CHEMICAL ANALYSES OF THE AIR IN THE HOUSE OF COMMONS.

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THE Select Committee of the House of Commons which was first appointed on April 16th, 1902, and subsequently re-appointed with certain changes in its constitution, for the purpose of inquiring into the Ventilation of the House, instructed the author to make for their information a number of analyses of the air in the Debating Chamber and many other parts of the House. In this communication only the methods used and the results obtained in the case of the Debating Chamber will be referred to. The Committee reported to the House on the 28th July last, and its report, which is published by H.M.'s Stationery Office (No. 283), should be consulted for particulars of its conclusions and recommendations in regard to the ventilation of the House.

The object of the analyses made by the author was (to quote the words of the Committee) "to determine as exactly as present scientific methods will allow the actual condition of the air in the Chamber when in use." Before proceeding to describe the methods used, it will be convenient to give a short account of the way in which fresh air is supplied to and vitiated air withdrawn from the Chamber.

The air-supply is drawn from the outer air at a point on the ground level of the Houses of Parliament on the Terrace facing the river. A passage, having its mouth here, serves to pass the air from this intake to the House. It takes a somewhat circuitous course in the basement of the building, and in it are set up various arrangements for the treatment of the air, some of which will be somewhat altered in consequence of the recommendations of the Committee. The description here given applies to the arrangements existing at the time (1902) the author's observations were made (and for many years previously).

The treatment of the air is varied in some respects according to the prevailing atmospheric conditions. In warm dry weather cold water is sprayed into the passage a short distance from the intake. If the weather is hot, the air passes over blocks of ice placed in the passage way. In cold weather, the spray of water and the use of ice are discontinued. Under all circumstances the air is next filtered through an open-meshed canvas (scrim-cloth) screen, which is stretched diagonally across a widened space in the air way, so that the air traverses the screen at relatively low velocity. This filtration of the air serves to remove from it the grosser particles of soot and dust, and under ordinary atmospheric conditions no further filtration is required. But when fog prevails, it is necessary to employ additional means for the removal of the finer particles of smoke which abound in the air. The air is then forced through a layer of cotton-wool about six inches thick spread between two frames of wire netting, built into a long wooden framework which is V-shaped in cross section. It presents a filtering surface of about 1000 square feet, and has been ascertained by Dr Haldane to pass 1,500,000 cubic feet of air per hour, when the difference of pressure between the two sides is 4·2 mm. (0·17 inch) head of water, or 1 lb. per square foot. This is at the rate of 1500 cubic feet of air per hour per square foot of filter area. The flow of air varies directly as the pressure[1]. This cotton-wool filter is only in use in foggy weather and appears, from the evidence of Members of the House to be highly effective; at other times doors are left open which allow the air to pass on without traversing the layer of cotton-wool. The filter is apt to become more or less blocked in continuous use in damp weather, owing to the condensation of water in its pores.

The flow of air from the intake below the Terrace to and past or through the cotton-wool filter is maintained by a large propeller fan placed in the air passage. The speed at which this fan is run has to be considerably increased when the cotton-wool filter is brought into use in order to maintain the difference of pressure between the two sides of the layer of cotton-wool which is necessary to secure the passage through it of the normal quantity of air supplied per hour to the Chamber. The temperature of the inflowing air is kept very nearly constant, at about 62° Fahr., under all conditions.

The canvas screen and the end of the cotton-wool filter are shown in the annexed figure (Fig. 1), which is a cross-sectional view of the

[1] *Report of the Departmental Committee on the Ventilation of Factories and Workshops*, 1902 [Cd. 1302], p. 102.

lower part of the Debating Chamber of the House, and of the underlying chambers. Above the filter is a battery of steam pipes and radiating plates by means of which the air is warmed in cold weather.

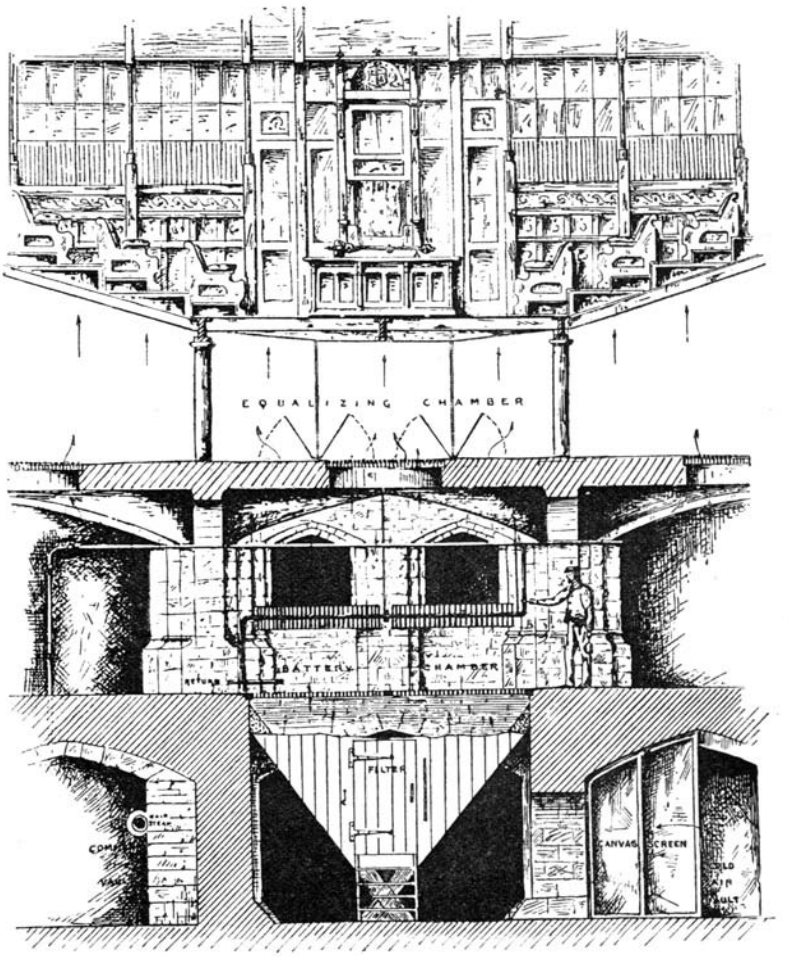

Fig. 1.

It then passes upwards to the chamber immediately below the Debating Chamber, known as the equalizing chamber. From the latter the air passes up through gratings in the floor, and beneath the seats, of the Debating Chamber. The gratings are covered by open-mesh matting, and one of the main objections raised against the present system of ventilation was that the inflowing air to the Chamber is

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liable to be vitiated by thus passing through the matting which covers the floor over which Members are constantly passing.

Reference to the longitudinal and transverse sections of the Debating Chamber of the House of Commons, given herewith (Figs. 2 and 3), by

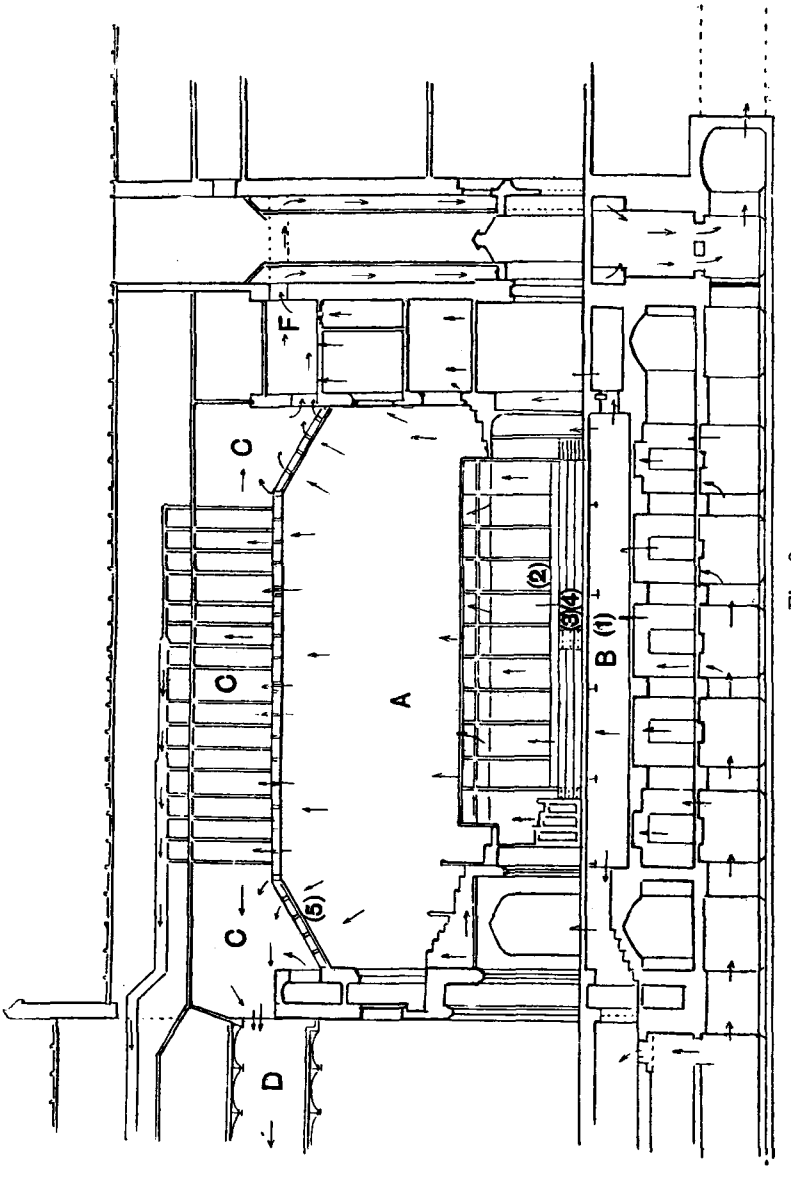

Fig. 2.
See Description below Fig. 3, next page.

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kind permission of the First Commissioner of H.M.'s Office of Works, will show the course taken by the air into and through the Chamber. The arrows indicate the manner in which the air supply enters, and is distributed over the Chamber, and the vitiated air withdrawn from it. The outflow of vitiated air takes place through the ceiling of the Chamber, which is lighted by means of a large number of Argand gas

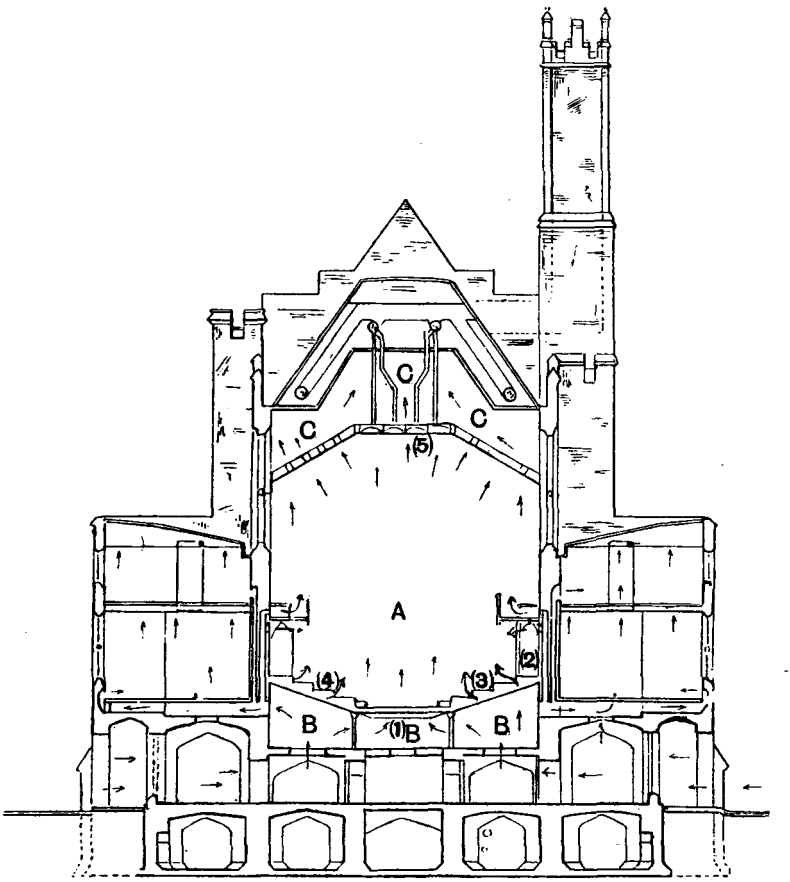

Fig. 3.

(A) Debating Chamber. (B) Equalizing Chamber. (C) Space above ceiling of Debating Chamber, with flues to gas burners. (D, Fig. 2) Main exit for vitiated air. (F, Fig. 2) Secondary exit for vitiated air, leading to downcast shafts leading to the Clock Tower.

Approximate positions from which air for analysis was drawn:—(1) Centre of Equalizing Chamber; (2), (3) and (4) About breathing level in Debating Chamber; (5) 6 inches below ceiling of Debating Chamber.

burners, the products of combustion from which are carried away by the flues shown in Fig. 2 into a main flue. These burners assist the outflow of vitiated air from the Chamber, and further a strong pull is maintained on the openings in the ceiling by means of coke fires at the base of the upcast shafts by which the air eventually escapes to the open. The arrows in the illustration indicate the courses taken by the vitiated air. The bulk of it is discharged up the shaft above the Commons Lobby, but a portion passes through downcast shafts which lead to the base of the Clock Tower, and escapes up the latter.

The chemical analyses of the air in the Chamber comprised merely the estimation of the proportion of carbonic acid present at various points, and incidentally the proportion of moisture was ascertained. With regard to the choice of method for the determinations, on the one hand the Committee wished the results obtained to be not merely sufficiently accurate for most practical purposes, but as accurate as it was possible to obtain by any method of estimation, and on the other hand the taking of samples had to be carried out without violating the historic rule against the admission of strangers to the floor of the House during the sittings. The gravimetric method of Haldane and Pembrey[1] was chosen as fulfilling these conditions. It presented the further advantage of affording facilities for making simultaneous observations on the bacteriological condition of the air without the use of additional or independent measuring and sampling apparatus. The bacteriological determinations were carried out by Dr G. S. Graham-Smith, and he is giving an account of them in another part of this number of the *Journal of Hygiene*[2]. The arrangements adopted for the determinations on the air at the breathing level in the body of the Chamber may be briefly described as follows.

Lead or "composition" gas piping was laid from the equalizing chamber through holes beneath the seats to each of the places at which it was decided to make an examination of the air. The places actually selected are approximately indicated by the figures 2, 3 and 4 in Figs. 2 and 3. The end of the pipe within the Chamber was bent over so that for about six inches it was at an angle of about 15° to the horizontal. This end protruded, in the case of two positions, over a vacant seat on the benches, and at the appointed time for the commencement of a determination, Members, who had offered their aid, attached to the end of each pipe a glass tube packed with sterilized glass wool for filtering out the germs in the air which was drawn through

[1] *Philosophical Magazine*, April, 1890. [2] See p. 498.

the pipe. The other position was against the wall on one side of the chamber about 5 feet from the floor level, and the end of the pipe was bent over, and the germ filter attached in the same manner. These positions were varied slightly in the different sets of determinations. The piping was carried to convenient positions in the equalizing chamber for stands to support the tubes for the absorption of carbonic acid and moisture, as well as the aspirators which served to suck the air at the desired rate of flow from the Debating Chamber through the germ filters, piping, and train of absorption tubes, and to measure the volume of air so drawn through the apparatus. In addition to the three sets of tubes, piping, and aspirators already referred to, a similar set of apparatus was established in the equalizing chamber to draw air from that chamber in order to obtain, for comparative purposes, determinations on the fresh air about to be supplied to the Debating Chamber. This position may be conveniently numbered "1," as it represents the incoming air to the Chamber of the House. A fifth set of apparatus was established on the roof of the Chamber, the end of the composition piping being passed in to a point about six inches below the ceiling near the bar end of the Chamber. The object of this set of apparatus was to obtain determinations on the air as it was about to leave the Chamber.

The germ filters were prepared, and the subsequent bacteriological investigations carried out, by Dr G. S. Graham-Smith (see p. 499).

A rate of flow of about one litre per minute has been found most convenient for the carbonic acid determinations with the form of absorption tubes employed, and a suitable duration for a determination was known to be from 30 to 40 minutes. The same rate of flow also answered for the bacteriological investigation. The aspirators therefore had to have each a capacity of fully 40 litres, and to be capable of affording measurements accurate on this volume to within 0·5 per cent. In order to avoid measuring large volumes of the effluent water from the aspirators each time they were used, the total capacity of each aspirator was accurately determined in the first instance, and, the aspirators being chosen of such a size that their capacity exceeded by only a little the volume required for each determination, the actual volume of air drawn into them was ascertained by difference, *i.e.* by measuring the volume of water—a few litres only—remaining in the aspirator and deducting it from the previously ascertained total capacity. Suitably chosen carboys, fitted with rubber plugs and connexions of glass tubing, served as the aspirators, and in addition to the total

capacity being determined and marked on each, for convenience of controlling the rate of flow each was provided with a litre scale, which enabled the number of litres of air drawn in to be approximately read off at any moment.

The order in which the component portions of the complete train of apparatus were set up was—reckoning from the place from which the sample of air was drawn—as follows: (1) The bacteria arresting tube, which was unsealed and attached at the moment of commencing a determination. (2) The length of lead or "composition" gas piping leading from the sample intake to the bench on which the absorption tubes and aspirator were set up. (3) The double-limbed absorption tube, charged with pumice saturated with sulphuric acid, for the absorption of moisture. (4) The first or principal double absorption tube, containing in one limb soda-lime, and in the other sulphuric acid pumice, for the absorption of the carbonic acid. (5) The second or guard tube, similar to the last, for the absorption of traces of carbonic acid which might escape absorption in the preceding tube. (6) The aspirator, arranged to give a flow at a rate of about one litre per minute.

Five of these sets of apparatus were used simultaneously on four occasions, *i.e.* twice on each of two evenings. There were therefore required for carrying out the determinations (1) five double absorption tubes for the absorption of moisture, and one tube similarly prepared and charged, against which each of the five tubes was weighed; (2) five principal double absorption tubes for the absorption of the carbonic acid, and five similar guard tubes, as well as a similarly prepared and charged tube against which each of these ten tubes was weighed. A covered box, with numbered places for the reception of the tubes, was used for carrying them to and from the laboratory and the House of Commons. The three absorption tubes in each set were connected up shortly before the commencement of a determination by means of short lengths of sound well-fitting flexible tubing, and communication between them and the inlet pipe and aspirator was cut off for the time being by means of clips. The whole of the five sets being thus in readiness, the clips were opened, and the aspirators started, all virtually simultaneously, at the moment when the germ filters had been attached to the inlets of the pipes at a signal preconcerted with the Members who had charge of the filters in the Chamber. The filters were removed and plugged, and the aspirators stopped simultaneously, after running from 30 to 40 minutes, on another pre-

concerted signal being given. The whole was carried out so that very few Members in the Chamber except those who were co-operating were aware that the tests were in progress. After the aspirators had been stopped, the absorption tubes were disconnected, and returned to their places in the box, which was then taken to the laboratory for the weighings to be made, while the volumes of air aspirated were accurately ascertained in the manner already described.

The tests were carried out on the 7th and 21st July, 1902, when the attendance of members in the Chamber was quite up to the average. From 200 to a little over 300 persons were present on these occasions in the body of the Chamber and galleries. The first set of determinations on each date terminated shortly before 7.30 p.m. (when the House adjourned for dinner), and the second set about 11.15 p.m. Each set covered a period of from 30 to 40 minutes, as already stated. The outside air was clear on both occasions, and the cotton-wool filter was, therefore, not in action.

The following details of one set of determinations will indicate the magnitude of the actual weighings and measurements, and the degree of accuracy attained in working:

Position No.	Volume of air aspirated. (Corrected to normal temp. and pressure) litres	Increase in weight of			Moisture. Grammes per litre of air	Carbonic acid. Volumes per 10,000 volumes of air
		Moisture tube grammes	No. 1 CO_2 tube grammes	No. 2 CO_2 tube grammes		
1	39·32	0·3152	0·0262	+0·0005	0·00802	3·39
2	38·55	0·3106	0·0357	+0·0001	0·00806	4·71
3	41·35	0·3397	0·0335	+0·0002	0·00821	4·12
4	43·40	0·3510	0·0305	+0·0002	0·00809	3·58
5	42·28	0·3526	0·0448	+0·0005	0·00834	5·39

It will be seen that the alteration in weight of the second or guard tube for absorbing carbonic acid was so small as to be within the possible error in weighing. In other sets the alteration was occasionally in the opposite direction, *i.e.* the tube had apparently lost in weight by 0·0002 gramme. The changes in weight of this second or guard tube, the primary object of which was merely to indicate whether the first tube had absorbed the whole of the carbonic acid in the aspirated air, were therefore disregarded in calculating the results shown in the last column. The connexions had to be made in the equalizing chamber, which directly communicates with the Debating Chamber by gratings,

rapidly, while the House was sitting, without disturbing the Members either by noise or reflection from a strong light. The time between the two sets of determinations on one evening was none too much for finishing the one set and being ready for the next, as the author deemed it expedient in order to avoid possible confusion to make all the weighings himself. There was less than three hours available for disconnecting the absorption tubes, one set of which was on the ceiling of the Chamber apart from the others, conveying them to the laboratory ½ mile away, making the fifteen weighings, returning with them to the House and connecting them up in the proper order.

Results of Determinations.

Volumes of Carbonic Acid in 10,000 *volumes of Air.*

Position	7th July, 1902		21st July, 1902	
	First Period 6.30 to 7.10 p.m.	Second Period 10.35 to 11.5 p.m.	First Period 6.48 to 7.30 p.m.	Second Period 10.32 to 11.18 p.m.
1. Centre of Equalizing Chamber, representing the air before it passes into the Debating Chamber	3·74	3·21	3·14	3·39
2. Against the wall on Ministerial Side of Debating Chamber	5·22	4·21	4·72	4·71
3. Ministerial Side, over empty seat in middle row of benches, near gangway	5·17	4·79	3·35	4·12
4. Opposition Side, over empty seat in middle row of benches, near gangway	5·23	5·04	4·96	3·58
5. About 6 inches below ceiling of Debating Chamber, near Bar end	5·60	4·82	5·29	5·39

The results obtained, which are shown in the accompanying table, may now be referred to. Position 1, from which air was drawn for analysis, was in the centre of the equalizing chamber. The air here represented the average condition of the air supplied to the Debating Chamber. The mean of the four sets of determinations showed that there was present on the average 3·37 volumes of carbonic acid in 10,000 volumes of air. The maximum figure obtained was 3·74; the minimum 3·14. As pure country air contains on the average 3 volumes, and the air of towns—in the absence of fog—from 3 to 4 volumes of carbonic acid per 10,000 of air, it will be obvious that the air supplied to the Chamber was, in this respect, commendably good.

Positions 2, 3 and 4 were, as already indicated, in the body of the Chamber, one being against the wall on one side, and the other two in corresponding positions among the benches on opposite sides of the House. The positions were altered slightly for the different sets of determinations, and one very low result is explained by the fact that the air was drawn in close to one of the gangways, to which it would pass almost directly from the equalizing chamber. The results obtained at these three positions in the four sets of determinations may be summarized as follows: The mean was 4·59 volumes of carbonic acid per 10,000 volumes of air—an excess of 1·22 volumes over the mean for the incoming air. The maximum results obtained in the 12 determinations showed an excess of 1·83 volumes, and the minimum an excess of 0·19 volume over the result for the incoming air (Position 1) at the same time.

Position 5, near the ceiling of the Chamber, served to indicate the condition of the vitiated air passing away from the Chamber. The mean result for this position was 5·27 volumes, or an excess of 1·90 volumes over the mean result for the air about to enter the Chamber. The maximum result showed an excess of 2·15 volumes, and the minimum an excess of 1·61 volumes, over the result for the incoming air at the same time.

It will thus be seen that the air supply to the Chamber was adequate to avoid a rise of 2 volumes of carbonic acid over that present in the incoming air, except close to the ceiling, where the rise was on one occasion slightly more than 2 volumes. The highest absolute figure obtained was 5·60 volumes close to the ceiling.

In order to indicate how excellent is the renewal of the air of the Chamber which these figures prove, some suggested standards of ventilation and results obtained in other buildings may be quoted. Pettenkofer held that 10 volumes of carbonic acid per 10,000 volumes of air (or an excess of about 6 volumes over the proportion he found in the air of towns) should not be exceeded in the air of rooms, etc. But the observations of Carnelley, Haldane and Anderson on the air in crowded elementary schools showed that a lower limit than 13 volumes per 10,000 could not be fixed for such buildings in 1887, though now improved means of mechanical ventilation might lead to a revision of this limit. Finally the Departmental Committee which reported to the Home Secretary on the Ventilation of Factories and Workshops in August, 1902, concluded that it was reasonable to expect that under ordinary circumstances 10 volumes should not be exceeded in such

places unless gas was burning. This committee recommended that a maximum limit of 12 volumes should be prescribed as a standard of ventilation for factories and workshops when gas was not burning, and that compliance with it should be ultimately enforced on employers.

It will be seen that the ventilation of the Debating Chamber of the House of Commons was shown by the author's determinations of carbonic acid to be exceptionally good, when judged by the standards of ventilation which have received authoritative recognition.