratings on July 31st, 1905, have been written in black ink over these figures.

The total velocity at the 9 circular gratings in the 1904 observation was 446 feet per minute, and in the 1905 observation 1,022 feet per minute. The velocity of the air in the 1904 observation, therefore, was 43 per cent. of that observed in 1905; and, as the sectional area was the same on both occasions, it follows that the quantity of air passing up in 1904 was 43 per cent. of that passing up in 1905.

In the 1905 observation the quantity of air passing to the Debating Chamber was found by deducting the air passing out laterally from the Equalising Chamber to the Division Lobbies from the quantity passing in through the floor of the Equalising Chamber on the same occasion. The figure thus arrived at was 23,585 cubic feet of air for the Debating Chamber per minute, and 43 per cent. of this quantity gives 10,141 cubic feet of air per minute as the amount of Terrace air passing into the Debating Chamber on August 3rd, 1904.

The question may be asked, but was the proportion of total air distributed to the lobbies the same in 1905 as in 1904? This, unfortunately, cannot be answered absolutely, but it is reasonable to suppose that if different, the proportion passing to the lobbies was relatively greater in

1904 because the pull of the extract against the inlets to these lobbies from the Equalising Chamber was less.

According to the computation, therefore, the supply of Terrace air to the Debating Chamber on August 3rd, 1904, was sufficient for 202 persons, whereas on July 31st, 1905, it sufficed for 471.

It will be further observed that on both occasions the extraction from the Debating Chamber exceeded the supply which that Chamber received from the Terrace. The quantity of air extracted in the 1904 observation was sufficient for an assembly of 313 persons in the Chamber; whereas, on July 31st, 1905, it sufficed for 920. In comparison with the supply, therefore, the excess of the extract was greater in 1905 than in 1904.

According to the estimate, the proportion of Terrace air in the atmosphere of the Debating Chamber on August 3rd, 1904, was 64 per cent., whereas, on July 31st, 1905, owing to the excess of extraction being relatively greater, the proportion of Terrace air in the Debating Chamber was only 51 per cent.

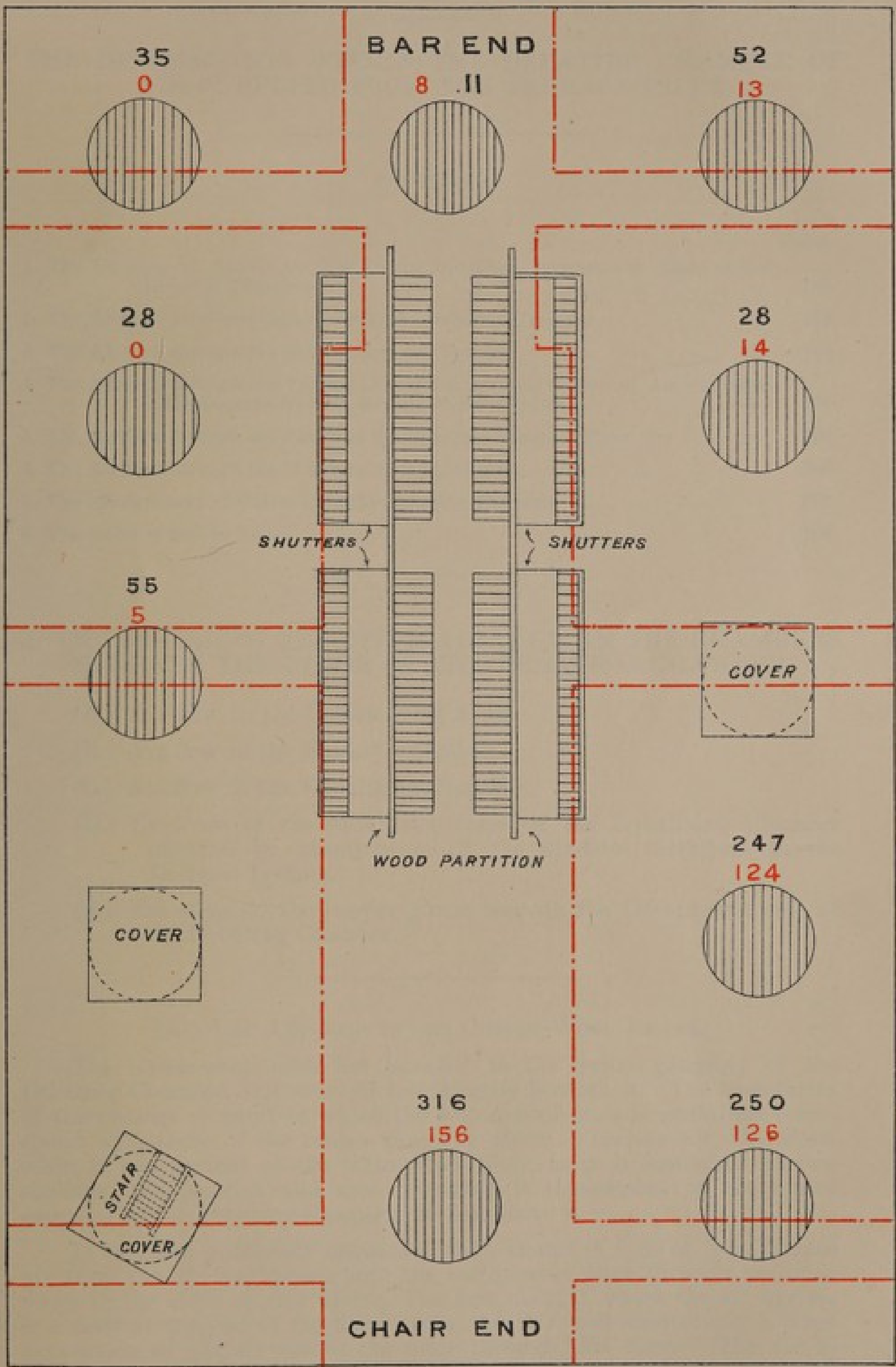
Although almost double the quantity of air was being passed through the Debating Chamber in the 1905 debate, therefore, the proportion of Terrace air in the atmosphere of the Chamber was actually less.

To face page 168.

GRATINGS IN THE FLOOR OF THE EQUALISING CHAMBER

LOOKING FROM ABOVE.

Velocity readings August 1904 red August 1905 black.



RED NUMBERS = Mean Anemometer Readings. Feet per minute.

—·—·— = Position of Gangways above

420, 6108.

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SECTION V.

THE DISTRIBUTION WITHIN THE DEBATING CHAMBER OF AIR SUPPLIED FROM THE TERRACE INLET.

CONTENTS.

1. THE DISTRICTS OF ACTIVE AIR-FLOW IN THE CHAMBERS BENEATH THE FLOOR OF THE DEBATING CHAMBER.

(A.) Air-flow in the Cotton-Wool Filter.

(B.) Air-flow in the Battery Chamber.

(C.) Air-flow in the Equalising Chamber.

(D.) Evidence of the equalising value of the Equalising Chamber afforded by examination of the air-flow therefrom to the Division Lobbies.

(E.) The effect of the copper gauze beneath the Government side of the Debating Chamber.

(A.) The Air-flow in the Cotton-Wool Filter.

The cotton-wool filter lies parallel to the centre gangway of the Debating Chamber, and some 30 feet directly beneath it. The boundaries of the passage or vault in which the cotton-wool filter is contained correspond with those of the centre gangway above. Terrace air, therefore, when it has arrived at the cotton-wool filter, is in a somewhat narrow chamber, the position and area of which is represented by the centre gangway of the Debating Chamber, 30 feet above it.

It has been previously mentioned that, except in time of fog, Terrace air from the air-way passes into the cotton-wool filter through the open doors in the sides of this filter. The first door at which the air arrives is a door at the end of the filter under the Bar, and accordingly a large proportion of the air enters the filter through this door. The air so entering streams down the whole length of the interior of the filter until it meets the foundation of the wall that bounds the Debating Chamber at the Chair end. It is then reflected upwards.

(B.) Air-flow in the Battery Chamber.

Through a series of gratings in the ceiling of the cotton-wool filter the air passes upwards into the Battery Chamber. The part of the Battery Chamber floor at which Terrace air enters, therefore, is the middle third only, that is to say, the part of it which lies below the centre gangway. Although the Battery Chamber and its annexes extend below the whole of the floor of the Equalising Chamber and Division Lobbies, the main stream of Terrace air in traversing the Battery Chamber is at present limited to that part of it below the centre gangway. At the end under the Chair, this limitation of the air current to the middle third of the Battery Chamber is effected by enclosing it with boarding.

On examining with the anemometer the upflow of air through gratings in the floor of the Battery Chamber, it has been found that the gratings under the Chair end are the most active, and that at the end of the Battery Chamber under the Bar not only is there no up current, but actually a down current when the ventilation is on.

The reason of this down current at the Bar end of the Battery Chamber is that the main stream of Terrace air enters the cotton-wool filter below this point and rushes horizontally along the interior of the filter for some 40 feet until reflected up by the wall at the further end under the Chair. The first grating in the Battery Chamber, therefore, *i.e.*, the grating under the Bar, at present merely serves to enable air to be dragged down from above to join the swift horizontal current shooting past its lower surface in the cotton-wool filter.

That this explanation is correct is shown by the fact that when the doors into the filter are shut, the down current disappears. In this case, however, as before, the main upcurrent of Terrace air still passes up into the Battery Chamber at the end under the Chair.

One of the recommendations that will be suggested is to restore the walls of the Battery Chamber and to remove the boarding by which, below the Chair, the air-stream is confined to the middle line. Two great advantages would thereby be gained, viz.: (1) better diffusion of the Terrace air throughout the Battery Chamber, and as a result of this (2) all the gratings in the floor of the Equalising Chamber could then be made operative. By this measure the Battery Chamber would become a preliminary Equalising Chamber, and the area of inlet in the floor of the Equalising Chamber above it would be increased by some 43 square feet.

(C.) Air-flow in tne Equalising Chamber.

The air-flow through the floor of the Equalising Chamber is best seen by reference to the accompanying diagrams, which show the position of the gratings, and the velocity of the air passing up through them in three typical tests.

The gratings in question are of two kinds, viz., circular, and rectangular. Of the 12 circular gratings, three are at present closed; and of the nine open, one has a spiral staircase within it, the remaining eight being grated.

The rectangular gratings in the middle of the Equalising Chamber may be briefly differentiated into inner and outer. Of these, the inner gratings are immediately under the centre gangway between the Bar and Table, and are always wide open during debates. The outer gratings have their covers only half raised in order to deflect the air issuing from them to the floor of the Debating Chamber on either side beneath the Benches.

The total sectional area of all parts of the Equalising Chamber floor at present open to the passage of air is 199·8 square feet, of which the circular gratings contribute 131·4 square feet, and the rectangular gratings 68·4 square feet.

But in spite of the sectional area of the rectangular gratings being only about half that of the circular gratings, it has been found in numerous tests that whatever the fan combination may be, and whether the cotton-wool filter be in action or not, the total quantity of air passing up through the circular and rectangular gratings, respectively, is about the same.

The reason of this equal delivery no doubt lies in the fact that the rectangular gratings are over the middle of the Battery Chamber where a good part of the main stream of Terrace air passes up.

With regard to the comparative activity of the various circular gratings, it has been invariably found that the three gratings at present open at the Chair end of the Equalising Chamber are the most active. The quantity of air passing up through the three gratings in point is generally between two-thirds and three-quarters of the total quantity passing up through all the circular gratings. When the cotton-wool filter is in action, this proportion diminishes to half the total air-flow through the circular gratings, or about a quarter of the whole flow through the floor of the Equalising Chamber.

The reason of the excessive activity of the three gratings in question, is because they lie over that end of the Battery Chamber at which the chief part of the main current of Terrace air passes up. Conversely, at the Battery Chamber under the Bar a down current was found, and hence the circular grating over this point in the Equalising Chamber is the least active. When the cotton-wool filter is in action, however, the down current disappears, and this Bar grating becomes far more active.

Summary.

The air entry through various gratings in the floor of the Equalising Chamber is at the present time exceedingly unequal. This inequality is due to the confinement of the air-stream to the middle line below the Equalising Chamber. The chief up current occurs at the end of the Equalising Chamber under the Chair, and also under the block of Government Benches above the gangway, and under the centre gangway between the Bar and the Table. The worst air entry is under the Opposition Benches, and below the Bar.

The air-flow through various gratings in the floor of the Equalising Chamber in a number of tests is seen from the following table :—

Air-flow through different gratings in floor of Equalising Chamber.

Test	1	2	3	4	5	6	7	8	9
Special Conditions.	Test	Test	Test	Test	Test	Test	Cotton Wool in action, Commons Lobby shut.	Gangways thoroughly carpeted Oct. 13.	String on gangways Oct. 13.
Input Fan	0	0	Max.	Med.	Max.	Max.	Max.	Max.	Max.
Extract Fan	0	Max.	0	Med.	Max.	Min.	Min.	Med.	Med.
Total flow through Equalising Chamber Floor.	2,561	9,005	44,801	37,786	42,271	40,725	41,476	37,531	39,313
Flow through rectangles.	0	292	23,357	18,824	23,271	22,835	20,972	18,732	20,292
Flow through circles.	2,561	8,713	21,444	18,962	19,000	17,900	20,504	18,799	19,021
Flow through 3 circles at Chair end.	2,561	5,619	14,824	13,037	13,054	11,987	9,900	14,044	13,883

D. Evidence of the Equalising Value of the Equalising Chamber afforded by Examination of the Air-flow therefrom to the Division Lobbies.

The uniform evidence afforded by observations of the air-flow from the Equalising Chamber into the Division Lobbies on a large number of occasions, goes to show that in spite of the unequal entry of air through the floor gratings of this Chamber at the present time, the supply of air from the Equalising Chamber to the Division Lobbies on either side of it is as a rule exceedingly equal.

A special opportunity arose of examining the equalising power of this Chamber on occasions when the cotton-wool filter was being tested, for, as a result of throwing the cotton-wool filter into action, a distinct alteration was found to take place in the comparative air-flow through the various gratings in the floor of the Equalising Chamber. The effect of passing the air through the wool appeared to be to make the air entry through the various inlets in question much more equal; though the equality was still far from being complete.

The comparative activity of the various inlets to the Equalising Chamber being thus altered by throwing the cotton-wool filter into action, it became of some interest to ascertain what proportion of the air entering the Equalising Chamber floor passed out to the Division Lobbies with the wool off and on respectively. Moreover, the proportion of the Equalising Chamber supply that passed out to the Division Lobbies having been determined, it follows that the remainder must have passed into the Debating Chamber. The results of three tests of this matter are seen in the following table:—

Test	1	2	3
Cotton Wool Filter	Off	On	On
Proportion of Air entering Equalising Chamber that passed out into Division Lobbies.	36 per cent.	34 per cent.	35 per cent.
Proportion going into Debating Chamber...	64 per cent.	66 per cent.	65 per cent.

When the cotton-wool filter was in action, therefore, in spite of the alteration produced thereby in the comparative activity of the various inlets in the floor of the Equalising Chamber, no alteration occurred in the proportion of this air distributed by the Equalising Chamber to the Division Lobbies and Debating Chamber respectively.

These results show that in spite of its being handicapped by the present exceedingly unequal entry of air at its floor, a circumstance that might well have wrecked the function of this Chamber, the Equalising Chamber is, nevertheless, of great efficacy for the purpose for which it was designed by Dr. Reid. Moreover, the conclusion thus arrived at from investigation of the air entry to the Division Lobbies will be found to be confirmed when the results of the examination of the air entry to various districts of the floor of the Debating Chamber come to be described.

E. The Effect of the Sheet of Copper Gauze fixed beneath the Floor on the Government side of the Debating Chamber.

A sheet of copper gauze, 30 meshes to the linear inch, is fixed in the ceiling of the Equalising Chamber underneath the Government side of the Debating Chamber, but not elsewhere. This gauze produces a slight but distinct resistance to the up-flow of air on this side of the Debating Chamber, as may be proved by fixing one of Dr. Shaw's sensitive revolving spinners under the floor of the Debating Chamber in one of the compartments covered by the gauze, and by then alternately raising and lowering the section of gauze beneath it. When the gauze is raised, the dimunition in the upward air-flow produced by the resistance offered by the gauze results in the rate at which the wheel is revolving becoming distinctly slower. On lowering the gauze the speed of the wheel increases.

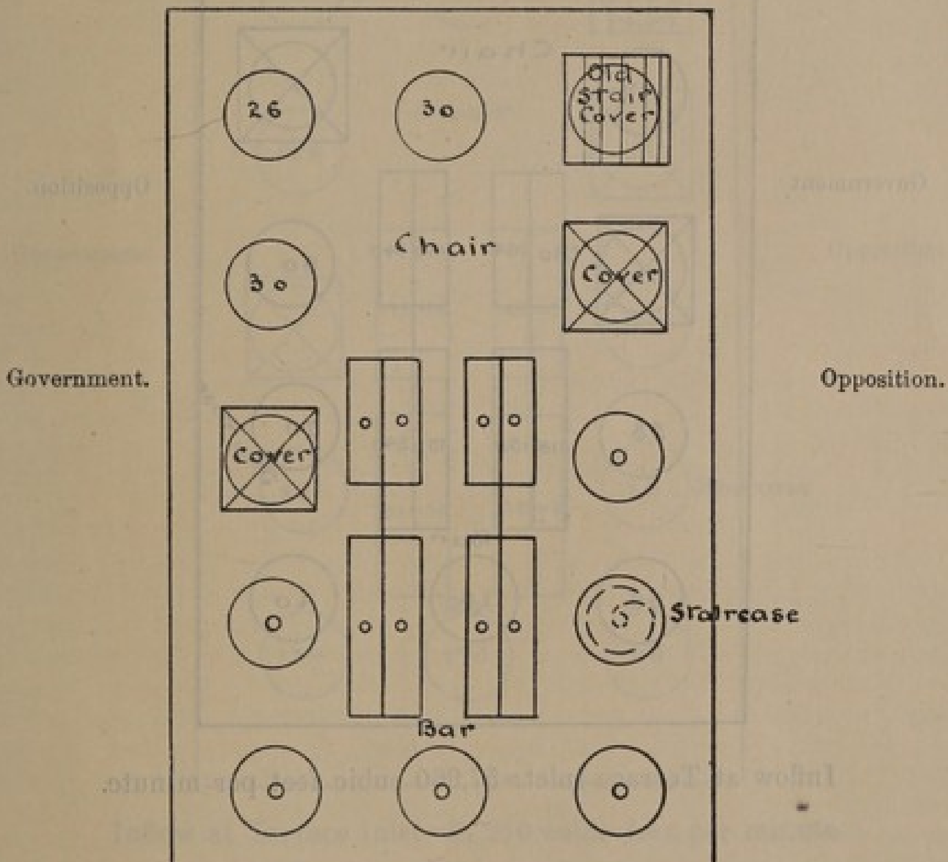
Diagrams illustrating the Air-flow through Gratings in the Floor of the Equalising Chamber.

Diagram I.

In the test here illustrated both fans were stopped. The only gratings at which anemometer readings were obtained were the three circular gratings under the Chair end of the Debating Chamber. These gratings are always the most active of all the circular gratings, the reason being that the main current of Terrace air enters and leaves the Battery Chamber below this part.

Both Fans Stopped.

(*July 31st*, 1905.)



Air inflow at Terrace inlet = 2,490 cubic feet per minute.

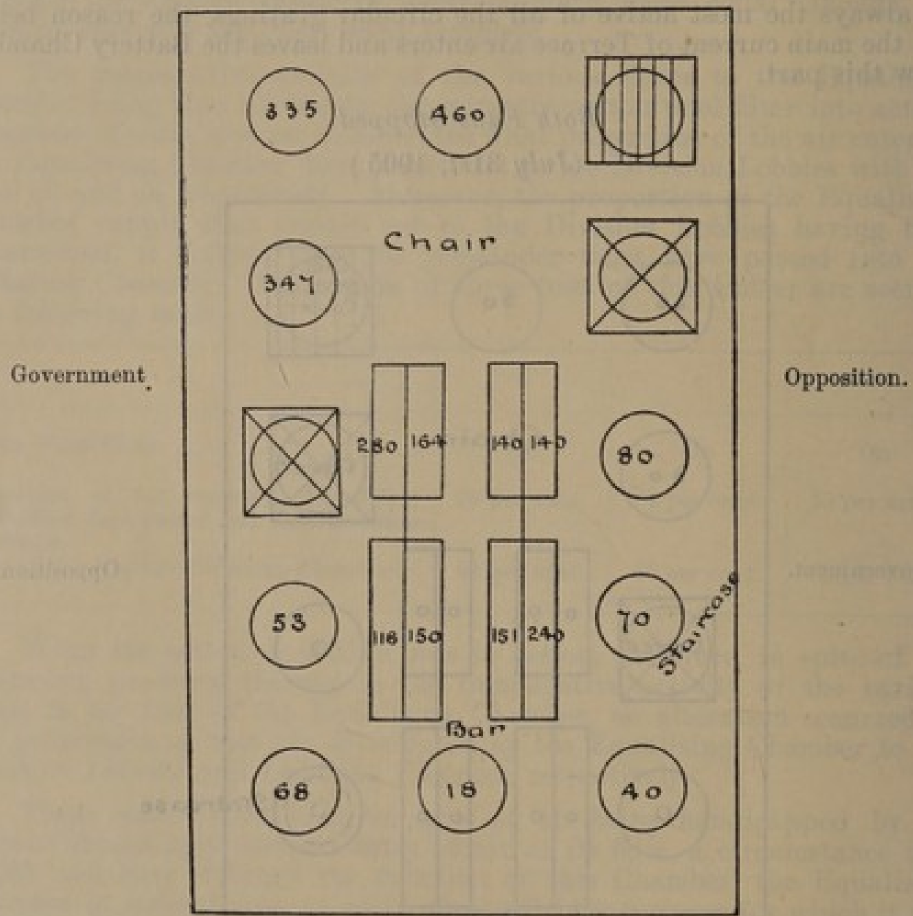
(In this and the following diagrams the velocity readings are recorded without adding any correction for the instrument.)

In this and the other two diagrams the numbers on the gratings indicate the velocity of the air in feet per minute.

Diagram II.

The test here illustrated is typical of the air-flow as it occurs under ordinary circumstances when the ventilation is at work. The input fan is at maximum, the extract at minimum. As usual, the three circular gratings at the Chair end show the highest velocity. The circular grating under the Bar is also, as usual, the least active, owing to the down-draught in the Battery Chamber beneath it.

Input Fan—Maximum. Extract Fan—Minimum. Cotton-Wool off.
(*July 25th*, 1905. 7.45-8.15 *p.m.*)



Inflow at Terrace inlet=57,960 cubic feet per minute.

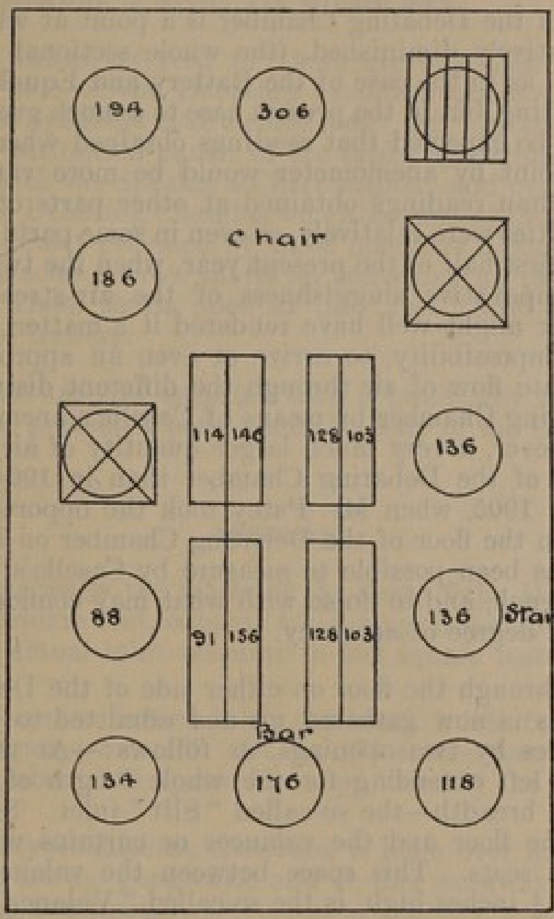
Diagram III.

The test here shown was the companion test to that seen in the last diagram. The only alteration introduced was that the doors of the cotton-wool filter were now shut, and the air thus compelled to traverse the wool. The total air-flow to the Equalising Chamber is diminished, but on comparing the velocity readings at the various gratings with readings at the same gratings in Diagram II, it is seen that the air-flow has become more equal. The velocity at the Bar grating has gone up from 18 to 176.

Conditions ditto of II, but Cotton-Wool now on.

(*July 25th*, 1905. 8.15-9 *p.m.*)

Government.



Opposition.

Inflow at Terrace inlet=51,210 cubic feet per minute.

(2.) THE AREAS OF INLET AND OUTLET WITHIN THE DEBATING CHAMBER.

THE AREA OF INLET.

(A.) FLOOR.

General Description of the Floor Inlets with Special Reference to recent Alterations.

As the floor of the Debating Chamber is a point at which the velocity of the air is relatively diminished, (the whole sectional area of the air stream being here, as in the case of the Battery and Equalising Chambers, intersected by grating, but in the present case to a much greater extent than before,) it was to be expected that readings obtained when examining the air-flow at this point by anemometer would be more variable and more subject to error than readings obtained at other parts of the air course, where such difficulties were relatively, or even in some parts entirely, absent. Now, prior to the first half of the present year, when the two new fans were installed, the comparative sluggishness of the air-stream entering the Debating Chamber might well have rendered it a matter of extreme difficulty, if not an impossibility, to arrive at even an approximate estimate of the proportionate flow of air through the different districts of the floor area of the Debating Chamber by means of Casella's anemometer. At the present time, however, a very much larger quantity of air is being passed through the floor of the Debating Chamber than in 1904, and since the Whitsun recess of 1905, when Mr. Patey took the opportunity of making some alterations in the floor of the Debating Chamber on both sides under the benches, it has been possible to measure by Casella's anemometer the air-flow to each bench, and to do so with what may confidently be claimed to be a reasonable degree of accuracy.

Air passing through the floor on either side of the Debating Chamber under the benches is now gathered up and admitted to Members seated upon those benches by two openings, as follows:—At the back of each bench a space is left extending for the whole length of the bench, and about 3 inches in breadth—the so-called "Slit" inlet. Secondly, a space is left between the floor and the valances or curtains which hang down from beneath the seats. This space between the valance and the floor, averaging about $1\frac{1}{4}$ inches high, is the so-called "Valance" inlet. Details of the gathering ground of these two inlets are most easily seen by reference to the accompanying section, from which it is clear that the only places where air can pass directly to Members seated on the benches is through the openings mentioned—the rest of the grating being covered over either by the under part of the seat of the bench, or else by the board on which is placed the thick mat upon which Members sitting on the benches rest their feet.

Sectional Area of the various Inlets at the Floor of the Debating Chamber.

Total area of floor.

The total area of the floor of the Debating Chamber is 3,090 square feet. Of this floor area the part actually open to the passage of air from the Equalising Chamber is 293 square feet.

Of the 293 square feet of general area of inlet, the inlets at the Benches contribute 120 square feet, of which amount the slits furnish 81 square feet, and the valances 39 square feet. Benches.

When the valances are lifted right up, the valance inlet is increased from 39 to 423·6 square feet.

The remaining 173 square feet of general area of inlet is at the part of the floor occupied by the gangways. These gangways consist of grating covered by string matting, and the 173 square feet of gangway inlet is largely reduced by the string matting, the interstices of which do not accurately coincide with the apertures in the grating. The amount of occlusion due to this non-correspondence is arrived at by comparing the velocity of air passing up through the same area of grating when bare, and when covered with the string matting, respectively. Tests made of this matter have shown that the effect of the string matting is to reduce the air velocity by 60-70 per cent. Gangways.

The portion of the 173 square feet of gangway area of inlet contributed by the Centre Gangway is about 115 square feet. Centre Gangway.

Besides the inlets referred to, there are openings beneath the back bench on either side of the Debating Chamber under the Gallery. The total area of these openings is 18 square feet. Air also enters the Debating Chamber by the perforated panels of the table, by perforations in the base of the dais on which the Speaker's Chair stands; and by perforated panels at each end of the Debating Chamber on either side of the Centre Gangway. The total area of inlet provided by these openings is some 12 square feet. Finally, there are some narrow shafts for conveying air to the back benches on either side. These shafts open at the "fret" level above the wainscotting under the Gallery. Other inlets to the floor area.

As these seats are now carpeted with a practically impervious carpet, their occupants at present depend upon the body of the Debating Chamber for fresh air. Permanent Officials' Seats.

Summary.

Although practically the whole of the floor of the Debating Chamber, an area of 3,090 square feet, consists of grating in some form or other; the sectional area of actual inlet amounts to 293 square feet.

Of this 293 square feet of inlet, the bench inlets furnish 120 square feet, and the gangways the rest. Of the 173 square feet of inlet provided by the gangways, about 115 square feet is provided by the Centre Gangway.

Under ordinary conditions, therefore, a little over half the total area of inlet is located at the gangways, and of this gangway inlet the centre gangway provides two-thirds.

It must be remembered, however, that owing to occlusion from the string matting, the inlet area of the gangway grating is considerably diminished; and further, that air passing to the benches has to pass through gratings in the floor beneath the benches, before it arrives at the slit and valance inlets.

By lifting up the valances, the total inlet area at the benches is increased from 120 to 504 square feet. The bench inlet area, therefore, now exceeds the gangway inlet area of 173 square feet, and it has the advantage over the gangway inlet area in that there is no string matting or other material under the seats to impede the egress of air. The effect of this will be seen later.

The Area of the Debating Chamber at various Levels.

Before proceeding to refer to the outlets from the Debating Chamber, it is advisable to point out that the sectional area of the air-stream is diminished in the middle of the Chamber by the projection of the galleries; and that above the gallery rail, the area of the Chamber expands again until it is greater than at the floor level. Thus, the horizontal area of the Debating Chamber at different levels is as follows:—

At floor	3,090 square feet.
At level of gallery rail	1,731 ,, ,,
At level of ladies' gallery grille ...	3,895 ,, ,,

The smoke tests have shown that this contraction and expansion of the sectional area of air-flow is of great importance in reference to the service of fresh air to the galleries under present conditions.

(B.) GALLERIES.

The Members' gallery on either side is supplied with air by shafts from the Equalising Chamber, and the air-flow through these shafts has been examined in the Equalising Chamber on a number of occasions. The rest of the galleries at present depend entirely on the body of the Debating Chamber for air supply.

The Area of Outlet.

The effective area of outlet from the Debating Chamber was investigated by testing at the spaces between the raised panels of the ceiling with an anemometer. The total area of these panel outlets is estimated at 153 square feet.

The extraction through the Ladies' and Speaker's Gallery has also been examined.

As data concerning the gas extract were already available, no investigation of this has been made.

Distribution (3).

3. THE AIR-FLOW THROUGH THE INLETS AT THE BENCHES KNOWN AS THE SLITS.

(1.) The general delivery of air by the slits.

(2.) The influence of various factors on the air-flow through the slits.

(3.) Brief summary.

(1.) The General Delivery of Air by the Slits.

As the benches of the Debating Chamber are divided by the centre and cross gangways into four blocks, it will be convenient in considering the air-flow through the slits, to deal with the air-flow through the slits of each of these blocks of benches as a whole. In this connection it must be stated that the benches above the cross gangways are longer than those below, and that by means of the brass name-plates it is found that the former blocks seat on each side of the House 80 Members, the latter 62.

In all tests made of the air-flow through the slits, two observations were made of the velocity of the air issuing from each slit at each bench. The air-flow from the Terrace inlet, and at the Shutter outlet from the ceiling of the Debating Chamber, was also observed in all the tests.

The quantity of air delivered at the benches by the slits at various fan speeds is seen from the following table. In all these tests the wire gauze was in its usual position under the Government side of the Debating Chamber :—

Air-flow through the Slits.

(Usual conditions; gauze acting.)

No.	1	2	3	4	5	6	7	8
Date	July 6.	Oct. 16.	Oct. 12.	Oct. 13.	July 17.	July 27.	July 27.	Nov. 24.
Input Fan	Min.	Med.	Med.	Med.	Near Max.	Max.	Max.	Max.
Extract Fan	Min.	Med.	Near Max.	Near Max.	Near Max.	Max.	Max.	Min.
Air-flow at Terrace Inlet	36,300	47,250	46,035	45,720	54,540	53,600	53,600	54,000
Air-flow at Debating Chamber Outlet.	37,400	45,200	54,000	53,000	48,370	55,500	56,500	38,800
Government Benches above Gangway.	2,420	2,932	3,113	2,861	3,369	3,998	3,965	3,746
Government Benches below Gangway.	1,740	1,848	1,878	1,882	2,373	2,486	2,531	2,614
Total Government side...	4,160	4,780	4,991	4,743	5,742	6,484	6,496	6,360
Opposition Benches above Gangway.	2,269	2,537	2,750	2,561	2,773	2,997	2,953	3,555
Opposition Benches below Gangway.	1,658	1,780	1,984	1,743	2,064	2,312	2,400	2,826
Total Opposition side ...	3,927	4,317	4,734	4,304	4,777	5,309	5,353	6,381
Total flow through slits	8,087	9,097	9,725	9,047	10,519	11,793	41,849	12,741

Analysis.

Stability of the air-flow through the slits.

It is advisable to deal first with the result of tests 6 and 7 in the table. These tests were made on the same date, and were parts of an experiment made at Mr. Lempfert's suggestion in order to investigate the *stability* of the air-flow through the slits during the same test. Both fans were put at maximum speed, and anemometer readings were taken at the slits in the ordinary way and then, after an interval of half an hour, repeated.

The method adopted of describing the air-flow at the four blocks of benches is by means of a cross the limbs of which represent the gangways.

The air-flow through the slits of the four blocks in the two tests was as follows :—

Test A.	Test B.
Chair. 3,998 — 2,997 Govt. — Opp. 2,486 — 2,312 Bar.	3,965 — 2,953 2,531 — 2,400

In test A. therefore, the slits were found to be delivering 11,793 cubic feet of air per minute; and in test B., half an hour later, they were found to be delivering 11,849 cubic feet. These results show very clearly that the air-flow at the slits is quite stable when the general conditions of the ventilation remain unaltered, and it may be added that the result of repeating tests with the same fan combination on different days has confirmed this conclusion.

Gross air-flow through the slits.

The gross air-flow through the slits recorded in the table is seen to vary according to fan speed from 8,087 cubic feet per minute with both fans at minimum speed, up to 12,741 cubic feet per minute when the input fan was at maximum and the extract at minimum.

The number of Members for whom there is seating accommodation in each block being known, it is simplest in dealing with the relative delivery of air by slit to each block to consider the results according to the amount of air delivered by this channel to *each Member* when all the seats of each block are occupied.

The quantity of air delivered to each Member by the slits.

The cubic feet of air distributed per minute by the slits to each Member in each block of benches when all the seats are occupied is as follows :—

Both Fans Minimum Speed.	Both Fans Medium Speed.	Both Fans Maximum Speed.	Input Fan Maximum Extract Minimum.
Chair. 30 — 28 Govt. — Opp. 28 — 26 Bar.	36 — 31 29 — 28	49 — 37 40 — 37 ½-hour later. 49 — 36 40 — 38	46 — 44 42 — 45

As regards quantity of air per Member, therefore, the delivery at the slits is seen to be most active when the input fan is at maximum and the extract at minimum, under which conditions a mean of 44 cubic feet is delivered to each Member per minute.

The equalisation of the delivery at the four blocks of benches.

Regarding, in the second place, the comparative supply per Member in each block respectively, it is seen that the excess above (+) and below (−) the mean was as follows in each test :—

Both Fans Minimum Speed.	Both Fans Medium Speed.	Both Fans Maximum Speed.	Input Fan Maximum Extract Minimum.
		Mean 40.	Mean 44.
+2 0	+5 0	+9 −3	+2 0
0 −2	−2 −3	0 −3	−2 −1
Total Variation 4.	Total Variation 10.	Total Variation 15.	Total Variation 5.
		½-hour later.	
		+9 −4	
		0 −2	
		Total Variation 10.	

It is seen from these figures that the total variation above and below the mean was least (1) when both fans were at minimum, and (2) when the inlet fan was at maximum and the extract at minimum—in other words, when the input of Terrace air most nearly approached the quantity extracted from the Debating Chamber, the best equalisation occurred in the Equalising Chamber.

Cause of excess of air-flow through Government block above gangway.

Considering, next, the relative distribution to the various blocks, it is seen that in all the tests an undue proportion of air was delivered by the slits of the Government benches above the gangway. The reason of this excess is not far to seek, for in dealing with the air-flow through various parts of the Equalising Chamber it will be remembered that the circular gratings under this part of the Debating Chamber floor were found to be far more active than any of the others, and, further, that the cause of this excess was found to lie in the fact that below the gratings in question, both in the Battery Chamber and in the cotton-wool filter, the chief volume of Terrace air was found to be passing upwards.

Testimony of the slits results to the efficiency of the Equalising Chamber.

But when the present exceedingly unequal air entry at the floor of the Equalising Chamber is taken into account, and especially when it is remembered that the circular gratings under the Opposition side of the Debating Chamber are the feeblest of all as regards air-flow, the conclusion is unavoidable that, handicapped though it be at the present time, the Equalising Chamber is, nevertheless, an exceedingly efficient device.

The fact, moreover, that the Equalising Chamber at present remedies the faults in the air-flow at its inlet to the remarkable extent that it does, is a most promising sign with regard to effecting improvement in the equalisation. For it is probable that the alterations in the air entry at the floor of the Equalising Chamber need only be of a comparatively minor description in order to get full equalisation of the Terrace air by the time that it reaches the floor of the Debating Chamber. Possibly the alterations suggested in the Battery Chamber may alone suffice for this purpose.

(2.) THE EFFECT OF VARIOUS FACTORS ON THE AIR-FLOW THROUGH THE SLITS.

A. The effect of the wire-gauze screen under the Government side of the Debating Chamber.

B. The effect of the cotton-wool filter.

C. The effect of opening the windows of the Debating Chamber.

D. The proportion of Terrace air entering the Debating Chamber by the slits and by other channels, and the effect of carpeting the gangways.

A. The effect of the Wire-Gauze Screen.

It was proved in the Equalising Chamber that the wire gauze diminishes the upflow of air under the Government side. This action of the gauze is at present a welcome one, because it helps to dam back the too active upstream of air under the block of Benches above the gangway on this side. But that the inhibitory value of the gauze is not complete in effecting equalisation at this part, is seen from the observations at the slits which have been described, and in all of which this gauze was in position.

In order to ascertain the value of the gauze more exactly, observations of the air-flow at the slits have been made with the gauze down and with it up, respectively. The results of these tests are contained in the following table :—

Air-flow through the Slits with the Equalising Chamber Gauze off and on, respectively.

Date	July 11th.	July 6th.	July 12th.	Oct. 16th.	Nov. 24th.	July 27th.
Wire Gauze Screen...	Not acting	Acting	Not acting	Acting	Not acting	Acting
Input Fan	Min.	Min.	Med.	Med.	Max.	Max.
Extract Fan... ...	Min.	Min.	Med.	Med.	Max.	Max.
Inflow from Terrace Inlet.	36,490	36,300	45,810	47,250	53,600	53,600
Outflow from Debating Chamber.	36,800	37,400	43,400	45,200	56,000	56,500
Slits.						
Government Side above Gangway.	2,604	2,420	3,233	2,932	4,898	3,965
Government side below Gangway.	1,480	1,740	1,902	1,848	3,241	2,531
Total Government side.	4,084	4,160	5,135	4,780	8,139	6,496
Slits.						
Opposition side above Gangway.	1,775	2,269	2,305	2,537	3,586	2,953
Opposition side below Gangway.	1,558	1,658	1,960	1,780	3,110	2,400
Total Opposition side.	3,333	3,927	4,265	4,317	6,696	5,353
Grand Total by Slits.	7,417	8,087	9,400	9,097	14,835	11,849

Analysis.

In comparing these results with the gauze in and out of action, respectively, it is best to compare the quantity of air delivered per Member per minute at each of the four blocks of Benches.

When both fans were at minimum speed, the cubic feet of air delivered per Member per minute was as follows :—

Both fans minimum speed.

Gauze not Acting.		Gauze Acting.	
32	22	30	28
23	25	28	26
Mean 25.		Mean 28.	

The figures above and below the mean, therefore, are as follows :—

Gauze not Acting.		Gauze Acting.	
+7	−3	+2	0
−2	0	0	−2
Total Variation 12.		Total Variation 4.	

When the fans were at minimum speed, therefore, the effect of the gauze was distinctly to improve equalisation.

The results obtained when the speed of both fans was increased to medium were as follows :—

Cubic feet of air per Member per minute.

Both fans medium speed.

Gauze not Acting.		Gauze Acting.	
40	28	41	31
30	31	29	28
Mean 32.		Mean 32.	

The figures above and below the mean, therefore, were now as follows:—

Gauze not Acting.		Gauze Acting.	
+8	−4	+9	−1
−2	−1	−3	−4
Total Variation 15.		Total Variation 17.	

With increased fan speed, therefore, the equalising value of the gauze disappeared.

Both fans maximum speed.

The results obtained when both fans were at maximum speed were as follows:—

Gauze not Acting.		Gauze Acting.	
61	44	49	36
52	50	40	38
Mean 51.		Mean 40.	

Variation above and below the mean:—

Gauze not Acting.		Gauze Acting.	
+10	−7	+9	−9
+1	−1	0	−2
Total Variation 18.		Total Variation 15.	

At maximum speed of both fans, therefore, the equalising action of the gauze was but small.

Inferences.

The evidence of the air-flow through the slits goes to show that the gauze underneath the Government side of the Debating Chamber has a distinct value for improving equalisation when the fans are at lowest speed, but that this effect of the gauze disappears when the speed of both fans is increased.

The equalising action of the gauze was, in short, best marked when the quantity of air impelled into the Debating Chamber most nearly balanced the quantity extracted thereform.

The equalising value of the gauze, however, is entirely due to the fact that the air entry into the floor of the Equalising Chamber under it on the Government side above the gangway is far too excessive—a fault due to insufficient distribution of the Terrace air in the Battery Chamber and cotton-wool filter below.

When the faulty distribution in the Chambers below is remedied, it is unlikely that the impeding action of the gauze will any longer be found to be of advantage.

B. *The effect of the Cotton-Wool Filter.*

On August 8th, when the effect of the cotton-wool filter on the distribution of air in the Equalising Chamber was being examined, the opportunity was also taken of examining its effect upon the flow of air through the slits in the Debating Chamber.

It will be remembered that the effect of the cotton-wool filter on the Equalising Chamber was to diminish the total flow of Terrace air into the Equalising Chamber by some 20 per cent., but to improve the equalisation of the air entry.

The effect of the cotton-wool filter on the air-flow through the slits is seen from the following two experiments :—

A. Control experiment. Cotton-Wool Filter off. (November 24th, 1905.)

Input Fan—maximum.
Extract Fan—minimum.
Terrace inlet—54,000.
Ceiling shutter—38,800.

Total Delivery at Slits.		Air per Member.		Variation.	
3,746	3,555	46	44	+2	0
2,614	2,826	42	45	−2	+1
		Mean 44.		Total Variation 5.	

B. Cotton-Wool Filter on. (August 8th, 1905.)

Input Fan—maximum.
Extract Fan—minimum.
Terrace inlet—52,145.
Ceiling shutter—40,400.

Total Delivery at Slits.		Air per Member.		Variation.	
3,100	3,010	38	37	+4	+3
2,012	2,019	32	32	−2	−2
		Mean 34.		Total Variation 11.	

Inference.

The effect of the cotton-wool filter, therefore, did not appear to be in the direction of improving equalisation in the Debating Chamber. This is at first sight surprising, as it produced such a marked improvement in that respect at the inlet to the Equalising Chamber. The explanation, however, lies in the fact that the two experiments are not strictly comparable, for, when the wool was on, the air-flow to the Debating Chamber was much reduced, and hence the extract fan was withdrawing far more air from the Debating Chamber than was passing in from the Equalising Chamber. The two experiments, therefore, are not strictly parallel, and no inference can be drawn from them.

C. *The effect of opening the Windows of the Debating Chamber on the Air-flow through the Slits.*

The results of a test made to determine this matter are contained in the following table. During the test referred to, both fans were kept at the same medium speed, the amount of air entering at the Terrace inlet being 47,745 cubic feet per minute, and the outflow from the Debating Chamber being 48,320 :—

The effect of opening the Windows of the Debating Chamber on the Air-flow through the Slits.

(*August 2nd.*)

——	Windows shut.	Windows open.	Difference.
Government Benches above Gangway ...	2,913	2,979	66
Government Benches below Gangway ...	2,336	2,045	291
Total Government Side	5,249	5,024	225
Opposition Benches above Gangway ...	2,861	2,629	232
Opposition Benches below Gangway ...	2,210	1,985	225
Total Opposition Side	5,071	4,614	457
Total flow through Slits	10,320	9,638	682

The effect of opening the windows, therefore, was to decrease the air entry by slit on the Government side by 225 cubic feet per minute, and on that of the Opposition by 457 cubic feet per minute, the total decrease for both sides being 682 cubic feet per minute.

The cause of this decrease is that the pull on the slits from the extraction fan is diminished by opening the windows of the Debating Chamber.

D. *The proportion of Terrace air entering the Debating Chamber by the Slits and by Other Channels, respectively; and the effect thereon of Carpeting the Gangways.*

(1.) *The proportion of Terrace air entering the Debating Chamber by the Slits and by Other Channels, respectively.*

The general area of inlet at the floor of the Debating Chamber is 293 square feet, of which the slits provide 81 square feet.

The proportion of Terrace air passing from the Equalising Chamber into the Debating Chamber by the slits and by elsewhere in four tests is seen from the data contained in the following table:—

Comparison of the amount of Terrace air admitted to the Debating Chamber by the Slits and by Other Channels, respectively, on the same occasion.

Date	Aug. 2.	Nov. 14.	Oct. 12.	Oct. 13.
Input Fan	Medium	Medium	Medium	Medium
Extract Fan	Medium	Medium	Near Maximum	Near Maximum
Inflow at Terrace Inlet	47,745	44,325	46,035	45,720
Outflow from Debating Chamber ...	48,320	(45,000)	54,000	53,000
Air-flow from Equalising to Debating Chamber.	31,534	31,576	37,964	35,924
Portion of this Air entering by Slits.	10,320	10,776	9,725	9,047
Portion entering by other Channels therefore.	21,214	20,800	28,239	26,877
Percentage entering by Slits ...	32	34	25	25
Percentage entering by other Channels.	68	66	75	75

It appears from these results that when the two fans are at medium speed, about one-third of the air enters by the slits; but that when the extract fan's speed is increased, a larger proportion enters by the other channels from the Equalising Chamber than before, and the air entry by slit falls to one-fourth of the total.

In a test made on August 8th, the effect of the cotton-wool filter on the relative air entry by slits and by the other channels can be seen. Particulars of this test are as follows:—

Cotton-wool filter in action. Input fan maximum, extract minimum. Air passing from Equalising Chamber into Debating Chamber, 26,901 cubic feet per minute; air entering by slits, 10,141; air entering by other channels, 16,760 cubic feet per minute. According to this experiment, therefore, the proportion of Terrace air entering by slit was about 37 per cent.

The effect will now be described of replacing the string matting by carpet.

(2.) *The effect on the Slit supply of replacing the String Matting on the Gangways by Carpet.*

The results of two tests made to determine this matter are contained in the following table:—

The effect of Carpeting the Gangways.

No.	1	2	3	4
Date	Oct. 12	Oct. 12	Oct. 13	Oct. 13
Covering of the gangways	String Matting (Control test).	Partially Carpeted.	String Matting (Control (test).	Thoroughly Carpeted.
Input Fan	Medium	Medium	Medium	Medium
Extract Fan	Near Maximum.	Near Maximum.	Near Maximum	Near Maximum.
Air-flow into Equalising Chamber	39,042	39,286	39,313	37,531
Air-flow out of Equalising into Debating Chamber.	37,964	37,842	35,934	30,786
Air-flow by Slits	9,725	11,765	9,047	11,817
Air-flow by elsewhere	28,239	26,077	26,877	18,969
Percentage entering Debating Chamber by Siit.	25	31	25	38
Percentage entering Debating Chamber by elsewhere.	75	69	75	62

In test 2 the carpet was put down on all the gangways except the centre gangway behind the Chair, which part was left bare. In test 4 the whole surface of the gangways was carpeted.

Analysis.

The Equalising Chamber inflow.

The first point to be observed about these tests is that the air-flow into the Equalising Chamber remained practically constant throughout the first three tests. In the last test, although the inflow of air at the Terrace inlet was found to be unaltered as compared with the control, there was 2,000 cubic feet per minute less entering the Equalising Chamber. This loss, however, is comparatively small.

The Debating Chamber inflow.

The air-flow to the Debating Chamber also remained practically constant until the last test, when the flow was diminished by 5,000 cubic feet per minute—a loss of 18 per cent. The air thus lost by the Debating Chamber passed laterally from the Equalising Chamber into the Division Lobbies owing to the increased resistance to the vertical flow through the floor of the Debating Chamber produced by the carpet.

The effect of the carpet on the air-flow viâ the slits. (*a*) Absolutely.

The effect of partial carpeting of the gangways was to increase the flow of air by the slits absolutely by 2,040 cubic feet per minute; and the effect of complete carpeting was to increase this flow by 2,770 cubic feet per minute.

(*b*) Relatively.

When, however, the air-flow through the slits is viewed relatively to the total flow from Equalising to Debating Chamber, it is seen that the effect of partial carpeting of the gangways was only to increase the proportion of Equalising Chamber air entering the Debating Chamber viâ the slits by 6 per cent.; and when the gangways were completely carpeted the rise was increased until 13 per cent. of the whole Equalising Chamber air entered by the slits.

Conclusion.

The effect of carpeting the gangways on the gross air-flow through the slits is not so great as might have been expected. Although when viewed by itself, the increase in the delivery by the slits seems to be large, this increase is found to be but small in relation to the whole quantity of air passing from the Equalising into the Debating Chamber. The proportion of the whole equalising air-flow passing by slit was only increased by 6 per cent. when the gangways were partially carpeted, and by 13 per cent. when the carpeting was complete. In the latter case, however, the total flow into the Debating Chamber from the Equalising Chamber was decreased by 18 per cent.

Effect of carpet on the distribution to the four blocks of benches.

The effect of carpeting the gangways on the distribution by the slits of the four blocks of Benches, respectively, is seen from the following :—

—	Air-flow.		Air per Member.		Variation.	
(A) Control Expt. String Matting. (October 12th).	3,113¾	2,750	38	34	+5	+1
	1,878	1,984	30	32	−3	−1
			Mean 33.		Total Variation 10.	
(B) Gangways partially carpeted. (October 12th).	3,486	3,477	43	43	+3	+3
	2,302	2,500	37	40	−3	0
			Mean 40.		Total Variation 9.	

From the point of view of air per Member on the Benches, therefore, there was a mean rise from 33 cubic feet of air per minute to 40, when the gangways were partially carpeted. The distribution effect of the carpet is what might have been anticipated. The Opposition block above the gangway now shares the excess of the Government block opposite it, and the Irish Benches also get a rise, with the result that the Opposition now get more Terrace air than the Government. The total variation above and below the mean with either string or carpet comes out about the same.

—	Air-flow.		Air per Member.		Variation.	
(C) Control Expt. String Matting. (October 13th.)	2,861	2,561	35	32	+4	+1
	1,882	1,743	30	28	−1	−3
			Mean 31.		Total Variation 9.	
(D) Gangways completely carpeted. (October 13th.)	3,609	3,402	45	42	+5	+2
	2,329	2,477	37	39	−3	−1
			Mean 40.		Total Variation 11.	

The supply of air per Member, therefore, rose to practically the same extent as before. Again the Opposition side got more air than the Government when the carpet was down, and again the Government block below the gangway was the worst affected by this covering up of the gangways.

The reason why the Opposition side get more air than the Government side of the Debating Chamber when the gangways are carpeted is clearly because of the increased resistance on the Government side produced by the wire gauze.

(3.) Brief Summary of the Chief Results of Observations made at the Slits.

When both fans are at minimum speed, the air-flow is well equalised at all the four blocks of Benches; a mean supply of 28 cubic feet of air per Member being obtained at each.

The best delivery of air by the slits is when the input fan is at maximum and the extract at minimum speed, under which conditions a mean delivery is obtained at the slits of 44 cubic feet of air per Member per minute, and the flow is well equalised in the four blocks.

The Government block of Benches above the gangway gets more air by slit than the other blocks. The cause of this undoubtedly lies in the fact that there is an excessive upflow of air into the Equalising Chamber underneath the block of Benches in question.

For the latter reason the wire gauze under the Government side of the Debating Chamber is at present of value for helping equalisation, provided that the extract fan be kept at its minimum. Unless the supply of Terrace air is sufficient to replace the air extracted by the extract fan from the Debating Chamber however, this gauze does not appear to be of any value for equalising purposes.

The result of the single experiment made to ascertain the effect of the cotton-wool filter on the distribution at the slits of the four blocks of Benches, implies that the filter had no beneficial effect to speak of in this sense; but it must be remembered that the extract was far in excess of the input in this experiment, and that, therefore, its result is inconclusive.

The opening of the windows in the Debating Chamber by lessening the pull of the extract fan on the floor, decreased the flow of air upwards through the slits.

The effect of carpeting the gangways was to increase the air-flow through the slits, but not to the extent that might have been anticipated. It must be remembered, however, that the valance delivery has also to be added to the slit delivery. When the carpeting was complete, the upflow of air from the Equalising Chamber into the Debating Chamber was decreased by 18 per cent. The air thus lost from the Debating Chamber was gained by the Division Lobbies.

When the gangways were carpeted, rather more air entered by the Bench inlets on the Opposition side of the House than on that of the Government—an effect due to the increased resistance on the Government side caused by the wire gauze.

(4.) THE AIR-FLOW THROUGH THE VALANCE INLETS, AND THE TOTAL DELIVERY OF AIR AT THE BENCHES BY BOTH SLIT AND VALANCE.

(1.) Brief description of valance inlet.

(2.) The comparative air-flow by slit and valance in the same test.

(3.) The total quantity of air delivered to Members on each block of benches by both slit and valance inlets.

(4.) The effect upon the air-flow into the Debating Chamber of lifting up all the valances.

(5.) Brief summary of the result of observations at the valances.

(1.) The Valance Inlet.

The valances, or curtains hanging down from the under surface of the seats, terminate at a distance of $1\frac{1}{4}$ inch from the floor by a fringed extremity, and the clear space thus left free for the egress of air at the level of the heels of Members' boots is known as the valance inlet. When the ventilation is on, good readings are obtained by exposing the wheel of the anemometer to the air flowing out through this space below the valance.

The total area of the valance inlet on either side of the Debating Chamber is 39 square feet. The area of inlet in question is thus about half the area of the inlet at the slits which amounts on either side of the chamber to 81 square feet.

Since the average height of the valance inlet is but $1\frac{1}{4}$ inch, and the width of the wheel of the anemometer is 3 inches, anemometer readings at the valances must, of necessity, be more liable to error than readings obtained at the slits. The question of the extra correction needed for the valance readings was examined into by Mr. Patey at some length, and his observations, which have been previously described, led to the belief that the reading given by the anemometer at the valance inlet under ordinary conditions is about two-thirds of the reading that the anemometer would give were the whole of the surface of its wheel exposed to a current of the same velocity as that issuing from the valance inlet. The velocities found by anemometer at the valances, therefore, have had one-third of the reading added to them before adding the necessary Kew correction for the instrument.

(2.) The Comparative Air-flow by Slit and Valance in the same Test.

The results of four tests in which the air-flow through both slits and valances was observed on the same occasion, are seen from the following table.

Air-flow through Slits and Valances at the same Time.

No.		1	2	3	4
Conditions		Test	Test	Control	Gangways thoroughly carpeted.
Date		July 17	Nov. 24	Oct. 16	Oct. 16.
Input Fan		Near Maximum.	Maximum	Medium	Medium.
Extract Fan		Near Medium.	Minimum	Medium	Medium.
Inflow at Terrace Inlet		54,540	54,000	47,250	47 250
Outflow from Debating Chamber		48,370	38,800	47,200	47,200
Government Block above Gangway.	Slit	3,369	3,746	2,932	4,291
	Valance	1,170	1,414	1,241	2,009
Government Block below Gangway.	Slit	2,273	2,614	1,848	2,796
	Valance	905	1,392	899	1,634
Total Government side.	Slit	5,742	6,360	4,780	7,087
	Valance	2,075	2,806	2,140	3,643
Opposition Block above Gangway.	Slit	2,773	3,555	2,537	3,388
	Valance	1,228	1,807	1,268	2,223
Opposition Block below Gangway.	Slit	2,064	2,826	1,780	3,129
	Valance	809	1,524	902	1,557
Total Opposition Side.	Slit	4,777	6,381	4,317	6,519
	Valance	2,037	3,331	2,170	3,780
Total both Sides.	Slit	10,519	12,741	9,097	13,604
	Valance	4,112	6,137	4,310	7,423
Grand Total to Benches		14,631	18,878	13,407	21,027

Analysis.

Relative air-flow by Slit and Valance.

It appears from these results that when the string matting was on the gangways as usual, the total delivery of air by slits and valances respectively was as follows, at the different fan speeds examined.

I.

Input fan, near maximum.
Extract fan, near medium.

Government side, slits ...	5,742	
„ „ valances	2,075	
Opposition side, slits ...	4,777	
„ „ valances ...	2,037	
Total slits		10,519
„ valances		4,112
Grand total to benches		14,631

II.

Input fan, maximum.
Extract, minimum.

Government side, slits	... 6,360		
" " valances	2,806		
Opposition side, slits	... 6,381		
" " valances ...	3,331		
	Total slits		12,741
	" valances		6,137
	Grand total to benches		18,878

III.

Input fan, medium.
Extract fan, "

Government side, slits	... 4,780		
" " valances	2,140		
Opposition side, slits	... 4,317		
" " valances ...	2,170		
	Total slits		9,097
	" valances		4,310
	Grand total to benches		13,407

It is seen from these three tests that the air-flow through the valances is about half the flow through the slits, a proportion that corresponds to the relative area of these two inlets.

The air-flow through both slits and valances was most active when the fans were most nearly balanced, viz., in Test II., when the input was at maximum and the extract at minimum.

The effect of carpeting the gangways is seen by comparing the last test (III.) with the following:—

IV.

Gangways now carpeted.
Input fan, medium.
Extract fan, "

Government side, slits	... 7,087		
" " valances	3,643		
Opposition side, slits	... 6,519		
" " valances ...	3,780		
	Total slits		13,604
	" valances		7,423
	Grand total to benches		21,027

The effect of carpeting the gangways, therefore, was to increase the flow at the bench inlets by one-third, and the flow by the valance inlets appears to have been increased far more in proportion than the flow by the slits. The explanation is that the valance inlets became somewhat dilated by the increased pressure.

The air supply per Member by Slit and Valance respectively.

The air-supply per Member at each block of benches in these tests by slit and valance respectively was as follows:—

Fans.

Input, near maximum.
Extract, near medium.

Slits.		Valances.	
42	34	14	15
38	33	14	13
Mean 36.		Mean 14.	

Fans.

Input, maximum.
Extract, minimum.

Slits.		Valances.	
46	44	17	22
42	45	22	24
Mean 44.		Mean 21.	

Both Fans, Medium.

Slits.		Valances.	
36	31	15	15
29	28	14	14
Mean 31.		Mean 14.	

Ditto, but Carpet on Gangways.

Slits.		Valances.	
53	42	25	27
45	50	26	25
Mean 47.		Mean 25.	

Once again it is seen from these figures that the volume of air supplied by the valance inlets is approximately half the volume supplied by the slits under the same conditions.

(3.) THE TOTAL VOLUME OF AIR DELIVERED PER MEMBER AT EACH OF THE BLOCKS OF BENCHES BY BOTH INLETS.

The cubic feet of air supplied per Member per minute by both inlets in all four tests referred to is, therefore, as follows:—

1. Input Maximum. Extract Medium.		2. Input Maximum. Extract Minimum.		3. Input Medium. Extract Medium.		4. Same Conditions as in 3, but Gangways carpeted.	
56	50	64	67	52	47	78	70
52	46	64	70	44	43	71	75
Mean 51.		Mean 66.		Mean 46.		Mean 73.	

Gross quantity of air per Member at the benches.

With the string matting, therefore, on the gangways, the best delivery of air at the benches took place in Test II. when the input was at maximum, and the extract at minimum, and a mean delivery of 66 cubic feet of air per member was obtained. The effect of carpeting the gangways was to raise the delivery from 46 to 73 cubic feet per minute in the test in which this was examined.

(4.) THE EFFECT ON THE AIR-FLOW INTO THE DEBATING CHAMBER OF LIFTING UP ALL THE VALANCES.

Before proceeding to describe the result of the next two tests, it is necessary to state exactly what difference in the area of inlet at the floor of the Debating Chamber resulted from the alterations made.

The total area of inlet in the floor of the Debating Chamber is 293 square feet, and of this the gangways contribute 173 square feet, and the bench inlets 120 square feet. When the valances are hanging down as usual, the valance inlets contribute to the bench area of inlet 39 square feet.

But when the valances are all raised, the valance inlet area is increased to 211·8 square feet on either side of the Debating Chamber, or altogether to 423·6 square feet. The total area of inlet at the floor of the Debating Chamber, when all the valances are raised, therefore, is 677 square feet, of which the valances and slits contribute 504 square feet, and the gangways, &c., 173 square feet. The bench inlets, however, have the advantage over the gangway inlets that there is no string matting or other material over the grating under the seats.

Experiment I.

This test was made on August 14th. Both fans were put at medium speed, and all the valances in the Debating Chamber were lifted up and tucked under the cushions of the seats.

From observations in the Equalising Chamber it was found that 35,574 cubic feet of air was passing into the Debating Chamber therefrom per minute.

The total quantity of air found to be entering the Debating Chamber by the bench inlets was as follows:—

Slits	4,376
Valances	31,420
Total by bench inlets	35,796

In other words the whole of the air entering the Debating Chamber from the Equalising Chamber was now accounted for at the benches.

The distribution of this air over the four blocks of benches was as follows:—

Slits.		Valances.		Both together.	
1,505	999	10,376	8,007	11,881	9,006
838	1,034	5,402	7,635	6,240	8,669

The cubic feet of air delivered per member per minute at the blocks was:—

Slits.		Valances.		Both together.	
18	12	129	100	148	112
13	16	87	123	100	139
Mean 14.		Mean 109.		Mean 124.	

The fact that the Opposition benches below the gangway got second best supply of air per Member by the valance inlet is remarkable.

The Effect on the Air Supply of the Division Lobbies of Dropping the Valances in the Debating Chamber.

While the valances were all raised up in this test, 5,313 cubic feet of air was found to be passing per minute from the Equalising Chamber into the Division Lobbies. At the end of the experiment all the valances in the Debating Chamber were dropped back into their usual position. The air-flow from the Equalising Chamber into the Division Lobbies now measured 7,953 cubic feet per minute. The result of dropping the valances, therefore, was to increase the lateral air-flow from the Equalising Chamber into the Division Lobbies by 2,640 cubic feet per minute.

Experiment II.

On November 14th, a control experiment was first made with the valances all down, and then the experiment of raising the valances was repeated. The result of this test is seen in the following table.

Position of Valances.	Down.	Up.
Input Fan	Medium	Medium
Extract Fan	Medium	Medium
Inflow at Terrace Inlet	44,315	44,325
Air-flow to Equalising Chamber	35,812	33,414
Air-flow to Division Lobbies	4,236	1,734
Air-flow to Debating Chamber	31,576	31,680
By Slits of Debating Chamber	10,776	4,656
By Valances	5,085	25,183
Total Flow by Bench Inlets	15,861	29,839
Air-flow by Gangways, &c....	14,531	472

It is seen from these results that the air-flow into the Debating Chamber was practically equal in the two tests, and that, as in the previous test, on August 14th, when the valances were raised, practically the whole of the air passing from the Equalising Chamber into the Debating Chamber was accounted for at the bench inlets.

The distribution of the air over the four blocks of benches in the two tests on November 14th was as follows:—

Experiment A (Valances down).

Slits.		Valances.		Both together.	
3,060	3,076	1,376	1,338	4,436	4,414
2,162	2,478	1,154	1,217	3,316	3,695

Experiment B (Valances all up).

Slits.		Valances.		Both together.	
1,488	1,292	6,985	7,159	8,473	8,451
960	916	5,412	5,627	6,372	6,543

Cubic feet of air delivered per member at the four blocks of benches was as follows:—

A. Valances down.

Slits.		Valances.		Both together.	
38	38	17	16	55	55
34	39	16	19	63	59
Mean 37.		Mean 17.		Mean 58.	

B. Valances up.

Slits		Valances.		Both together.	
18	16	87	89	105	105
15	14	87	90	102	105
Mean 15.		Mean 88.		Mean 104.	

The quantity of air delivered per Member at the benches was rather smaller in this experiment with the valances up, than in the previous experiment on August 14th, when the valances were raised. The reason of the difference lies in the fact that 4,000 more cubic feet of air entered the Debating Chamber per minute in the previous test.

The equalisation, however, was better in the present test with the valances up than on August 14th, and though the Opposition side get more air than the Government side as before, the difference was so small that it may be neglected.

The Effect of Raising the Valænces on the Air Supply to the Division Lobbies.

On August the 14th, when the valances were dropped, 2,640 cubic feet more air passed into the Division Lobbies than when the valances were all raised. In the present experiment the reverse test was made, *i.e.*, the air-flow to the Division Lobbies was first measured with the valances all down, and secondly, with them all up, with the result that when the valances were raised the air-flow to the Division Lobbies was found to be diminished by 2,502 cubic feet per minute. The effect, therefore, of the valances on the air-flow to the Debating Chamber was practically the same on both occasions.

Inference.

When the valances in the Debating Chamber are raised, practically the whole of the Terrace air passing into the Debating Chamber enters it by the bench inlets.

(5.) BRIEF SUMMARY OF THE RESULT OF OBSERVATIONS AT THE VALANCE INLETS.

When the valances are in the usual position, the air-flow through the valance inlets is about half the flow through the slits on the same occasion.

When string matting was on the gangways the best delivery of air at the benches occurred when the input fan was at maximum speed, and the extract at minimum. Under these conditions, a total of 66 cubic feet of air was delivered per minute by both the inlets at each Member's seat.

Carpeting the gangways increased the delivery of air at the benches by about one-third, and the increased delivery was more marked at the valances than at the slits. This was due to the valance inlets being expanded by the increased pressure of the air.

When the valances in the Debating Chamber are all lifted up, practically the whole of the air passing from the Equalising into the Debating Chamber appears to flow through the inlets at the benches, even though string matting be on the gangways.

Distribution (5).

5. THE AIR-FLOW THROUGH THE PANELS OF THE DEBATING CHAMBER FLOOR AREA.

The panels in question are 20 in number, and are situated as follows:—4 at the Bar end of the Debating Chamber; 14 in the sides of the table, and 2 at the Chair end of the Debating Chamber. Owing to the large part of their area composed of carving, the area of inlet of the 20 panels only amounts altogether to about 12·5 square feet.

On October 16th, both fans being at medium speed, the air-flow through these panels was observed (*a*) when string matting was on the gangways, (*b*) when the gangways were carpeted. The volume of air entering the Debating Chamber through the whole of the panels came to the following figures:—

(A.) With string matting on the gangways 1,260 cubic feet of air per minute.

(B.) With carpet on the gangways 2,010 cubic feet of air per minute.

In the former case the air-flow at the benches was as follows:—

Slits	9,097
Valances	4,310
Total	13,407

When the gangways were carpeted the air-flow at the benches was:—

Slits	13,604
Valances	7,423
Total	21,027

Distribution (6).

6. THE AIR-FLOW THROUGH THE SHAFTS TO THE MEMBERS' GALLERIES.

The Members' Gallery seats 54 persons on either side of the House, or, altogether, 108.

Shafts, four in number, and varying in sectional area from 0·8 to 1·8 square feet, spring from the sides of the Equalising Chamber between the "port-hole" openings to the Division Lobbies, and rise up in the wall on either side of the Debating Chamber to terminate under the seats of the Members' Gallery.

The air-flow through these shafts has been examined on a number of occasions in the Equalising Chamber by placing an anemometer well inside the rising part of each shaft. The air-flows observed are seen in the following table :—

Air-flow through the Members' Gallery Shafts.

Date	July 31.	July 31.	Aug. 1.	Aug. 1.	Nov. 3.	Nov. 3.	Aug. 2.	Nov. 14.
Input Fan	0	0	Max.	Max.	Max.	Max.	Med.	Med.
Extract Fan	0	Max.	0	Max.	Max.	Min.	Med.	Med.
Members' Gallery, Shafts, Government Side.	0	−262	674	581	597	585	549	696
Members' Gallery, Shafts, Opposition Side.	0	−671	611	721	588	451	428	488
Total Air flow through Shafts.	0	−933	1,285	1,302	1,185	1,036	977	1,184
No. of persons for whom supply of air sufficient.	0		25	26	23	29	19	23
Remarks	Control test.	Down-flow.	Division Lobbies' best supply here.					

It will be remembered that when the extract fan alone was acting, and at maximum, a downflow of air occurred from the Division Lobbies into the Equalising Chamber. The Members' Gallery shafts, which open between the lobby inlets, also had a downflow in this case as is seen from the table.

The best supply of air to the Division Lobbies occurred when the input fan alone was acting, and at maximum. Under this condition also the Members' Gallery shafts were almost at their maximum as regards air-flow.

The quantity of air passing through the shafts was sufficient for from 19-25 persons.

The effect of Carpeting the Gangways in the Debating Chamber on the Air-flow through the Members' Gallery Shafts is seen in the following table:—

Date	October 12.	October 12.	October 13.	October 13.	October 13.*
Gangways of Debating Chamber	Partially Carpeted.	String Matting.	Thoroughly Carpeted.	String Matting	String Matting.
Input Fan	Medium	Medium.	Medium	Medium	Medium
Extract Fan	Maximum	Maximum	Maximum	Maximum	Medium
Members' Gallery Shafts, Government side.	453	516	612	484	572
Members' Gallery Shafts, Opposition side.	417	379	533	389	410
Total	870	895	1,145	873	982
No. of persons for whom supply of air sufficient.	17	17	22	17	19

* The extract diminished in this test.

From these results it appears that when the gangways are thoroughly carpeted the Members' Gallery shafts supply rather more air, but that when the carpeting is imperfect no such improvement takes place.

It is also seen from the last test in the table that when the extract fan's speed was slowed down, the air-flow up these shafts increased.

Inference.

Under no conditions examined did the quantity of air passing up these shafts suffice for more than 25 persons. Yet the galleries to which they go seat 108. It must be added, however, that according to the smoke tests the Members' Galleries get more fresh air from the body of the Debating Chamber than do the other galleries.

Distribution (7).

7. THE EFFECTIVE AREA OF OUTLET FROM THE DEBATING CHAMBER.

Air is extracted from the Debating Chamber by three channels: (1) through the grille of the Speaker's and Ladies' Gallery, (2) through the open spaces between the raised panels of the ceiling and their supports, and (3) through the gas-burner extraction which operates at the middle part of the ceiling.

(1.) The extraction through the Ladies' and Speaker's Gallery.

Air from the Debating Chamber enters the Ladies' and Speaker's Gallery through the grille, and is extracted through the ceiling of the gallery into a chamber above. From this chamber the air passes through a small area to the air-space above the panels of the ceiling. The extract fan at the opposite end of the ceiling is the agency relied upon for extracting air from these galleries.

An opening through which the vitiated air from the Ladies' and Speaker's Gallery passes to join the vitiated air extracted through the panels of the ceiling by the extract fan is a convenient spot at which to measure the extraction from both these galleries. Three observations of this matter are recorded in the following table :—

The volume of Air extracted from the Ladies' and Speaker's Gallery.

Date ...	June 7.	June 27.	August 3.
Input Fan ...	0	0	Maximum
Extract Fan ...	Minimum	Medium	Maximum
Air extracted from both Galleries ..	2,185	2,261	2,698
Total ceiling extract by extract Fan on same occasion.	40,000	48,460	56,360

On the last occasion, August 3rd, a careful survey was made of both the Ladies' and Speaker's Gallery ceiling from above. Actual anemometer readings obtainable showed 608 cubic feet passing out from the Ladies' Gallery, and 524 cubic feet from the Speaker's Gallery per minute. Owing to structural difficulties, the remaining 1,566 cubic feet of air passing out from these galleries escaped measurement at this point.

Seating accommodation is provided in the Ladies' Gallery for 42, and in the Speaker's Gallery for 24; a total of 66. The extraction, therefore, when working at its maximum would withdraw 40 cubic feet of air for each of the 66 occupants of these galleries. According to the 50 cubic feet per minute standard, therefore, the present maximum extraction is sufficient for 53 persons in the two galleries in question.

The extraction from the Ladies' and Speaker's Gallery, therefore, is not sufficient if both galleries are crowded to the full.

One of the suggestions recommended is to provide the Ladies' and Speaker's Galleries with a fresh air supply of their own, and to extract these galleries *through the grille.**

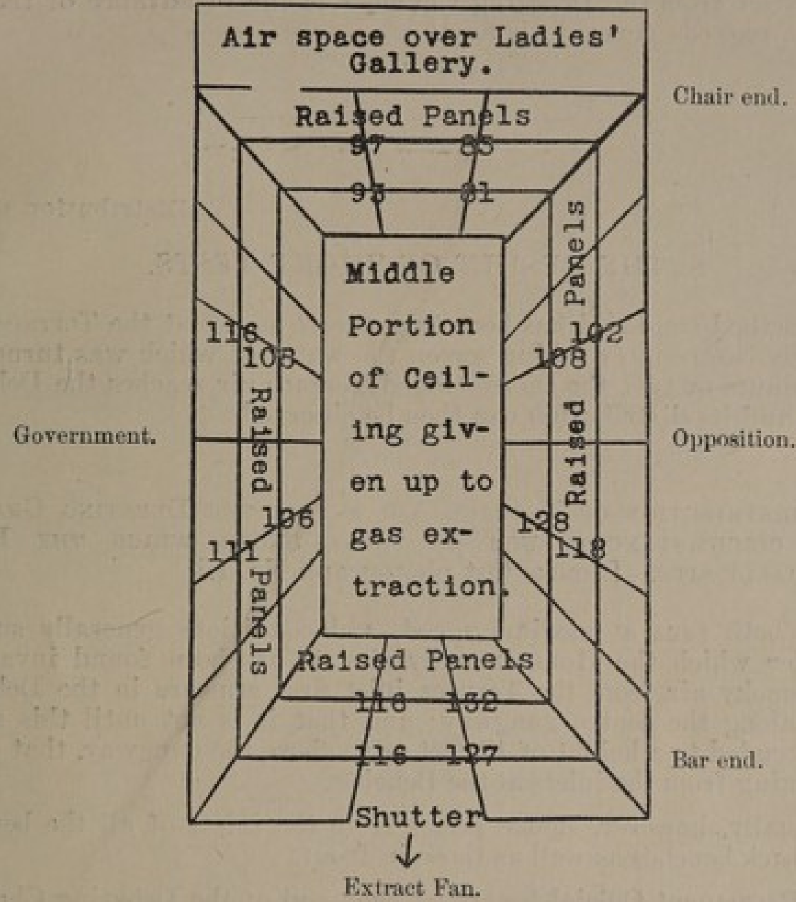
(2.) The extraction through the Spaces between the Panels of the Ceiling.

On the same occasion as the last test (August 3rd), anemometer observations were made over the spaces between the panels of the ceiling. These openings are each 3 feet long by 2½ inches wide, thus providing a

* This recommendation is about to be carried out.

superficial outlet area of 1·5 square feet. The velocity of the air observed issuing at these outlets is seen in the following diagram :—

Diagram of Upper Surface of Ceiling of Debating Chamber showing velocity of Air issuing at Raised Panels.



The numbers indicate the velocity (feet per minute) of air issuing at various points.

As was to be expected, higher velocity readings were obtained at the Bar end of the ceiling owing to its being nearer to the extract fan.

As each of the openings at which the velocities shown in the diagram were obtained, has an area of 1·5 square feet, well over 100 cubic feet per minute was being extracted at all these outlets.

This result is very satisfactory. It shows that the extract fan operates all over the panelled parts of the ceiling, and that even at the Chair end, over 100 cubic feet of air can be extracted from each opening between the panels per minute.

3. The Gas Extraction.

No observations were made of this during the present enquiry. In 1904, however, Mr. Patey made some observations of the air-flow through the large tubes in which the gas fumes are conveyed away, and he found that according to the quantity of air then being extracted, the gas extraction alone was sufficient to change the air of the Debating Chamber 1-1½ times per hour. As the cubic capacity of the Debating Chamber is estimated at 165,000 cubic feet, the amount withdrawn by the gas extraction would appear to be about 2,750 cubic feet per minute.

Inference.

The present extraction from the Ladies' and Speaker's Gallery is not sufficient when these galleries are crowded, as they sometimes are. The extraction from the Debating Chamber, however, is at present very active on all four sides of the ceiling. It has been previously shown that the area of outlet from the Debating Chamber is far in advance of the area of inlet as regards general air-flow.

Distribution (8).

8. THE RESULT OF SMOKE TESTS.

The method employed has been to generate smoke at the Terrace inlet immediately before the washing screen the water of which was turned off. After a minute or two, the smoke-tinged Terrace air reaches the Debating Chamber, and its distribution can then be observed.

(1.) The distribution of Terrace Air within the Debating Chamber in circumstances such as those under which the House usually sits. [Smoke test photograph No. 1.]

Floor of Debating Chamber. With both fans at medium speed, and conditions generally such as those under which the House usually sits, it has been found invariably that the smoky air from the Terrace inlet first appears in the Debating Chamber along the centre gangway; and that it is not until this smoky air has ascended to a height of 12 feet or so above the gangway, that smoke is seen issuing from the inlets at the Benches.

Gradually, however, smoke issues from the inlets of all the benches; from the back benches as well as those in front.

The Permanent Officials' seats, at each end of the Debating Chamber, under the gallery, get comparatively little of the smoky air by reason no doubt of the impervious carpet which is here laid over the grating of which the floor consists. If that carpet is lifted up, however, good velocity readings can be obtained with the anemometer over the grating at this part.

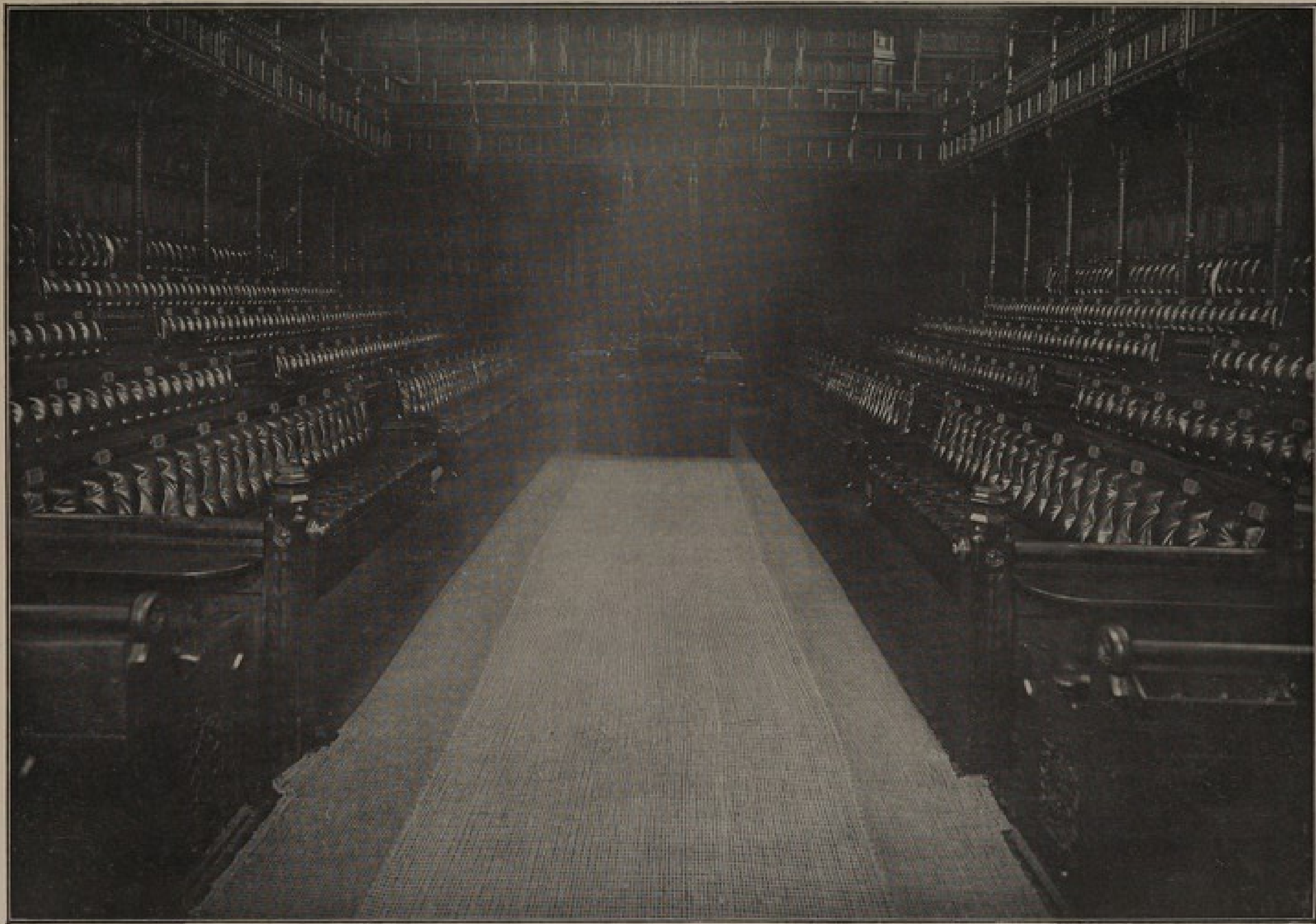
According to the smoke tests, the best ventilated part of the Debating Chamber floor area under present conditions when the House is sitting is the centre gangway.

Galleries. The Ladies' and Speaker's Gallery escapes the Terrace smoke to a great extent.

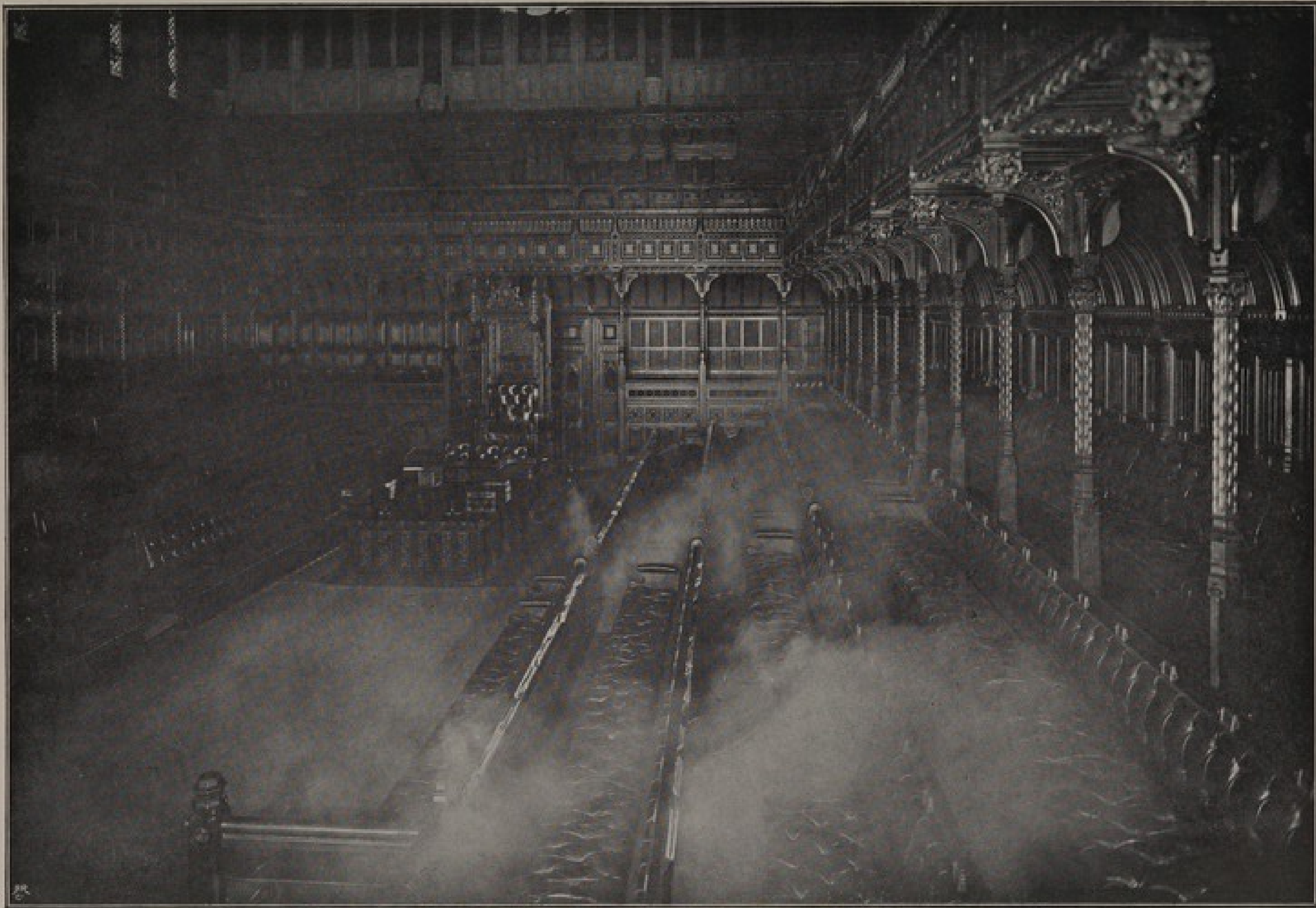
The Press Gallery is also shown by the smoke test to get comparatively little Terrace air.

The Members' Galleries, on either side of the Debating Chamber, are somewhat better off than the other galleries, although a good deal of the Terrace air that reaches them descends from the ceiling rather than ascends from below.

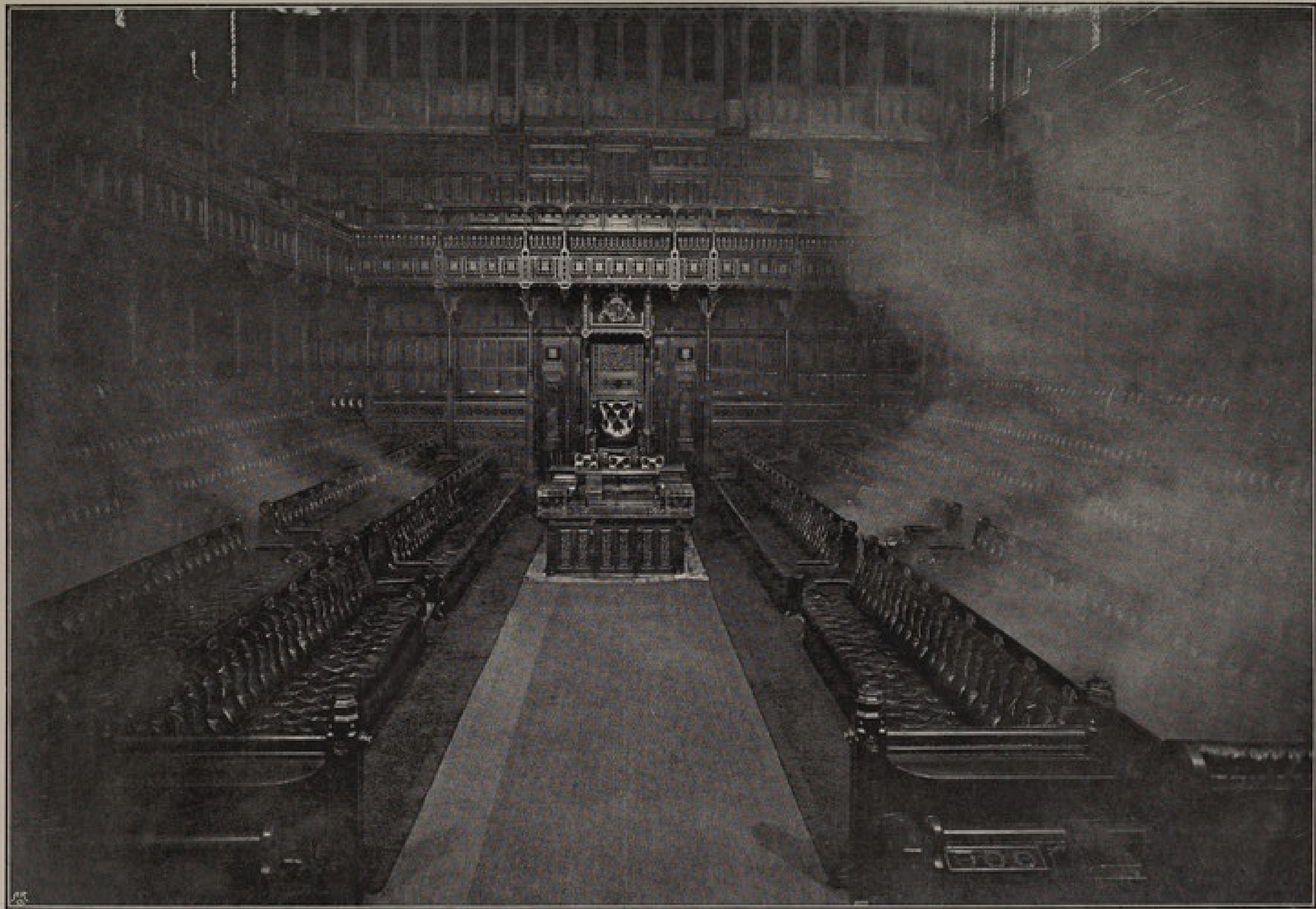
The Distinguished Strangers' Gallery, and the Strangers' Gallery, behind it, do not appear to derive the advantage from the extraction that had been anticipated from their nearness to the extract fan. The smoke appears to hang about over these galleries for some time; and it also lingers at the corners of the Chamber at the opposite end by the grille of the Ladies' Gallery. Even when a panel of the ceiling over the Strangers' Gallery was raised, the smoke over the Strangers' Gallery did not disappear so speedily as might have been expected.



Smoke test photograph No. 1.



Smoke test photograph No. 2



Smoke test photograph No. 3.

It has been previously mentioned that the horizontal area of the cavity of the Debating Chamber is, at the level of the heads of Members sitting on the Benches, 3,090 square feet; at the gallery rail, 1,731 square feet; and at the grille of the Ladies' and Strangers' Galleries, 3,895 square feet. The smoke tests indicate that the narrowing of the area of the Debating Chamber caused by the projecting of the galleries, tends to constrict the upward current of Terrace air, and although some of this air is reflected from the ceiling and descends again so that the atmosphere of the Chamber gradually becomes charged with smoke—except, perhaps, the atmosphere of the Press and Ladies' Galleries—such passage of fresh air as these smoke tests have demonstrated to obtain, is a most crude and unsatisfactory affair.

The smoke tests, in fact, demonstrate that under present working conditions, the freshness of the air supplied to the Debating Chamber from the Terrace inlet is not likely to be evident to the occupants of the Permanent Officials' seats, and even less so to the occupants of the galleries. The Members are much better off than their visitors. It would seem also that the freshness of the atmosphere of the Debating Chamber is likely to be least perceptible of all in the Press, and in the Ladies' and Speaker's Galleries.

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2. The effect of substituting Carpet for the String Matting on the Gangways. [Smoke test photographs 2 and 3.]

The contrast produced by this change is striking. Smoke is now seen spreading from the Bench inlets, and it curls up on either side of the Debating Chamber over the projecting rail of the Members' Gallery. But while the Members are clearly benefited by the carpeting of the gangways, the galleries at either end of the Debating Chamber do not even now seem to get their due proportion of fresh air from the Terrace.

The smoke tests, in short, indicate that the Ladies' and Speaker's Gallery and the Press Gallery at the one end of the Debating Chamber, and the Strangers' and other galleries at the opposite end, will only get their due proportion of fresh air by conveying it to them direct. This was undoubtedly the intention of Dr. Reid when he designed the present system; as may be seen from his book.

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3. The results of a Smoke Test in the Ladies' and Speaker's Gallery.

On generating smoke in the Ladies' Gallery it has been found that although the extract fan was at maximum speed, the smoke was very stagnant in this gallery. The smoke does not diffuse out through the grille into the atmosphere of the Debating Chamber, and it is many minutes before the gallery becomes free of it.

On the other hand, if the door and windows at the back of this gallery are opened, the extract fan is now found to draw the smoke out through the grille and up through the spaces between the panels of the ceiling of the Debating Chamber.

These results indicate that if a channel were to be opened by which fresh air could be conveyed from below to the back of the Ladies' Gallery, the extract fan would extract a large portion of this air through the grille. A shaft already in existence could be made use of for this purpose.

Ths question whether the present extract from this gallery should also be retained, and further details, can be decided best by actual experiment.

4. THE RESULT OF SMOKE TEST TO DETERMINE THE DISTRIBUTION WITHIN THE DEBATING CHAMBER OF FRESH AIR ADMITTED FROM WITHOUT BY OPENING THE WINDOWS.

This matter has been examined on three occasions by generating smoke outside the windows of the Debating Chamber and then observing its course within the Chamber.

It has been found that the smoky air passing in through the windows is not altogether drawn up immediately through the ceiling by the extract fan. Although a proportion is so drawn up, part of the smoky air is blown into the body of the Debating Chamber, and it has been seen that the Members', Press, and Strangers' Galleries in particular get fresh air from without, when the Debating Chamber windows are open. When gusty outside, the smoky air from without has been seen to be blown down through the windows on to the Speaker's Chair and the Benches on the floor.

Opening of the windows in the Debating Chamber, therefore, undoubtedly enables a number of persons in the Chamber to obtain more fresh air, but at the expense of Members on the floor of the House, because the pull of the extract fan upon the Equalising Chamber has been proved to be diminished by opening the windows of the Debating Chamber.

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5. THE DIVISION LOBBIES.

As was to be expected, a comparatively small amount of smoke was to be seen in the Division Lobbies during the tests in which smoke was generated at the Terrace inlet.

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6. THE RETIRING ROOMS.

The atmosphere of these as a rule remained perfectly free of smoke during the same tests.

Inferences.

Tests made by the smoke method confirm a conclusion previously arrived at from anemometer observations in the Debating Chamber, viz., that under present circumstances an undue proportion of Terrace air streams up the centre of the Debating Chamber through the centre gangway. They indicate also that the supply of fresh Terrace air to the Permanent Officials' seats and to the galleries of the Debating Chamber is imperfect.

When the gangways are carpeted, the occupants of the seats over the floor area have a much better service of fresh air from the Terrace than when these gangways are covered with the present string matting. The service of Terrace air to the galleries, however, even with carpet on the gangways, is still imperfect.

The remedy in the case of the Permanent Officials' seats is clearly to remove the carpet under these seats, or else to increase the area of operative inlet there in some suitable fashion.

The remedy for the galleries at either end of the Debating Chamber is to convey fresh air to them direct from the Battery Chamber. Shafts exist in the wall at each end of the Chamber that can be utilised for this purpose.

The present imperfect extraction from the ceiling of the Ladies' and Speaker's Gallery can be supplemented, or, if need be, replaced, by extraction through the grille.

The opening of the Debating Chamber windows when the ventilation is on, benefits persons present in some of the galleries, and may also benefit the Speaker and Members on the floor.

The smoke tests showed that under the conditions examined, comparatively little Terrace air passed into the Division Lobbies. This matter, however, has been previously investigated in much detail by the anemometer, and full particulars of the results are seen in the quantity section of the present report.

The Retiring Rooms appeared to get no air from the Terrace inlet under the conditions examined.

SECTION VI.

SUMMARY OF THE PRINCIPAL RESULTS OF PART II. OF THE INVESTIGATION.

I. Quality of the Air.

Filtration. The washing screen at the inlet removes 62 per cent. of the bacteria from the Terrace air passing into the Debating Chamber system.

The cotton-wool filter removes about 83 per cent. of the fine dust particles from the air.

Humidity. The washing screen has a marked action in the way of rendering the air of the Debating Chamber more moist. This appliance, however, is not adjustable enough to enable the humidity of the air passing to the Debating Chamber to be regulated with any nicety. Such regulation, moreover, is best attempted after, and not before, the temperature of the air has been artifically raised.

The cooling effect of the screen is a welcome one during the summer months. Mr. Lempfert's observations, however, show that some more powerful mode of cooling the air would be of advantage at that season.

Warming Dr. Aitken draws attention to the disadvantages of steam heating. Mr. Lempfert's observations, while testifying to the good distribution of heat obtained, also raise the question whether the present apparatus satisfactorily meets the varying requirements of the Debating Chamber. The comparative value of the present mode of raising the temperature of the air has not been examined.

Leakage. The manner of raising the Terrace inlet adopted during last session has been proved to entail the transference of air from Refreshment Room D to the Debating Chamber. This particular mode of raising the inlet is therefore undesirable.*

The leakage of basement air into the airway between the Terrace inlet and the input fan has been found to still obtain, but every effort is being made to diminish this inleakage as much as possible, both by improving the fitting of the doors into the airway, and also by doubling each of these doors on the principle of an "airlock."

II. Quantity.

Although ample for ordinary requirements, it has been found that owing chiefly to the resistance of the Terrace airway to the flow of air, the input fan is not sufficiently powerful to supply the maximum requirements of the system.

Debating Chamber. The extract fan, on the other hand, is too powerful. Under present conditions this extract fan when at its minimum speed extracts the Debating Chamber in excess of the average requirements of the Chamber; and owing to the excess of exhaust over supply, it has been found that Terrace air forwarded to the Debating Chamber by the input fan is diluted by a varying amount of air drawn into the Chamber from the atmosphere outside the building.†

Division Lobbies. The extract fan diminishes the flow of air from the Equalising Chamber into the Division Lobbies. The maximum amount of air that can be supplied to these lobbies under present circumstances is insufficient to meet

* The mode of raising the inlet here referred to has now been discontinued.

† The minimum of the extract fan has now been diminished so as to bring this fan into harmony with the input fan.

their maximum requirements. The extraction, moreover, from the Division Lobbies is more inadequate than the supply, and is not able at present to meet even average requirements.

The ventilation of the Commons Lobby is sufficient. Commons Lobby.

It is proposed to diminish the resistance of the Terrace airway, so as to increase the volume of air indrawn by the input fan. Remedies proposed.

It is also proposed to join the ceiling of the Division Lobbies to the extract fan, and thus by one remedy to diminish the too active pull of that fan on the Debating Chamber, and to apply this excess of energy for the purpose of increasing the ventilation of the Division Lobbies.*

III. The Distribution of Fresh Terrace Air within the Debating Chamber.

It has been found that owing in great part to faulty distribution of this air in the chambers beneath the floor of the Debating Chamber, the main volume of Terrace air under present conditions streams straight up through the centre gangway to the ceiling of the Debating Chamber. Floor.

For a similar reason the Government block of benches above the gangways gets a larger supply of Terrace air relatively than the other blocks.

When the string matting on the gangways is replaced by carpet, the service of air from the Terrace to Members sitting on the benches has been shown to be very greatly improved.

If the valances of the benches are lifted entirely up, the whole of the air estimated to be passing into the Debating Chamber from the Terrace can be accounted for at the benches.

Owing to the projection of the galleries, the main volume of fresh Terrace air appears to pass up to the ceiling of the Debating Chamber without being deflected to the galleries before it has reached the ceiling. The galleries least supplied with Terrace air are the Press Gallery and the Ladies' and Speaker's Galleries. The galleries at the opposite end of the Debating Chamber, however, also do not appear to get much *fresh* air from the Terrace. Galleries. (Smoke tests).

The minor structural alterations proposed in the Battery Chamber will enable this Chamber to be formed into a preliminary Equalising Chamber, and as a result all the gratings in the floor of the Equalising Chamber proper can then be utilised for the entry of air. Remedies proposed.

The alterations referred to, as also the alterations suggested in case of the Division Lobbies are better specified as restorations.

It will be possible to make use of shafts already in existence in the wall at either end of the Debating Chamber, and to supply fresh Terrace air direct from the Heating Chamber to the Ladies' and Press Galleries and Press Rooms at the one end of the Debating Chamber, and to the Strangers' Gallery at the other.

It is quite clear both from his book, and also from the arrangement of the air courses that Dr. Reid, the designer of the system, intended that fresh air should be supplied directly to the galleries.

The recommendations briefly outlined above were submitted to the Committee in fuller detail and, after amendment, incorporated by them in the report which they presented to the First Commissioner of Works in June, 1906.

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* The ceiling of the Division Lobbies was joined to the extract fan during the Whitsun Recess, 1906.

SECTION VII.

GENERAL CONCLUSIONS.

Three problems were formulated at the beginning of this report as summarising the main points requiring investigation in reference to the ventilation of the Debating Chamber. These problems, and the solutions to them suggested by the investigation, are as follows:—

I.—*The Relationship, if any, between the Ventilation of the Debating Chamber and the Spread of Influenza.*

There is reason to believe that the mode of infection in the vast majority of cases of influenza* is by the inhalation of particulate material disseminated from the mouth and upper respiratory passages of a person infected with the specific micro-organism of this disease. Such persons are liable to give off the *materies morbi* when they cough, sneeze, or loudly articulate. According to a passage in the report of the Ventilation Committee,† at a time when influenza was prevalent, Members still in a convalescent stage of the disease were present during a Debate. These Members would be liable to transmit the infection by giving off particulate matter in performance of the acts above mentioned.

At the time when the ventilation system of the Debating Chamber was designed, the object in view was the removal of the gaseous products of respiration, and nothing definite was then known of particulate matter disseminated in the breath and liable to contain morbific virus. It is hardly surprising, therefore, to find that, at the time when the experiments were made, the ventilation failed either to limit the spread of breath-borne particulate material, or to efficiently remove it from the Chamber. The speaking experiments with B. prodigiosus as index clearly show this to have been the case. The effect of the ventilation was to distribute the breath-borne particulate material over a wider area within the Chamber.

It may be argued that the dispersion or dilution of the particulate material effected by the ventilation would diminish the liability of those in the immediate neighbourhood of the infectious person to derive the virus. If so, it is also true that their salvation would tend to be effected to some extent at the expense of persons present in distant parts of the Chamber.

But before these experiments can be applied as an absolute index of the effect of the ventilation on the spread of influenzal virus,‡ three admissions must be made. First, it must be conceded that B. prodigiosus was present in the mouth of the person who spoke far more abundantly than B. influenzæ would have been present in the mouth of a person convalescent from influenza, yet well enough to attend a debate. Though an excellent method, therefore, of demonstrating the spread of organic matter derived from the mouth, the analogy of the results as an index of the spread of influenzal virus must not be pushed too far. Secondly, it must be admitted that even if a Member convalescent from true influenza did attend the Debating

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* At present, at least two different infections are included under the general term "influenza." Influenza Vera is clinically a severe disease, and is associated with the presence of B. influenzæ (Pfeiffer). A milder affection of a catarrhal nature is by no means uncommon in this country, especially during the winter, and though frequently called influenza, this disease is distinct from influenza vera not only clinically, but also bacteriologically, for the infecting agent in this case is micrococcus catarrhalis. The common cold would appear to be distinct from both the above infections.

† First Report of the Committee, June 25th, 1903, page 36, question 678.

‡ The influence exercised by convection currents due to the presence of persons in the Chamber has not yet been determined.

Chamber, it is improbable that he would take an active part in the debate; and particulate matter is not given off from the mouth during silence, or even during quiet speaking. Thirdly, it must be admitted that the influenza bacillus is a highly delicate micro-organism that quickly tends to perish outside the body, whereas B. prodigiosus is of more hardy constitution. The longer distance to which the droplets were carried when the ventilation was in action, therefore, would probably be more destructive to the virus of influenza than was the case with B. prodigiosus.* Finally it must be borne in mind that since these speaking experiments were made the air-supply has been approximately doubled, and that under present conditions, therefore, the dilution is increased.†

II.—*The Extent to which the Air of the Debating Chamber is liable to Pollution from Material continually being brought in upon Members' Boots, the exact Nature of such Material, and its Capacity, actual and potential, of producing Disease.*

(a) *The Extent to which the Air of the Chamber is liable to Pollution from this Cause.*

Taken with other facts, the occasional detection of B. mycoides in air passing out of the Debating Chamber during Debates is evidence that the air of the Chamber derives particulate material from Members' boots. The air obtains this particulate material on entrance through the floor of the Debating Chamber, and the part of the floor where pollution from material brought in on boots was chiefly found to occur was at the Centre Gangway, between the Bar and the Lobby door under the clock. After this spot, pollution from material brought in upon boots was found to occur chiefly behind the Speaker's Chair, and at the side Gangways.

(b) *The exact Nature of the Material brought in.*

No evidence was found of particles of sputum being brought in on Members' boots from the public streets and pavements and communicated to the air. The chief pollution brought in on boots was fæcal—probably horse-dung.

(c) *The Capacity of the Material brought in on Boots for producing Disease amongst Members.*

This question is of necessity an exceedingly difficult one to gauge. Although the Debating Chamber has been in use for over 50 years, no evidence appears to have been brought forward to show that actual disease has been contracted from material brought in on the boots. Bacteriological analysis of the material in question, however, and also index experiments with B. prodigiosus, distinctly emphasise the desirability of excluding pollution of the air from this source as far as possible.‡

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* It has recently been shown that the pneumococcus when sprayed into air in minute particles of sputum, perishes in a short time owing to the combined influence of daylight and dessication (Wood, Journal of Experimental Medicine, August, 1905.)

† The improved air supply would also tend to diminish susceptibility.

‡ The chief measures in force for reducing to a minimum pollution of the air of the Debating Chamber from material brought in upon boots are as follows :—The matting on the gangways is disinfected weekly. The Debating Chamber, Division Lobbies, and Equalising Chamber are dusted daily by hand with damp cloths, and the floors of the Debating Chamber and Division Lobbies are aspirated with the vacuum cleaner. When this instrument was first installed in 1904, the amount of dust extracted from the Debating Chamber during the first six weeks was 45 lbs. and during similar succeeding periods the amount extracted was 23 lbs., 17 lbs., and 14 lbs. respectively. The vacuum cleaning has now been extended to the libraries, minister's rooms, corridor's, etc., and the present weekly harvest of dust removed from all these sources averages 49 lbs. It may be of interest to add that during the last Whitsun Recess (1906) when the extraction of the Division Lobbies was joined to the Debating Chamber extract fan as recommended, the amount of dust removed from the space between the ceiling of the Division Lobbies and the floor of the Retiring Rooms amounted to 1 cwt. 0 qr. 8 lb.

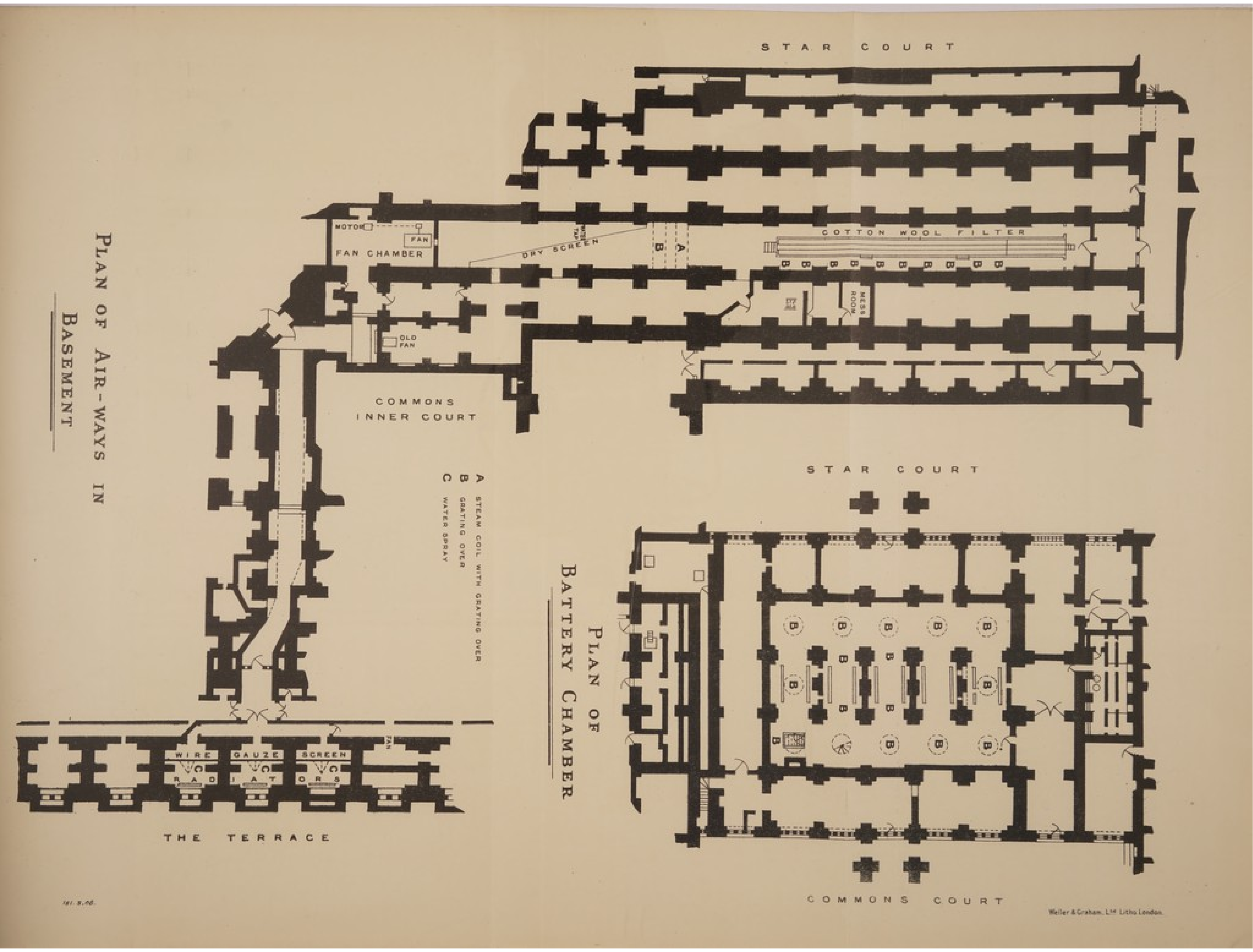
III.—*The reason of the want of Freshness in the Air of the Debating Chamber, and especially the Nature of the Fault in the Ventilation causing in Members the undesirable Symptoms drawn attention to in the Report of the Ventilation Committee.*

The "want of freshness" was probably the result of a number of causes. A distinct improvement in the quality of the air of the Debating Chamber, as judged by the subjective senses, was perceptible after the changes recommended by the Select Committee had been carried out; and as the quantity of air passed through the Chamber is now double as great as under the old conditions, and sometimes more than double, it seems clear that one of the chief reasons of the complaint was the deficient supply of fresh air. There is good ground for believing that further improvement in freshness of the air, not only in the Debating Chamber floor area, but in the galleries and also in the Division Lobbies, will be perceptible when the recommendations based on the results of the present investigation have been carried out.

The improvement in the effective area of air-inlet to the benches brought about by alterations made in the floor in 1905, and described in detail in the preceding report, has also undoubtedly effected a marked improvement in the quality of the air over the back benches. Under the old conditions the air entry at this part was very deficient.

The disadvantage of raising the temperature of the air without restoring some of its humidity has also to be taken into account in reference to this "want of freshness" in the past, especially during the earlier part of the session.

Effects due to an excess of temperature and humidity of the air—effects upon which Flügge and his associates have laid such stress—can be definitely excluded in the case of the Debating Chamber except during hot days in the summer months. The records have been examined as far back as 1896, and it has been found that, with the exception of occasions when the temperature of the air outside was so high that the appliances at the disposal of the ventilating staff were incapable of cooling it down to within the limits compatible with comfort, the temperature of the air of the Debating Chamber has been uniformly maintained below the lowest point at which unpleasant symptoms have been found by Paul to be induced. The observations referred to at the beginning of this report suggest that the enervating property which the atmosphere of the Debating Chamber may acquire on hot days in summer, especially if crowded, may be held in check to a considerable extent by increasing the draught of Terrace air throughout the Chamber. For this purpose, and also for the purpose of supplying the galleries with fresh air direct, it is essential that the volume of Terrace air which the input system is capable of supplying should be materially increased beyond the maximum at present obtaining.



PLAN OF AIR-WAYS IN BASEMENT
STAR COURT
MOTOR
FAN
FAN CHAMBER
DRY SCREEN
COTTON WOOL FILTER
MESS ROOM
OLD FAN
COMMONS INNER COURT
A STEAM COIL WITH GRATING OVER
B GRATING OVER
C WATER SPRAY
WIRE GAUZE SCREEN
RADIATORS
FAN
THE TERRACE
PLAN OF BATTERY CHAMBER
STAR COURT
COMMONS COURT
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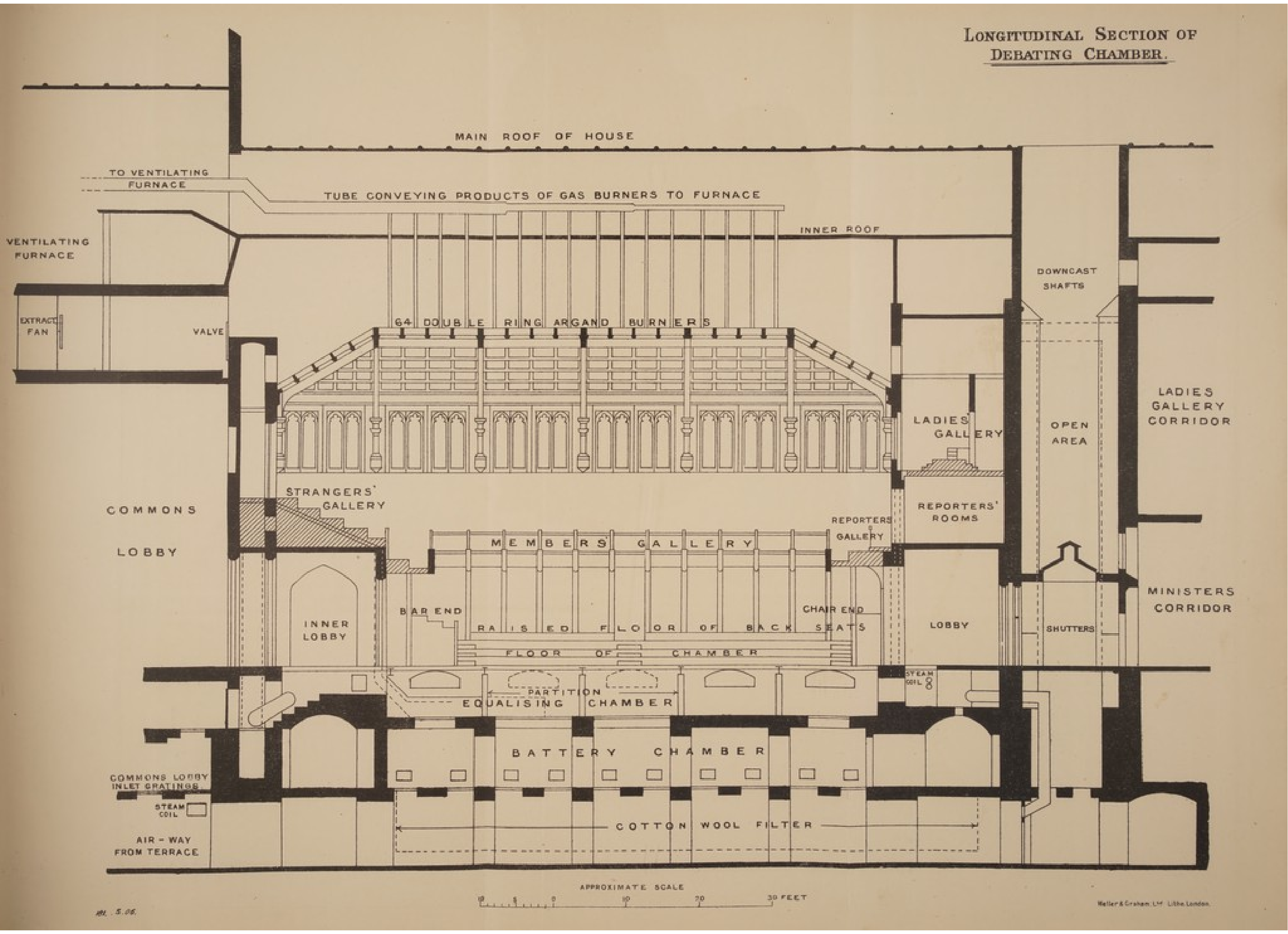
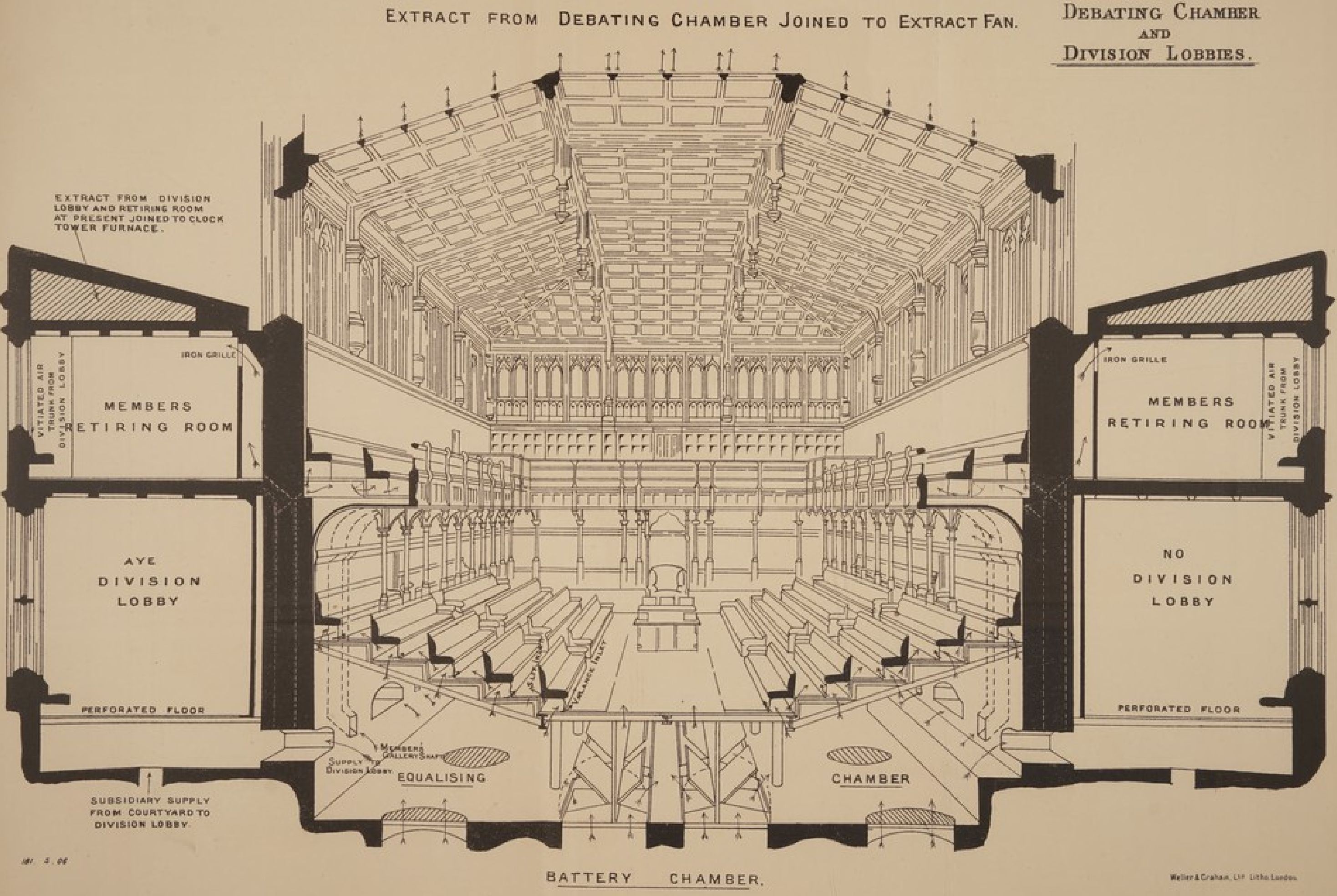

LONGITUDINAL SECTION OF DEBATING CHAMBER.
MAIN ROOF OF HOUSE
TO VENTILATING FURNACE
TUBE CONVEYING PRODUCTS OF GAS BURNERS TO FURNACE
INNER ROOF
VENTILATING FURNACE
EXTRACT FAN
VALVE
64 DOUBLE RING ARGAND BURNERS
DOWNCAST SHAFTS
LADIES GALLERY
OPEN AREA
LADIES GALLERY CORRIDOR
STRANGERS' GALLERY
COMMONS LOBBY
REPORTERS' ROOMS
REPORTERS GALLERY
MEMBERS' GALLERY
INNER LOBBY
BAR END
CHAIR END
RAISED FLOOR OF BACK SEATS
FLOOR OF CHAMBER
LOBBY
SHUTTERS
MINISTERS CORRIDOR
STEAM COIL
PARTITION
EQUALISING CHAMBER
BATTERY CHAMBER
COMMONS LOBBY INLET GRATINGS
STEAM COIL
AIR - WAY FROM TERRACE
COTTON WOOL FILTER
APPROXIMATE SCALE
10 5 0 10 20 30 FEET
Weller & Graham. Ltd Litho London.

Cross Section Debating Chamber and Division Lobbies.



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BATTERY CHAMBER.

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