THE REPORT, &c.

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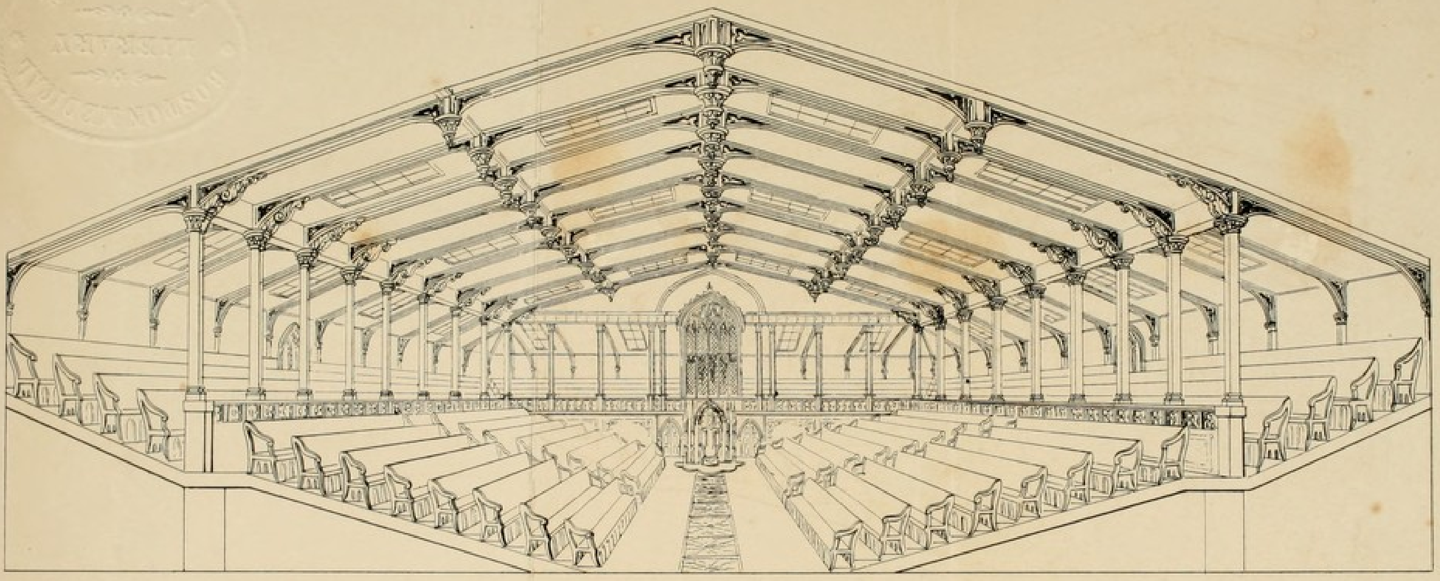

Dr. REID'S SKETCH FOR A HOUSE OF COMMONS.

The Body of the House _ the Curtains or moveable frame-work being pulled up between the Pillars, so as to render all or any part of the Gallery available, when the House is very full, and arranged with the required number of Seats.

Scale of 0 5 10 20 Feet

J. Basire lith.

REPORT

OF THE

COMMITTEE OF THE HOUSE OF COMMONS,

ON

VENTILATION, WARMING,

AND

TRANSMISSION OF SOUND.

ABBREVIATED, WITH NOTES, BY

W. S. INMAN,

FELLOW OF THE INSTITUTE OF BRITISH ARCHITECTS.

Ne sarà fuor di proposito, se noi piglieremo indizj dell' Aria e dei Venti.—*L. B. Alberti Architettura, lib.* 1.

A writer who pursues obscure and difficult inquiries is compelled to accept the proofs afforded by circumstantial evidence.—*Quarterly Review.*

Quelque respectable que soit une autorité en fait de science et d'art, on peut toujours la soumettre à l'examen. On n'aurait jamais fait un pas vers la vérité, si l'autorité eût toujours prévalu sur la raison.—*Duclos.*

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MDCCCXXXVI.

TO

BENJAMIN HAWES, ESQ., CHAIRMAN,

MR. HANBURY TRACY,
LORD VISCOUNT HOWICK,
MR. WARBURTON,
LORD GRANVILLE SOMERSET,
MR. STRUTT,
SIR GEORGE CLERK,
MR. HALL,
MR. BENJAMIN SMITH,
MR. COMPTON,
LORD VISCOUNT SANDON,
MR. PHILIP HOWARD,
MR. HUGHES HUGHES,

MEMBERS OF THE COMMITTEE,

THIS ATTEMPT TO DISSEMINATE THEIR LABOURS

IS RESPECTFULLY INSCRIBED

BY THEIR MOST OBEDIENT SERVANT,

THE EDITOR.

3, Eaton Square, Grosvenor Place,
1st May, 1836.

PREFACE.

SEVERAL months having elapsed since the Parliamentary Report was printed, and no architect or scientific man having responded to the call of the Committee, I have compiled this tract; collecting notes from as many of the best authorities as the limited period for publication would permit.

NEWTON, EULER, CHLADNI, and other philosophers have stated the difficulty of investigating the principles of heat and acoustics. Bearing in mind the axiom, "*Ne sutor ultra crepidam,*" it is with considerable diffidence that I venture any observations on subjects requiring the acumen of a WOLLASTON, and the accuracy of a KATER: but it appeared desirable, occasionally, to risk an opinion, and promote discussion, whereby facts may be elicited;—rather than, by forbearance, to screen myself from the responsibility to which an editor is subject. These observations neither direct, or assume to direct, the professional architect; but if their correctness be confirmed by practice, and the labours of eminent men be more generally diffused, the results must be beneficial.

Although the parliamentary evidence might have been more condensed, yet, in justice to the scientific individuals who gave it, I trust it will be found that not one opinion is omitted; and, to Members of the Legislature, and others interested in these subjects, the perusal will not occupy one-fourth of the time required for the original.

To treat of heat, its various applications and effects, would be to circle the sciences. It pervades nature and art, and almost comprises vitality.

Sound is a most interesting subject for research and experiment: although its applicability to this inquiry at present limits the pursuit, future circumstances may favour my resuming it. Those who have leisure and inclination for the study, will find it fraught with amusement and instruction.

The power and fascinating influence of sound are sometimes unheeded; but no one can be insensible to the encouraging "cheers of the House," to the inspiring effects of martial music, to the exhilarating cry of the huntsman, to the animating shout of the warrior, or to those deeper emotions, awaking the "hidden soul of harmony," while listening to the pealing swell of the organ, or the thrilling tones of the human voice.

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*** *Any facts or data, elucidating the Subjects in this Publication, addressed to the Editor, will be thankfully acknowledged.*

3, Eaton Square, Grosvenor Place,
1st May, 1836.

DESCRIPTION OF PLATE I.

Figure 1.—A Circle 100 feet in diameter traced in a meadow—a person in the centre, reading, was heard most distinctly in front, nearly as well at the sides, but scarcely at all behind. At $\frac{3}{4}$ of the diameter, or 25 feet behind the centre, he was heard best at the sides, CC, but indifferently heard in front or behind him.

Figure 2.—The Reader placed 17 feet behind the centre, was the spot whence he was *most distinctly heard all round* the circumference.

Figure 3.—Shows the *extreme distance every way on a plane*, at which the voice could be distinctly heard; viz. 92 feet in front, 75 on each side, and 31 feet in rear of the speaker at A.

Figures 4, 5, 6.—Specimens of the simplest manner in which sand is collected into lines on a plate of glass or metal, which is made to sound by the bow of a violin.

Figure 7.—A round plate performing some of its most complicated vibrations; the lines of division being indicated by the place of the sand—from Chladni.

Figure 8.—Waves or pulses of sound diverging from a point near the centre of a circle, and converging, after reflection, to a point at an equal distance on the other side of the centre.

Figure 9.—A wave or impulse of sound diverging from one of the foci of an ellipsis, and reflected towards the other.

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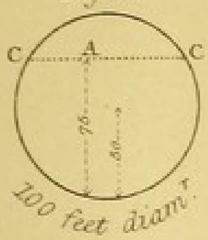
Figure 11.—A series of waves diverging from the centre, A, and passing through the aperture, B C, extend themselves on each side, so as to fill the space, B C D E, while they affect the parts without this space very sensibly less.

Experiments on the Voice.

Fig. 1.



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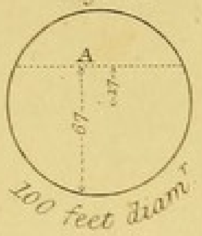
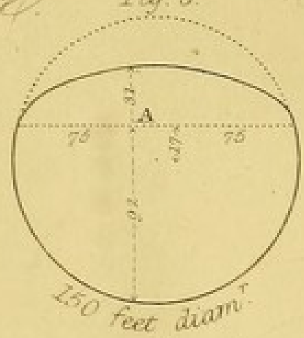


Fig. 3.



Sand on plates of Glass formed into figures by Sound.

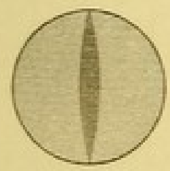
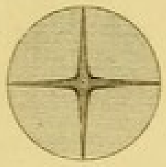


Fig. 4.



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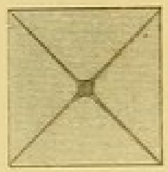


Fig. 6.

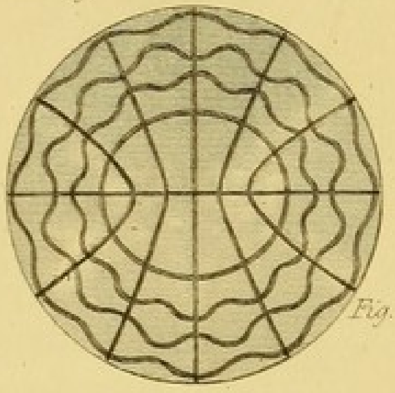


Fig. 7.

Progress and Reflection of Sound.

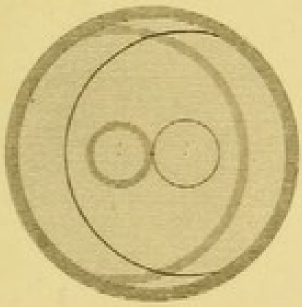
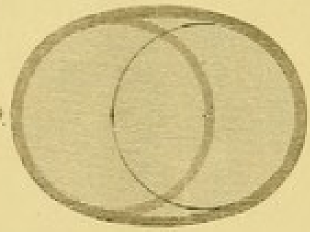


Fig. 8.

Fig. 9.



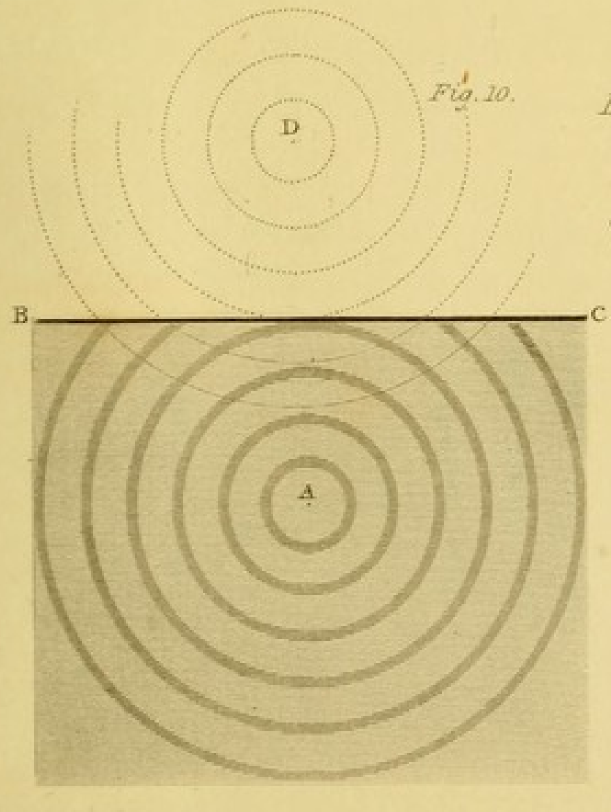
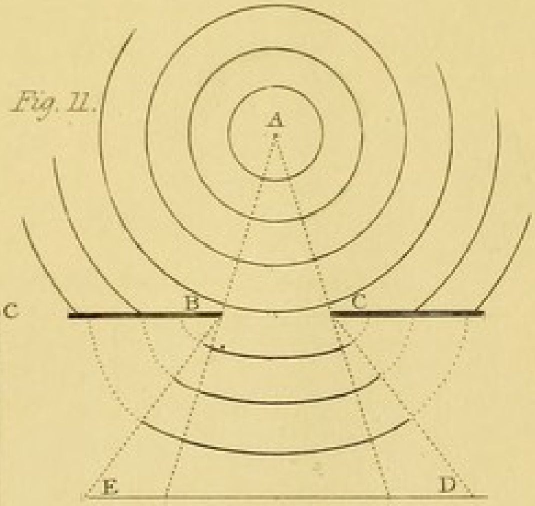


Fig. 10.

Fig. 11.



W. S. Inman del.

John Weale, Architectural Library, 59, High Holborn.

SUMMARY OF THE REPORT

OF

THE COMMITTEE APPOINTED ON THE TWENTY-NINTH OF JULY, 1835.

THE Committee examined several witnesses of high scientific reputation, with a view to make known general principles of a good system of warming and ventilating public buildings. The late period of Session, want of time, and more extensive means of information, necessarily made the inquiry imperfect; and therefore Committee offer no opinion on comparative merits of the Plans submitted.

To prevent expense and inconvenience, and insure a successful Plan, Committee recommend the subject to the attention of the House, and of architects in particular; so that a systematic Plan should be insured before commencing the New Parliamentary Buildings.

That the whole space above and below the Houses should be reserved for this purpose.

To insure *hearing*, all obstructions should be removed, and every facility given by *form* and *construction* of the interior of the Houses.

Committee request attention of Executive Government to improving Ventilation and Sound, in present House of Commons: both for transacting public business with decorum and dispatch, and for public interest and convenience;

Recommend that some, if not all, of Dr. Reid's suggested alterations should be submitted to experiment during the recess of Parliament, as the only means of accurately ascertaining soundness of Principles stated in evidence, and their useful application.

September, 1835.

NOTES.

1. Our knowledge of the theory of Sound (Phonics), or of Hearing (Acoustics), is very imperfect; but when we consider that until the last century the nature of Electricity was unknown, and yet contemplate the wonderful properties elucidated by Franklin, and their subserviency to chemical analysis in the researches of Davy and Faraday, we may hope for further improvements in their practical application to human welfare, and at every discovery have additional reason to admire the wonderful economy of the Great Architect of the universe. Or if we regard the immense extent of ventilation by the trade-winds—by the rarefaction and condensation of atmospheric air, whilst the sun is above or below the horizon—by the eternal ebb and flow of tides—or the equalization of temperature by the latent heat of the ocean—how truly must we perceive that "even the winds and the sea obey HIM!"

2. That their action is subject to occasional interruptions, militates not against their stability: the elementary principles of the physical world are as sure as those of the moral: aberration may seem apparent to man, but their truth is eternal.

The instance of deviation from the law of nature, in freezing water *expanding* from 39° to 32° Fahrenheit, is well known; and has not yet been satisfactorily explained; but variations may often be traced to visible causes—thus: "the extreme chilliness and dampness of weather on the coast of America, and over the eastern coasts of Europe, during the summer of 1817, were probably caused by the multitude of icebergs and quantity of field-ice dislodged from the northern seas in the spring of that year, and carried into the Atlantic, and the almost total absence of ice in 1818 produced that warmth and dryness felt through the winter, not only in Great Britain and the northern parts of Europe, but also along the coast of America. In the depth of that winter the Baltic was unfrozen, the bays of Newfoundland were free from ice; and even to the middle of April there had been neither ice nor snow in Iceland,—a circumstance which had not happened before in the memory of man. This was probably owing to long continued southerly winds fixing the ice in the Arctic seas.

3. "Lieutenant, now Captain Sir Edward Parry, R.N., measured an ice mountain 367 feet high, and more than two miles square: its weight by measurement was 1,292,397,673 tons, and it was capable of covering a space of 1750 square miles, one foot in thickness: the approach southward, and melting of such a mass, must influence the temperature and movement of the atmosphere.

4. "Some recorded observations on the temperature of the sea in Capt. (now Sir John) Ross's first Polar voyage, are very remarkable. It seems that in Baffin's Bay, generally speaking, the temperature *decreases* with the depth. In lat. 71° 24″. at 1008 fathoms, the temperature was 8½°; at the surface 36°; and whenever the depth exceeded 100 fathoms, the thermometer generally descended to 30° or lower, when it was 34° or 35° at the surface. Near Cape Walsingham, at the depth of 660 fathoms, the thermometer came up 25½°

400	28°
200	29°
100	30°
Temperature of air being	37°

It would be difficult to explain why the sea remained in the state of water at 25½° Fahrenheit.*—Did the pressure of the column of water prevent its freezing? or was the water more strongly impregnated with salt?

* Walker cooled water to 10° Fahrenheit without freezing it.—*Philos. Trans.* 1788.

"Observations on this voyage are completely at variance with isothermal lines of temperature, which it appears had been assumed from a too limited number of facts. But the most unaccountable is, that the Polar expedition in the seas of Spitzbergen, on the same parallels of latitude, invariably obtained a contrary result; the temperature of the sea *increasing* with the depth: the thermometer, at surface being 32° or 33°; at 300 fathoms, it was 36° or 37°. Within the arctic circle, for three months, Fahrenheit's thermometer in the shade never was above 53° or below 26½°, and at these extremes only once, the general average being 35° to 37°." *

5. The gulf stream on the American coast varies from the temperature of the Atlantic Ocean. According to Blagden, it is about 82° in the gulf of Florida; and in running northwards it loses 2° of heat for every three degrees of latitude up to 44° north. May not these contradictory temperatures be accounted for by warm and cold ascending and descending currents of the ocean, like similar currents of winds? Again, at the equator, the line of congelation is 15,000 or 16,000 feet above the level of the sea. At 80° north, it is not one-tenth of that height.

6. The daily increase of light and heat as the sun approaches the earth is so gradual as to be almost imperceptible.—The diurnal variation of temperature in spring and autumn, says Mr. Kirwan, will account for the frequency of colds and similar complaints at those periods: in the course of a day and night it is more than 5°, but less than 20°.

Mean diurnal variation of temperature in London:

January, 6° Fahr.	July, 10° Fahr.
March, 20° .	Sept. 18° .

7. Man appears to triumph over the various climates of the world, and is capable of sustaining an excessively high temperature. In the extraordinary experiments recorded by Tillet, of two girls in an oven at 286° for ten minutes; and by Dr. Fordyce, Sir C. Blagdon, &c. described in Philos. Trans. 1775, p. 111, the air in a room being at 260°, was endured by these gentlemen with their

* Quarterly Review, No. 41.

clothes on, and at 220° without clothes. No apparent perspiration—on the contrary water was deposited: they could not hold their watch-chains: eggs on a tin frame were roasted hard in twenty minutes, and a beef-steak was overdone in thirty-three minutes; the temperature of their bodies was raised more than three degrees, their pulses beat double the usual rate. The average temperature of human beings is 98°: water could not be borne at 125°, nor mercury at 120°; oil was supportable at 129°; spirits of wine 130°; a bath feels warm at 90° to 110°; and tea and coffee are usually drunk at 115° to 130° Fahrenheit.

In India, the air has been at 144°.

8. Various expedients for warming and cooling the atmosphere have been resorted to, from very remote periods. The ancient Persians erected wind-towers at Gombaroom: the Egyptians cooled the air by evaporation from water in vases. Palladio describes the prison of the winds, formed in an Italian Count's villa. Tatties* and punkahs (ventilators) are used to this day in India; and, from remains of Roman villas in England, and some utensils I have examined in the Pompeian Museum at Naples, I conclude that the Romans were as well, if not better acquainted with the subject than ourselves. Of their hypocausts and sudatories for baths and other apartments, we have ample accounts.

9. It has been affirmed that architects attend only to the exterior proportions of buildings: this is easily confuted by referring to their published works. Still it is extraordinary that their opinions on all objects connected with habitations are not oftener sought for. Gentlemen are continually imposed on by pretenders of every description, generally at great cost, and not seldom without danger to their residences. How frequently are houses burnt down by fires originating in a flue; or by a stove, which a moment's inspection by a professional architect would prevent being *dangerously* placed!

* Grass mats, or window blinds, which, being frequently wetted with water, have cooled the air 48° below the exterior atmosphere in very high temperatures.

Dr. Birkbeck's opinion of the general inadequacy of ventilation in public buildings is verified in many instances; but sometimes all the means provided by architects have not been made available.

10. Of the oppressive atmosphere and the baneful effects produced by some warming and ventilating operators, our houses, churches, and courts of justice are standing examples. It is unnecessary to particularize any of the numerous hot air, water, and steam apparatus offered for public patronage, most of which afford an ample *quantity* of heat, and often at too high a temperature; but *all*, unless combined with a proper system of ventilation, will prove inefficient for health and comfort, particularly when used for large assemblies.

11. Of the ventilating propositions in the parliamentary evidence, Dr. Reid's appears to have been most favourably received by the Committee. It is a mode commonly used in manufactories; and Sylvester's, that generally adopted in mines; but (with all deference to others' opinions,) I consider a steam-blast exhauster preferable for the Houses —as simpler, safer, easier managed, and not so liable to a back current as a chimney furnace. The daily practice in locomotive engines will prove it to be sufficiently powerful.

12. The best mode of communicating caloric to the atmospheric air is by steam or hot water, or by surfaces which will not obtain a heat much exceeding 200° Fahr.

13. One or more wind-towers and subterranean ventiducts are desirable if the locality be not subjected to overflow of tides; but if they do rise too high for the fresh air ducts to be underground, they must be kept as much below the House as possible.

14. Neither Westminster Hall or the Abbey are fittest places for air reservoirs; but a large air chamber furnished with purifying washers and cooling and warming apparatus is absolutely necessary. The air, after being attempered, may have a current (by machinery if desired) into the space under the seats of the House, each side of which may be considered as a lobe of the lungs. Here by its expansion

the current would be destroyed, and the air find its way into the House, almost imperceptibly, through numerous apertures screened by wire-wove gauze.

15. On so great a scale, an extensive apparatus is requisite; but when the air is prepared, it may be stowed away for use, like gas in the various manufactories; and, as the quantity for the extreme numbers can be calculated, any smaller portion could be the more easily supplied.

16. If the temperature be fixed at 55°, the air will require to be warmed for about 200 days; if at 60°, for about 250 days per annum.

Although the full power of ventilation is necessary only when the House is assembled, the system should be in permanent action during the whole session. In the present House, unpleasant effluvia are always perceptible.

17. If the new House of Commons be built to contain 1000 persons, there will be required 240,000 cubic feet of air per hour, according to Tredgold, to supply the consumption by breathing, exhalations, and artificial lights.

Until the plans and dimensions of the future Houses be finally determined, it would be premature to say what would be the best mode of arranging the details for warming and ventilating them; but, whatever system be adopted, it would be more satisfactory that it should be tested by experiment as nearly as possible, under the conditions in which it would be practically executed.

18. The ventilation must be arranged so as to be combined with, or separated from the warming apparatus, whenever desired. It should continually operate, and constantly afford a pure, wholesome atmosphere; pervading the house, and, as it were, breathing into and flowing through it, but with so gentle a current as to be imperceptible to members; and the inlets and outlets be perfectly under control, and adjusted to the numbers and state of temperature, relative height, and form of the ceiling, &c.

Thus, suppose the area of the house to be 5000 feet, and its height to average 30 feet, and that it will contain, including strangers, 1000 persons; and, according to Faraday, 10 to 20 gallons of air per individual per minute be required; or for an ample allowance, say 30 gallons for each; then the quantity to be changed every half hour would equal the cubical capacity of the house: and if it were supplied at the velocity of one foot per minute, the whole mass of atmosphere would be *constantly* replenished with fresh air, and entirely, but imperceptibly, cleared every half hour. I am induced to think that these will be about the proportions of air required for a practical and efficient system.

Any remarks on its adaptability to hospitals, prisons, barracks, stud-houses, conservatories, mines, ships, railway tunnels, &c., would be out of place here.

19. With the present inadequate systems there is scarcely a church or public assembly which on entering does not feel oppressive or offensive; and as to the Committee Rooms of the House of Commons, to remain in them is like being immersed in a hot-bed, or pine-pit.

20. The premature death of some eminent men at the American Bar has been imputed to the want of ventilation and dampness in the Supreme Court at Washington; and the prevalence of consumption in England has been attributed by Physicians to the defective management of heat and ventilation in dwelling-houses.*

It is absolutely essential that the halls in which the Legislature assemble, for hours together, should be rendered wholesome. Is there a member who has not experienced the noxious effect of the present vitiated atmosphere on mind and body? instead of being enabled to devote his best energies to the calm deliberation and discussion of the public weal, his mental powers are exhausted and his bodily feelings wearied: impatience and irritation succeed; and important measures are hurried over, or left to be settled by those, whose "*condition*" equally fits them for the arena of the Amphitheatre, or of the Forum.

* Vide New Philos. Jour. Oct. 1834, p. 416. Deaths in an hospital before Ventilation, as 1 in 6; after Ventilation, reduced to 1 in 20; as stated by Dr. Joseph Clarke, Edinburgh Meeting British Association.

OF SOUND.

Herschel states that sounds of all kinds agree in these particulars :—

"1. The excitement of a motion in the sounding body.

"2. The communication of this motion to the air or other intermedium, which is interposed between the sounding body and our ears.

"3. The propagation of such motion from particle to particle of such intermedium in due succession.

"4. Its communication, from the particles of the intermedium adjacent to the ear, to the ear itself.

"5. Its conveyance in the ear, by a certain mechanism, to the auditory nerves.

"6. The excitement of sensation."

The motion of sound has been demonstrated by Chladni on plates of glass and metal, by strewing sand on their surfaces, and observing the forms it assumed when the sound ceased, the sound being produced on the plates by a violin bow.*

The direction of military mining operations is sometimes attempted to be ascertained by strewing sand on a drum-head, the figures assumed by the sand, from concussions of the earth, indicating the situation of the counter mine.

The sounding-board of a piano-forte will give the motions of dancing to figures formed of light substances, as elder pith, cork shavings, &c.

* Regular geometrical forms may be produced at pleasure by repeated experiments.—Vide *Willis's Pencillings*, vol. I. "Vienna."

Sound has been used to discover the nature of disease: by the stethoscope, an instrument similar to a flute-tube, physicians ascertain the state of pulmonary disorders, by applying it to the exterior surface of the body covering the lungs.*

The coincidences, and in some cases the identical effects produced by heat and sound, and heat and light, were first noticed by the late Thomas Young, M.D., who remarked that heat and sound are both excited by friction and percussion, and communicated by contact and radiation: that the force of an artificial magnet may be quickly destroyed by heat, or more slowly by making it to sound for a considerable time. He also had the sagacity to discover the similarity of effect in two sounds and two rays of light, when conspiring or opposing each other's effects: in the one case wholly or partially destroying each other, producing silence and darkness; in the other, strengthening and increasing the sound and light. As regards propagation of sound, this celebrated philosopher declared that the particles of the air advance and recede, and those of light tremble laterally.

Chladni asserts that sound expands equally every way: if so, it would form concentric spherical laminæ: but the impulse transmitted by an elastic fluid acts primarily in the direction of its progress. The hearer turning towards the speaker, is the most natural illustration of the latter; the sound of a bell in a calm day, of the former.

Great sounds, from cannon, church bells, &c.,† are capable of being conveyed many miles by winds; and their being heard in various places depends on the hearer's nearness or remoteness to the direction of the currents of air. The more dense the atmosphere, the more it favors transmission of sound.

* This has excited ridicule: but why should not the ear thus discriminate between health and disease, as well as be able to distinguish between the goodness or badness of a stick of timber—a block of stone—a piece of porcelain or of metallic money? At Tattersall's, "warranted sound" is always allowed to be a criterion of value.

† The cannon on the field of Waterloo were heard at Dover.

Intensity should be distinguished from quantity of sound. The result of all Dr. Priestley's experiments was, that "the intensity of sound depends solely upon the density of the air in which it is made, and not at all upon any chemical principle in its constitution."—*Experiments in Natural Philosophy*, vol. ii. p. 298.

A noise is an impulse in one direction only; a sound, a succession of impulses too rapid to be separately distinguished; and, if equal among themselves in duration, a musical sound is produced: this may be exemplified by striking a drum; one stroke produces a noise; a rapid series of double strokes, a sound or roll.

VELOCITY OF SOUND.*

The average uniform velocity of any impression of sound transmitted by the atmospheric air is 1130 feet in a second. A scientific French journal recently stated it at 1038 feet = 1135 English feet.

OF REFLECTED SOUND.

La Grange has demonstrated that all impressions are reflected by an obstacle terminating an elastic fluid, with the same velocity with which they arrived at that obstacle. When the walls of a passage, or of an unfurnished room, are smooth and perfectly parallel, any explosion, or a stamping with the foot, communicates an impression to the air, which is reflected from one wall to the other, and from the second again towards the ear, nearly in the same direction with the

* In a communication by John Herapath, Esq., read at the Oxford meeting of the British Scientific Association, there is a very ingenious hypothesis on the nature of air and temperature as affecting the velocity of sound. He states that "in different cases of the same elasticity and temperature, the intensities are as the square roots of the densities or specific gravities, and inversely as the velocities with which sound is propagated; thus the tones or intensities become measures of velocities when applied to different cases." Vide *Railway Mag., and Annals of Science*, No. I.

original impulse: this takes place as frequently in a second as twice the breadth of the passage is contained in 1130 feet; and the ear receives a perception of a musical sound, thus determined in its pitch by the breadth of the passage. If the sound is predetermined, and the frequency of vibrations such, that each pulse, when doubly reflected, may coincide with the subsequent pulse, proceeding directly from the sounding body, the intensity of the sound will be much increased by the reflection; and also, in a less degree, if the reflected pulse coincides with the next but one, the next but two, or more, of the direct pulses.

The appropriate notes of a room may be readily discovered by singing the scale in it; and they will be found to depend on the proportion of its length or breadth to 1130 feet.

The sound of the stopped diapason pipes of an organ is produced in a manner somewhat similar to the note from an explosion in a passage; and that of its reed-pipes to the resonance of the voice in a room: the length of the pipe in one case determining the sound; in the other, increasing its strength. The frequency of the vibrations does not at all immediately depend on the diameter of the pipe. It must be confessed that much remains to be done in explaining the precise manner in which the vibration of the air in an organ-pipe is generated.—Dr. Young.

All stopped pipes except cylindrical, are unmusical.

"When a hemispherical pulse arrives at the surface of a plane solid obstacle, it is reflected precisely as a wave of water is reflected, and assumes the form of a pulse proceeding from a centre, at an equal distance on the opposite side of the surface of the plane. When this reflection returns back perpendicularly, it constitutes echo, if the reflecting object be at a sufficient distance to prevent its being combined with the original sound. The reflector must either have a smooth surface or consist of a number of surfaces arranged in a suitable form.

"If sound be reflected from a curved surface, its new direction will be determined either from the condition that its velocity will remain unaltered or from the law of reflection; viz., that the angle of reflection from the surface will be equal to the angle of incidence. Thus, sounds from the foci of an ellipsis will be reflected from the circumference toward each other.

"In the whispering gallery of St. Paul's, the effect may be considered as produced by a continued repetition of reflections" [and conduction.]

In studying experiments and deductions, it should be borne in mind that the transmission is through an elastic medium, and that the voice gives a certain direction to the sound; so that parts of the space are differently affected. Probably the particles behind the speaker are moving towards the centre of the circle, and the particles before him retreating from the centre, and wherever they intersect the motion would be neutralized; and there, most likely, the sound would be least audible.

Rising seats enable the sound to proceed direct from speaker to hearer. In a theatre front seats are best for *direct* hearing, and those against the walls for reflected and conducted sound. Drury Lane theatre, though elegant in appearance, and constructed on acoustic principles by Benjamin Wyatt, architect, in 1812,* has since been altered and reduced to suit the stage business and public preference for small houses. The smaller the Houses of Parliament, compatible with the numbers to be accommodated, the more likely are they to be approved.

DECADENCE OF SOUND.—The velocity appears to diminish as the distance from the centre increases; and the intensity or strength of sound varies as the square of the distance: thus, at 10 feet distant the velocity is $\frac{1}{10}$th as great as at one foot distant; and the energy or intensity of sound $\frac{1}{100}$th as great; and for each degree of Fahrenheit's thermometer the

* Original width 77 feet from back wall of boxes to opposite wall; 53 feet from front of stage to wall at back of boxes; area of house on dress-circle 58 feet; height of auditory 48 feet; boxes 8 feet deep; width of stage-opening 35 feet. In present House the distance from front boxes to curtain is 61 feet; transverse distance 50 feet.

velocity of sound varies about $\frac{1}{1000}$th part. The velocity is diminished by cold fogs, and increased by warm vapours; and in steam would be $\frac{3}{4}$ths greater than in air.

The sound of a bell, transmitted through water, was heard by professor Robison at 1200 feet distance. Calculated by the comparative elasticity of air to water, the velocity of sound in water would be 4900 feet per second; and of an impulse conveyed in direct or parallel lines, through fir-wood, would be 17,400 feet per second.

Dr. Young states that all minute impulses are conveyed through any homogeneous elastic medium (solid or fluid) with a uniform velocity, always equal to that which a heavy body would acquire by falling through half the height of the modulus of elasticity; *i. e.* in the case of air, half the height of the atmosphere supposed to be of equal density; which, taken at 28,000, would give 946 feet per second: but if the direct velocity of sound, by experiment, be 1130 feet, it would give a height of 39,800 feet for the modulus of the air's effective elasticity. Laplace suggested that the theory and experiment may be reconciled by the difference attributed to the effect of the elevation of temperature always accompanying the action of condensation, and to the depression produced by rarefaction.

*Direct Velocity of Sound in Atmospheric Air.**

Mersennus, Balistica	1474	Feet per second.
Walker, philos. trans., 1698	1338	
Roberts, do. do., 209	1300	
Boyle, on Motion	1200	
Cassini and others, Duhamel	1172	
Florentine Academicians	1148	
Flamstead, Halley, Derham	1142	
Parry, Philos. Trans., 1828	1038	

* Its state as to temperature, moisture, electricity, &c., must always influence the velocity.

Velocity in all Directions.

Pictet	1130	Feet per second.
Muller	1109	
Cassini	1107	
Meyer	1105	

Human voice heard at Gibraltar more than 10 *miles.*—DERHAM, *Philos. Trans.*, 1708.

Velocity in Different Substances.

In Tin	7800	Feet per second.
Silver	9300	
Brass	11800	
Copper	12500	
Tobacco-pipes	10000 to 12000	
Wood	11000 to 18000	
Fir	17300	
Glass, Iron	17500	
Crown Glass	17700	

The velocity may be easily calculated from the sound of a loose rod; if the number of vibrations of the gravest sound in a second be n, the velocity will be $\frac{\cdot 973\, n\, l^2}{d}$, l being the length and d the depth in feet. The times occupied by similar vibrations of elastic rods are directly as the squares of their depths, and inversely as their lengths.

Chladni finds the vibration of rings to be nearly as the squares of the odd numbers.

Effect of Condensation, Hawksbee, *Philos. Trans.*, 1705.,

With atmosphere in the usual state heard a bell at a distance of	30 yards.
With a force of two atmospheres	60
With a force of three	90

but not much increase at greater densities.

In a vacuum, no sound transmitted.

An instance of accurate measurement by sound is stated in Darwin's Zoonomia: "The late blind Justice Fielding walked for the first time into my room, and, after speaking a few words, said, 'This room is about 22 feet long, 18 wide, and 12 high;' all which he guessed by the ear with great accuracy."

The distance of a thunder-cloud, of a fort, or a ship at sea, may be estimated by the human pulse, marking the number between seeing the flash of lightning; or from a cannon, and hearing the report; at the rate of 300 yards for each pulsation; the wrist pulse of a healthy person averaging 76 beats in a minute, = $1\frac{1}{4}$ per second.

The sympathy of sound and motion is curious: two chords or two organ-pipes, placed near each other, and sounded together, will sometimes produce precisely the same note; which differs a little from that which each produces separately: they affect each other through the medium of the air. So two clocks, resting on the same support, have been found to modify each other's motions, and exhibit a perfect coincidence in all of them.

The mental and moral association of sound with the sublime and beautiful was evidenced in the philosophic Bacon, the majestic Milton, the impetuous Alfieri, the splendid Curran, the powerful and pathetic Massillon; who all sought music as a source of inspiration; and there is proof in Holy Writ of its subduing power on the afflicted monarch of Israel by the harp of the youthful minstrel, warrior, and prophet, *David.*

SAUNDERS'S DEDUCTIONS FROM HIS EXPERIMENTS FOR THEATRES WERE—

1. That sound expands equally every way.

2. To alter the form of its expansion, the interruption of a body is necessary.

3. That all bodies attract sound.

4. That sound is absorbed and conducted by a body more or less according to the nature of the material.

5. That in proportion to the conducting power of the material will be the resonance it occasions.

Which being admitted, it follows that nothing can be depended on in a theatre but *the direct force of the voice.*

To ascertain the extension of the human voice, he made the following experiments. Selecting a calm day, an open level meadow, the speaker reading from a book, and the hearer shutting his eyes, to prevent as much as possible all extraneous disturbance.

Fig. 1, plate 1.—A circle 100 feet in diameter; the speaker in the centre; the hearer moving on the circumference, 50 feet distant; heard most distinctly when in front of the speaker; not much less so at each side; but scarcely at all behind.

Exp. 2. Same circle; speaker placed at 75 feet from the front, or three-fourths of diameter; he was heard best at the sides C C; indifferently in front, and behind; though the latter only 25 feet distant.

Exp. 3. Fig. 2; speaker at 67 feet from front, and 17 feet from centre, was the position whence he was *most equally heard;* the hearer still moving round the circumference.

Exp. 4. To ascertain the *extreme distance* at which the voice could be *distinctly heard every way:* the extent from the speaker to the hearer will be 92 feet in front, 75 feet on each side, and 31 feet behind. The line it formed was that described in figure 3: speaker at A, 17 feet behind centre of the circle.

On water he could hear distinctly in a direct line at 140 feet distance; on land at 76 feet, and probably a much greater difference between land and water. The difference of form made by voice and that made by fixed sound is evidently occasioned by the voice being pushed forward from the mouth; and this difference will always be in proportion to the exertion of the speaker, and subject to very little variation.

Conductors of sound may be stated in the following order: water, wood, glass, metals, stone, brick, plaster, and earth.

Wood and metals are perhaps the most favorable to *formation* of sound, and therefore fittest for musical instruments. Woollen and other clothes, and loose earth, are the greatest absorbers of sound, and this quality may perhaps be in the ratio in which they absorb moisture.

Saunders recommends that 70 feet distance between speaker and hearer should never be exceeded in a theatre; both hearing and seeing being defective whenever it is.

HEIGHT OF CEILING.

"As we hear and see worse in proportion to the height from the speaker, the ceiling should be as low as may be agreeable for beauty, &c.: it does not appear that heightening ceiling will sensibly affect the voice,* but it will always be a conductor of sound to the upper seats. A proportionate height is about three-fourths of the diameter."

The best theatre for hearing is that in the ducal palace at Parma: it is a semi-circle, with elongated straight sides, 130 feet long, 102 feet wide. Saunders conversed distinctly in a low voice at 130 feet distance; and retiring towards the back of the stage, found 140 feet the extreme distance for proper distinct hearing. It is lined throughout with wood, to which is ascribed its facility for hearing. The seats range to the outline of the plan, and rise their whole height above each other; but the nearest spectators are forty feet distant from the stage.

* Nothing more so, in its effect on the hearer; though it is favorable to the speaker, if not immoderately high.—*Editor*.

OF THE FORM MOST ADVANTAGEOUS FOR THE VOICE AND SIGHT.

THE CIRCLE.

From Saunders's experiments, confirmed by Wyatt, a circular form of plan will combine more advantages for hearing and seeing than any other, and 17 feet in front of speaker will be its centre; and if three-fourths of its diameter be taken, this will bring the majority of spectators in face of the scene, and will contain greatest number in an equal space.*

THE OVAL.

Only those seated at the extremity of an oval see in a direct line; and, in proportion as spectators recede from that point, they advance the back towards the scene; for hearing, it is by no means calculated. All forms adapted to theories of reflection or conduction must be deficient.—SAUNDERS.

THE SQUARE.

The square preferable to the oval: it contains more in front; sides bad, particularly when much extended; obliging spectator to turn his face almost over his shoulder when he looks at the scene.

HORSE-SHOE.

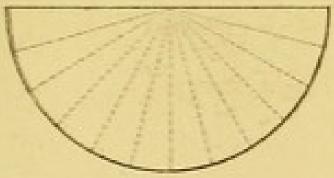
The horse-shoe form has great merit, but some disadvantages attending the sides of a square, occasioning a painful position of head; and the converging sides have a bad effect.

* Vide Report on House of Commons Buildings, 1833, question 576. G. Basevi, architect, evidence in favour of parallelogram for accommodating greatest number of persons, and as to hearing; questions, 509, 674, in Ancient Concert Room, Freemasons' Hall, &c.

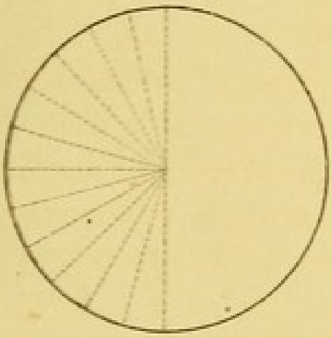
Comparative Advantages of Form for Seeing and Hearing.

vide Page 23.

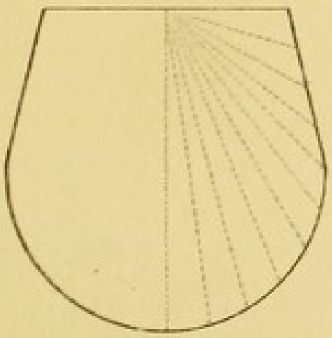
The Semi-circle.



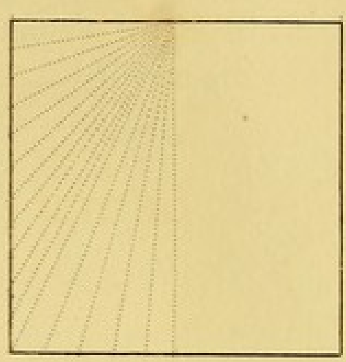
The Circle.



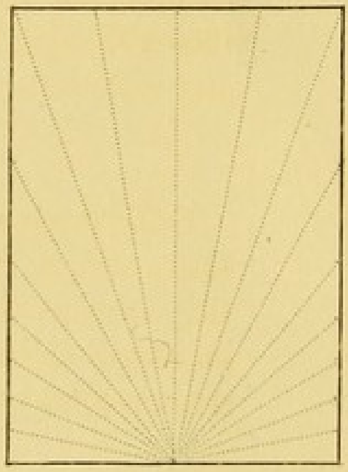
The Horse Shoe.



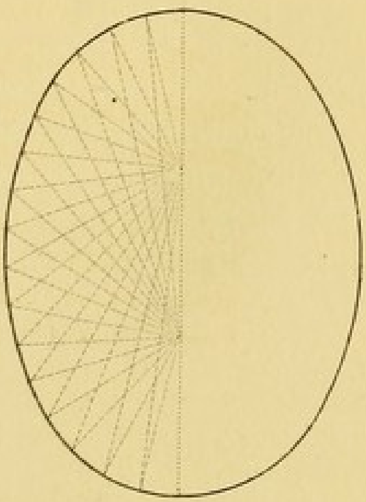
The Square.



The Parallelogram.



The Ellipsis, or Oval.



W. S. Inman del.

John Weale, Architectural Library, 59, High Holborn.

The dotted lines on each figure will illustrate these remarks, which are correct universally as to vision; but as it appears that all curved surfaces tend to reflect sounds towards their centre or foci, what might be an advantageous plan or form of room for speaking from a *fixed station* may be unsuited for a popular assembly where persons speak from *various parts of it.*

CHLADNI'S THEORY.

Chladni states, that rooms will be favorable to the transmission of sound;—

1. When arranged to facilitate its natural progress.
2. When its intensity is augmented by resonance or simultaneous reflection, so that the reaction is undistinguishable from the primitive sound.
3. When not too lofty or too vaulted.
4. When there is not a too extensive surface for the sound to strike against at once.
5. When the seats are successively elevated.

He observes that—

When the enclosed space does not exceed 65 feet, any form may be adopted for a room.

That elliptical, circular, and semi-circular plans produce prolonged reverberations.

Parabolic plans and ceilings are the best for distinct hearing.

And that for concert rooms; square, and polygonal plans should have pyramidal ceilings, and circular plans domed ones, and the orchestra be placed on high, in the centre, to produce the best effect, and avoid echo.

Dr. Reid's plan for a House of Commons is formed on the principle of reflection from the ceiling, and absorption by the floor, and coincides with some of Chladni's theories. On inspecting its transverse section, the rising seats and inclined ceiling on each side would nearly describe a parabola, whose focal axis would be the neutral or common line of the angles of reflection. Vide Plate at the end of this volume.

These parabolas, whose intersection would be a vertical plane through the centre of the house, represent the forms of a speaking and hearing trumpet in juxtaposition at their largest apertures.

Such a form will very likely be favorable to debaters from side to side; but will it be equally so for other Members and Peers, or for the reporters and public galleries?

As respects customs of the House and the Ventilation, this form may be questionable—particularly as to height—but, with some alterations, its adaptability may be desirable.

As regards the building of an experimental House of Commons on this model, would not a deputation to inspect Dr. Reid's class-room at Edinburgh answer the purpose at less expense? And though Dr. Reid's evidence is so prompt and ample, as fully to merit the attention it received, and his general attainments in science free him from the imputation of a systematizer; yet well reported instances have occurred, which on examination have proved to be fallacious.

A case in point is in the evidence of John Deering, architect: (vide the report on House of Commons buildings, May, 1833, question 660, page 45) as to the continuance of Echo in the theatre of the London University, he replies :—"I do not know: I find that in such inquiries I can only trust the evidence of my own senses: all the books quote the theatre of Bordeaux as a model with regard to hearing: I have been told by persons who have been in it, that nothing can be worse; and we find the foundation of its good character to have been, that its history was published by its projector. Under similar auspices the published account of the Derby Infirmary presents it as a model of ventilation: so much so, that I was tempted to visit Derby for the purpose of inspecting its merits; but I found the Resident very far from concurring in its eulogy; there was no part he did not take exception to; and when I asked if there was not an unpleasant scent perceptible on entering the building, he asked me how it could be otherwise, when the system of ventilation required that no air should be allowed to escape in that entrance." *

The difference between singing and speaking has not been sufficiently attended to, either in theory or practice. The voice in singing may sound well in several rooms, which in speaking would be indistinct. Many stammerers, who experience great difficulty in giving distinct utterance to words, can sing without impediment. This may explain why some rooms are reputed to be excellent for one purpose, which prove otherwise when used for another: besides, a small or great audience makes a difference in the air, in the absorption of sound by clothes, by conversation, &c. &c.

Gibbon states, that a rapid orator speaks two words per second: perhaps 5000 words per hour may be a fair average for public speakers. Stenographers can note 140 per minute.

An American brother architect (Robert Mills) describes the present House of Representatives of the United States Congress as the most elegant Legislative Hall in the world. The plan is a semicircle of 96 feet chord, elongated in its diameter line by a parallelogram 72 feet long, by 25 wide. Height to the entablature blocking is 35 feet, and to apex of domed ceiling 57 feet, which is pierced by a circular aperture crowned by a lantern. Besides additional seats and other improvements, a more important object has been accomplished—namely, rendering *this Hall a better speaking*

* To the late Charles Sylvester, and his patron, Mr. Strutt, of Derby, the Infirmary is indebted for its fame. Its plan, without their contrivances, would present more inconveniences than are here noticed. I derived both pleasure and instruction during my short intercourse with these amiable and intelligent men.—*Editor.*

and hearing room, in which it was before seriously deficient. The voice is now comparatively distinct, and the ear not sensible, except in a few particular points, of any reverberation of the sound; where the voice before was confused and indistinctly heard, it is now full and clear. There is still, however, a small perceptible echo in places, which arises from the too great loftiness of the dome, and which might be remedied by reducing it in its height. The architect suggested it, but time and expense prevented the execution. The adoption of the semicircular form in the plan of this Hall by the architect (Mr. Latrobe), was a result of a conviction of its being the best suited for legislative purposes.

When the French Chamber of Deputies resolved upon the erection of a New Hall for Debate, they appointed a Committee, composed of the most celebrated architects of France, to inquire into the subject, and report upon the best form of a room for legislative business. After examining the largest rooms in Paris, and the most celebrated buildings of antiquity, they unanimously recommended the horse-shoe or semicircular form, surmounted by a very flat dome; which plan was accordingly executed, and has given every satisfaction. The Hall of the Chamber of Deputies is said to be one of the finest speaking and hearing rooms known.*

There is an important difference, however, between the plan of that Hall and ours. The walls of the French Chamber are perfectly plain, (not fretted with repeated recesses) and covered with a very flat dome: the walls of our Hall are broken, or fretted with a series of projecting columns, forming a continuous colonnaded gallery, and covered with a too lofty dome. The position of the Tribune in the Hall of Deputies, from whence the members address the Chamber, is

* Vide Evidence of the Right Honourable J. W. Croker to the contrary. Parliamentary Report 1833, on New House of Commons. It is semicircular; the chord line is about 96 feet.—And of G. Basevi, architect, same report, page 40, in favor of it; and as to defective hearing in the courts at Glocester, which are semicircular: the judge only hears well, he sitting in the centre of the circle.

along the line of the diameter; consequently they speak TO the circle, and every member receives the full force of the words spoken. Before the alterations were made in the position of the Speaker's seat in our Hall, the members spoke FROM the circle; consequently they spoke to the diameter, or the straight line: hence the indistinctness of the voice, even under the most improved form, but more especially when subject to the former fretted surface. The alterations made were intended to correct this error, and, by smoothing the fretted surface behind the circular colonnade, lessen the evil arising from this cause. Though we cannot realize the full force of the voice here, owing to the yet fretted character of the surface of the walls, yet much has been gained by lessening their irregular superficies, and bringing them into correct form.*

After quoting the Greeks and Romans,† and theatres and amphitheatres, as authorities for circular forms as best adapted to the action of the voice, he proceeds:—"A room, to be properly constructed to support and convey the voice, must possess the capacity of producing a multitude of consonant echoes, and as few dissonant sounds as possible; for, in proportion to the predominance of the former, is the perfection of the room to produce a distinct utterance of the voice. Now the circular form is the best adapted to effect this; and in proportion as this surface approximates to the spherical form, the more powerful will be the effect of the sound propagated therein; for such a form would produce an infinity of consonant echoes: but the spherical form is not suited for practical purposes; and, if it were, the sound would be too powerful to be agreeable: more than is necessary is often as injurious as not having enough. In all operations there is a medium to be observed; and, in adopting a form of room special reference must be had to the object for which

* These frets are very useful in preventing echo.—*Editor*.

† Vide Evidence of Sir John Soane, R. A., Report on New House of Commons, 1833, in confirmation.

it is designed. A bad speaking room often makes a good music room.

The most practical form of room for legislative or forensic debate is a complete circle, covered with a very slight concave ceiling; the whole entire height, walls and dome, not exceeding the length of the radius describing the circle. Such a room Mr. Mills (architect) constructed for public speaking in the city of Philadelphia, and it is acknowledged to be a most perfect room for speaking and hearing in.

The first House of Representatives was a square plan bounded by two semicircles, surmounted by a dome according with Mr. Jefferson's idea. The dome had numerous pannel lights and a freestone colonnade. It was very handsome, and a very good speaking room.

"The Senate Chamber is of the same general form with the House of Representatives, but has the advantage of plain walls and few recesses; consequently, it is a good speaking and hearing room. The dome is very flat. The dimensions of this Chamber are as follows:—75 feet in its greatest length, or diameter; 45 feet in its greatest width; and 45 feet high. The President's chair is on the line of the diameter.

"The entrance rotunda of the United States capitol is 96 feet diameter, and 96 feet high: it is a perfect Babel of sounds, the slamming of a door producing a noise like thunder; for colloquial purposes therefore it is useless—nothing scarcely that is said at the least distance can be understood; yet, as a *music* room, and for a *single instrument* of the most delicate construction—for instance the musical box, the effect is most delightful; it is as if a whole band of music was performing, or as if the pealing of the full-toned organ swelled upon the ear. Those fond of plaintive music, may, in the deep silence of this room, enjoy a treat, if they will but bring with them a musical box. This dome has a fine whispering gallery, but it is inaccessible to the public."

OF ECHO.

Echo is the repercussion and repetition of a sound until it gradually decays, and eventually becomes imperceptible to the ear.

No laws of echo have hitherto been discovered : it appears to be caused by unequal reflections of sound, as well as by conduction, and to require a free space beyond the reflecting surface.

Saunders says moisture promotes it, and that a house in Lambeth Marsh produces echo in winter, but none in summer.

Wm. Alexander, of York, observes that a square room, whose height is one-third of its breadth, or a parallelogram, whose height is half of its breadth, will seldom, if ever, produce echo ; but if they be higher, they will ; and that no room designed to aid the voice should be much higher than 26 or 27 feet.

Circular or inclined ceilings in lofty or very long rooms also conduce to echo.

A lantern-light in the ceiling frequently produces echo in a room, and always interferes with its perfect adaptation for sound.

The most celebrated whispering galleries are those of Saint Paul's Cathedral (a circular and domed apartment, 120 feet diameter): a whisper is conveyed 200 or 300 feet. The shutting of a door produces echoes like distant thunder.

The east end of the choir of Gloster Cathedral, where a whisper is heard 25 yards distant.

In a room at the Observatory, and in an aqueduct at Paris. In both these instances, it is evidently caused by the vaults first conducting the sound to the ear, and afterwards its reaching the ear through the air, which thus receives two impressions from the same sound.

In Woodstock park, Oxfordshire, an echo repeats twenty times by night, and seventeen by day.—*Plot's Oxfordshire.*

At the villa Simonetta, near Milan, (three sides of a parallelogram,) visited by Kircher and Buonaparte. In the autumn of 1827, I counted forty repetitions of a pistol-shot by the echo : here the water has considerable influence. The Jesuits erected a similar edifice at Prague, but failed in their attempt to produce echo there.

The alcoves on Westminster-bridge (angular-niched formed), in which a conversation may be held by persons at 60 feet across, from side to side, without the passengers hearing them.

Near Sir W. W. Wynn's house, in St. James Square, there is a very strong echo when the bell is ringing for church, which appears to be similar to the effect of sound in the vestibule of a church mentioned by Dr. Reid.

A cloud near the earth will sometimes produce echo. In a fog, Addison heard fifty-six repetitions, at the villa Simonetta.*

* "Travels," edition 1718, p. 32.

Atmospheric air—Presuming its height to be 28,000 feet, its pressure on each square inch of the surface of the earth is $14\frac{3}{4}$ lbs; equal to a column of mercury 30 inches high; of water, 34 feet high: its density diminishes according to its height. It is supposed to extend 40 or 50 miles.

Barometer being 30, *Thermometer* 60°.

Specific Gravity will be		Weight of 100 cubic inches in grains will be		Capacity for Caloric.
Air, the standard.	Water, the standard at 1000.			
1000	1.2279	Atmospheric air	30.80	1.7900
1103	1.35	Oxygen gas .	33.82	4.7490
985	1.21	Azotic . .	30.50	.7936
84	.1031	Hydrogen .	2.25	21.4000
650		Carbureted .	20.00	
1142	1.36	Sulphureted .	34.28	
1500	1.84	Carbonic acid	46.5	1.6454

100 cubic feet of atmospheric air weigh about 112 oz., or 7 lbs. avoirdupois: 100 wine gallons weigh about 1 lb. avoirdupois. Air may be considered 820 times lighter than water.

If 1 cubic inch of water weigh .	252.525	grains,
1 cubic inch of air will weigh	.308	do.
If 100 cubic inches of air weigh .	30.808	do.
1 cubic foot will weigh	532.36	do.

Electricity.—Air of the natural atmosphere is generally positively electrified: air of close rooms, and noxious vapours, are always negatively electrified, and sometimes during rain.

*Absorption of Moisture.**—1 cubic foot of air absorbs 1 cubic foot of steam : 1 cubic foot equal to 527 grains.

When saturated at 32° contains of moisture 2 grains.

do.	48°	do.	4	do.
do.	60°	do.	6	do.
do.	68°	do.	8	do.

Its density thus mixed is about $\frac{3}{4}$ of that of the air itself. —Saussure.

If one cubic foot of perfectly humid air, at 32°, be mixed with one cubic foot of do. at 60°, their common temperature must be 46°, and there must be a precipitation ; for, fully saturated, they separately contain 8 grains; but when mixed, will be too cold by 2° to contain the same quantity.

Expansion of Air, is $\frac{1}{480}$ to $\frac{1}{500}$ of its bulk, for each degree from 32° to 56° of Fahrenheit ; less at higher, more at lower temperatures, whether dry or moist, or twice as dense: the gases the same according to Gay Lussac, and Dalton: by freezing reduced $\frac{1}{300}$ of its bulk. The bulk of atmospheric air is inversely as its pressure ; a double pressure reducing any given volume to half its bulk.—Mariotte. Under pressure of two atmospheres absorbs 50° of heat in expanding ; more than 50° produced when admitted into an exhausted receiver.—Dalton.

Velocity of air rushing into a vacuum is 1305 feet in a second, assuming its specific gravity to be $= \frac{1}{840}$ that of water. —Papin, Philos. Trans., 1686.

Of air divided by a twenty-four pound cannon ball, and returning into space, 1300 feet French = about 1500 English. Area of an aperture being .0046, 425.1 cubic inches were expelled in 33″ by pressure of 30 inches of water ; by 6 feet in 21.3″. Hence pressure of one foot = 147¼ ; of one inch, 42 ; or 20 miles an hour.—Banks, Manch. M. v. 398.

* Most hot air stoves destroy this moisture, and produce an excess of carbonic acid ; hence the dry unpleasant feeling in rooms thus heated : for asthmatic or consumptive persons, it increases their sufferings dreadfully ; and yet, in one year, twelve hundred pounds were expended, or rather thrown away, on stoves of this description, in a celebrated city.

Temperature.—Mean of the atmosphere at the equator, 84°; in Jamaica, 80°; Madeira, 70°; Rome and Montpelier, rather more than 60°; Paris, $54\frac{1}{2}$° ; London, $50\frac{1}{2}$° ;* at the Pole, 31°. The greatest cold is half an hour before sunrise; greatest daily heat in London about $\frac{1}{2}$ past 2 o'clock; pleasant temperature, 62°; greatest heat observed in England, 92° in shade, 126° in sun; in France, 104°; at Cawnpore, 144°; greatest cold in England, 20°. A heat of 109° was fatal to 10,000 persons at Pekin. This winter, 1835—6, killed several persons in Russia, the thermometer at Moscow being 35° below zero—of Reaumur.† Mean temperature of springs of water and atmosphere seldom vary half a degree: of the earth increases as its depth; increases in summer, decreases in winter: of coal-pits varies up to 77°. Temperate of Fahrenheit's thermometer, 55°; summer heat, 76°; freezing water, 32°; sea water freezes, 28°; wine, 20°; human blood heat, 98°; fever, 112°; pleasant bath, 92° to 106°; heat of incubation, 108°; water boils, 212°; Newton's metal melts, 212°; viz. 5 lead, 3 tin, and 8 parts bismuth: oil of turpentine boils, 314°; linseed oil, 600°; mercury, 680°; lead melts, 612°; brass, 1869°; copper, 2548°; cast iron, 3479°; iron, bright red, at night, 750°; just visible daylight, 980°; heat of a coal fire, 1050°.

Rain.—Mean fall of, in London, 23 inches; at Exeter, 33 inches; average of England and Wales, 31 inches per annum.

Respiration.—An adult respires at each breathing 40 cubic inches of air—Jurin; Menzies: whole contents of lungs, 280 cubic inches: 666 cubic feet of air respired by each person in 24 hours.—Bostock: superficies of air-vessels in lungs, 15 feet: adults respire about 20 times; youths, 15 times per minute: respired air contains 4 per cent carbonic acid.—

* Professor Daniel, 49 and a half.

† In the Antilles it has also been very severe; the thermometer ranging about 67 Fahrenheit. In France also unusually severe.

Brande. 24 grains will saturate 3200 cubic inches of atmosphere.

CONDUCTION OF HEAT.—

Conducting power of mercury being	1000
That of water was . .	313
Moist air . .	230
Common air .	80.41
Air $\frac{1}{4}$ as dense . .	80.23
Air $\frac{1}{24}$ as dense .	78.
Air of a vacuum .	55.

The last two numbers compared with the conducting power of common air appear to indicate a formula of this kind, $55 + 25.4d^{\frac{1}{31}}$, d being the density compared with that of the atmosphere.—Sir B. Thompson, Philos. Trans. 1786.

Brass and copper retain heat longer than iron; iron than tin; and tin than lead. Silver, best conductor; platina, the worst.—Lichtenberg.

Time of cooling, by radiation in still air, a hollow tin ball, 6 inches diameter, filled with water:

From 212° to 122° takes 124′.9; painted, 83′.2

From 212° to 50° takes 602′.; painted, 344′.1

COMBUSTION.—1 lb. of carbon consumes $2\frac{6}{10}$ lbs. of oxygen, which is that contained in 13 to 14 lbs. atmospheric air; 1 lb. of hydrogen consumes 8 lbs. of oxygen, which is that contained in about 40 lbs. of atmospheric air. Tallow, wax, and oil contain 77 to 80 per cent charcoal, and 11 to 14 per cent of hydrogen: remainder is oxygen. Coal gas spoils thrice its bulk of oxygen, or 15 times that of air.—Brande.

12 hole Argand burner, flame 3 inches high, consumes 3 feet cube coal gas per hour: 18 hole Argand burner flame, 3 inches high, consumes 4 feet cube per hour; at 1 inch pressure.

WATER, specific gravity 1000; weight of a cubic foot, $62\frac{1}{2}$ lbs.; weight of an ale gallon $10\frac{1}{5}$ lbs.; expands in bulk, by 1° of heat, $\frac{1}{3858}$.—Dalton.

Expands in freezing $\frac{1}{17}$ to $\frac{1}{13}$ of its bulk.—Williams.

Expansive force, in freezing, about 35,000 lbs. on square inch.—Muschenbroek.

One cubic inch makes one cubic foot of steam.—Watt.

Bad conductor of heat.—Roy, Philos. Trans., 1777.

CONGELATION.—Line of perpetual at the equator, 3 miles above the surface of the sea: Teneriffe, latitude 28°, 2 miles: London rather more than one mile; 80° north latitude; 1200 feet.

EXHALATION, HUMAN.—Vapour from the lungs 6 grains per minute, Thomson's Sys. Chem., = $1\frac{1}{2}$ lb. Troy per 24 hours.

Insensible perspiration 9 to 26 grains per minute, if taken at 18 grains averagely = $4\frac{1}{2}$ lbs. Troy per 24 hours.

VELOCITY AND INTENSITY OF WIND.

Comparison of Rouse's Table, published by Smeaton, with that of Lind.

Lind's Gauge.	Force on a square foot, in lbs. avoir. by calculation.	Feet per Second.	Miles per Hour.	Character and Designation.
	0.005	1.43	1	R. Hardly perceptible.
	0.020	2.93	2	R. Just perceptible.
	0.044	4.40	3	
	0.079	5.87	4	R. Gentle winds.
	0.123	7.83	5	
0.025	0.130	.	.	L. A gentle wind.
0.050	0.260	.	.	L. Pleasant wind.
	0.492	14.67	10	R. Pleasant brisk gale.
0.10	0.521	.	.	L. Fresh breeze.
	1.107	22.00	15	R. Brisk gale.
	1.968	29.34	20	R. Very brisk.
0.5	2.604	.	.	L. Brisk gale.
	3.075	36.67	25	R. Very brisk.
	4.429	44.01	30	R. High wind.
1.0	5.208	.	.	L. High wind.
	6.027	51.34	35	
	7.873	58.68	40	R. Very high.
	9.963	66.01	45	Derham, Great storm.
2.	10.416	.	.	L. Very high.
	12.300	73.35	50	R. Storm or tempest.
3.	15.625	.	.	L. Storm.
	17.715	88.02	60	R. Great storm.
4.	20.833	.	.	L. Great storm.
	21.435	96.82	66	Condamine, do.
5.	26.041	.	.	L. Very great storm.
6.	31.250	.	.	L. Hurricane.
	31.490	117.36	80	R. Hurricane.
7.	36.548	.	.	L. Great Hurricane.
8.	41.667	.	.	L. Very great hurricane.
9.	46.875	.	.	L. Most violent do.
	49.200	146.70	100	R. Hurricane that tears up trees, throws down buildings.
10.	52.083	.	.	
11.	57.293	.	.	
	58.450	160.00	109	Observed by Rochon.
21.	62.5			

Winds passing over land become dry and dense, passing over seas warm and light.—The Solanos in Arabia—the Harmattan in Africa are very scorching—Some winds in China are extremely moist. Ashes of a volcano have been carried 400 leagues.

Correspondence of the Thermometers of Fahrenheit and Reaumur, and that of Celsius, or the Centigrade Thermometer of the modern French chemists.

Fah.	Reau.	Centi.	Fah.	Reau.	Centi.	Fah.	Reau.	Centi.	Fah.	Reau.	Centi.
212	80.	100.	166	59.5	74.4	120	39.1	48.8	74	18.6	23.3
211	79.5	99.4	165	59.1	73.8	119	38.6	48.3	73	18.2	22.7
210	79.1	98.8	164	58.6	73.3	118	38.2	47.7	72	17.7	22.2
209	78.6	98.3	163	58.2	72.7	117	37.7	47.2	71	17.3	21.6
208	78.2	97.7	162	57.7	72.2	116	37.3	46.6	70	16.8	21.1
207	77.7	97.2	161	57.3	71.6	115	36.8	46.1	69	16.4	20.5
206	77.3	96.6	160	56.8	71.1	114	36.4	45.5	68	16.	20.
205	76.8	96.1	159	56.4	70.5	113	36.	45.	67	15.5	19.4
204	76.4	95.5	158	56.	70.	112	35.5	44.4	66	15.1	18.8
203	76.	95.	157	55.5	69.4	111	35.1	43.8	65	14.6	18.3
202	75.5	94.4	156	55.1	68.8	110	34.6	43.3	64	14.2	17.7
201	75.1	93.8	155	54.6	68.3	109	34.2	42.7	63	13.7	17.2
200	74.6	93.3	154	54.2	67.7	108	33.7	42.2	62	13.3	16.6
199	74.2	92.7	153	53.7	67.2	107	33.3	41.6	61	12.8	16.1
198	73.7	92.2	152	53.3	66.6	106	32.8	41.1	60	12.4	15.5
197	73.3	91.6	151	52.8	66.1	105	32.4	40.5	59	12.	15.
196	72.8	91.1	150	52.4	65.5	104	32.	40.0	58	11.5	14.4
195	72.4	90.5	149	52.	65.	103	31.5	39.4	57	11.1	13.8
194	72.	90.	148	51.5	64.4	102	31.1	38.8	56	10.6	13.3
193	71.5	89.4	147	51.1	63.8	101	30.6	38.3	55	10.2	12.7
192	71.1	88.8	146	50.6	63.3	100	30.2	37.7	54	9.7	12.2
191	70.6	88.3	145	50.2	62.7	99	29.7	37.2	53	9.3	11.6
190	70.2	87.7	144	49.7	62.2	98	29.3	36.6	52	8.8	11.1
189	69.7	87.2	143	49.3	61.6	97	28.8	36.1	51	8.4	10.5
188	69.3	86.6	142	48.8	61.1	96	28.4	35.5	50	8.	10.
187	68.8	86.1	141	48.4	60.5	95	28.	35.	49	7.5	9.4
186	68.4	85.5	140	48.	60.	94	27.5	34.4	48	7.1	8.8
185	68.	85.	139	47.5	59.4	93	27.1	33.8	47	6.6	8.3
184	67.5	84.4	138	47.1	58.8	92	26.6	33.3	46	6.2	7.7
183	67.1	83.8	137	46.6	58.3	91	26.2	32.7	45	5.7	7.2
182	66.6	83.3	136	46.2	57.7	90	25.7	32.2	44	5.3	6.6
181	66.2	82.7	135	45.7	57.2	89	25.3	31.6	43	4.8	6.1
180	65.7	82.2	134	45.3	56.6	88	24.8	31.1	42	4.4	5.5
179	65.3	81.6	133	44.8	56.1	87	24.4	30.5	41	4.	5.
178	64.8	81.1	132	44.4	55.5	86	24.	30.	40	3.5	4.4
177	64.4	80.5	131	44.	55.	85	23.5	29.4	39	3.1	3.8
176	64.	80.	130	43.5	54.4	84	23.1	28.8	38	2.6	3.3
175	63.5	79.4	129	43.1	53.8	83	22.6	28.3	37	2.2	2.7
174	63.1	78.8	128	42.6	53.3	82	22.2	27.7	36	1.7	2.2
173	62.6	78.3	127	42.2	52.7	81	21.7	27.2	35	1.3	1.6
172	62.2	77.7	126	41.7	52.2	80	21.3	26.6	34	0.8	1.1
171	61.7	77.2	125	41.3	51.6	79	20.8	26.1	33	0.4	0.5
170	61.3	76.6	124	40.8	51.1	78	20.4	25.5	32	0.	0.
169	60.8	76.1	123	40.4	50.5	77	20.	25.	31	0.4	0.5
168	60.4	75.5	122	40.	50.	76	19.5	24.4	30	0.8	1.1
167	60.	75.	121	39.5	49.4	75	19.1	23.8	29	0.3	1.6

Corrrespondence of the Thermometers of Fahrenheit and Reaumur, and that of Celsius, or the Centigrade Thermometer of the modern French chemists.

Fah.	Reau.	Centi.	Fah.	Reau.	Centi.	Fah.	Reau.	Centi.	Fah.	Reau.	Centi.
28	1.7	2.2	10	9.7	12.2	8	17.7	22.2	26	25.7	32.2
27	2.2	2.7	9	10.2	12.7	9	18.2	22.7	27	26.2	32.7
26	2.6	3.3	8	10.6	13.3	10	18.6	23.3	28	26.6	33.3
25	3.1	3.8	7	11.1	13.8	11	19.1	23.8	29	27.1	33.8
24	3.5	4.4	6	11.5	14.4	12	19.5	24.4	30	27.5	34.4
23	4.	5.	5	12.	15.	13	20.	25.	31	28.	35.
22	4.4	5.5	4	12.4	15.5	14	20.4	25.5	32	28.4	35.5
21	4.8	6.1	3	12.8	16.1	15	20.8	26.1	33	28.8	36.1
20	5.3	6.6	2	13.3	16.6	16	21.3	26.6	34	29.3	36.6
19	5.7	7.2	1	13.7	17.2	17	21.7	27.2	35	29.7	37.2
18	6.2	7.7	0	14.2	17.7	18	22.2	27.7	36	30.2	37.7
17	6.6	8.3	1	14.6	18.3	19	22.6	28.3	37	30.6	38.3
16	7.1	8.8	2	15.1	18.8	20	23.1	28.8	38	31.1	38.8
15	7.5	9.4	3	15.5	19.4	21	23.5	29.4	39	31.5	39.4
14	8.	10.	4	16.	20.	22	24.	30.	40	32.	40.
13	8.4	10.5	5	16.4	20.5	23	24.4	30.5			
12	8.8	11.1	6	16.8	21.1	24	24.8	31.1			
11	9.3	11.6	7	17.3	21.6	25	25.3	31.6			

SUMMARY

OF

THE EVIDENCE.

The Witnesses examined were:—

	No. of questions.
Professor Brande, F.R.S.L. & E., &c. .	78
Professor Faraday, F.R.S., &c. . . .	87
George Birkbeck, M.D., &c. . . .	88
David Boswell Reid, M.D. F.R.S.E. . .	147
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SUMMARY OF THE EVIDENCE.

George Birkbeck, M.D.,

Has paid great attention to the subject, as regards atmosphere of equable and proper condition—its elasticity—and salubrity. No public building well warmed and ventilated, from want of practical knowledge. Builders disregard it—doors are for passages; windows for light; ventilating apertures required. Plans of ventilating should be settled previous to building; both as to efficiency and economy; often attempted after building; always with great expense and inefficiently—is a matter of calculation, as to number of occupants—their impression on the atmosphere. Fresh air apertures—number and area of foul air apertures. Does not think, if the principles were mere calculation, they would be better understood. Scarcely a chimney judiciously built. Builders and architects resist the proper knowledge. Very few sources of such knowledge. Believes the best authorities to be late Mr. Tredgold, also Drs. Hall, Franklin, Professor Robinson, and Mr. Whitehurst, and the Encyclopedias—articles Pneumatics, and Ventilation. If air require change, it is either impure or heated. Cool air should always be introduced from without, by which you carry away the vitiated heated and expanded portion. An equally pure supply always obtainable from external atmosphere, in which chemistry can detect no variation. Never occurred to witness that a foggy atmosphere would require purification before being admitted. Always considered atmosphere pure enough, and abundant. If impure, considers it should be ameliorated or filtered, and best mode of doing so sought after. Has considered effects of a dry and a humid atmosphere, and in a few instances found it so moist as to be prejudicial, and then it should be warmed or dried. In very cold weather highly heated air has less moisture than summer air of same temperature, but even then scarcely necessary to introduce moisture. Has been in a manufactory warmed by pipes of hot air or water; moisture was not introduced there—if any difficulty arose, thinks it would be by heating the air too much. Does not think moisture in atmosphere essential to comfort or health of individuals. Thinks dry air quite as good as moist, and advantageous for carrying off fluids from surface (of body) more certainly than when air itself is charged with water. Chemical effect of a crowded room on air is too high temperature; deprivation of oxygen gas; superabundance of carbonic acid gas (from conversion of oxygen); too moist for comfort by personal exhalations; upper portions more azotic gas in proportion, and lower more carbonic acid gas of greater specific gravity: according to Lavoisier's experiments in theatres of Paris, not necessary to draw off impure air from top as well as from bottom of apartments, because heavier would mix and ascend with lighter gas, as in a chimney, by colder air pressing behind it —50° to 65°—60° best temperature for houses, but air from doors and windows would be uncomfortable. Lights, if placed near apertures, assist ventilation by effects like those of a chimney. Some buildings have foul-air exit-holes in ceilings, but none through roofs. If full supply of cold air from below, no occasion to turn external apertures in roofs from adverse winds. Cowls are used for badly-drawing chimnies; but rarefied air force enough for ventilation, but best to remove impediments to currents of air; perhaps a cowl best; but sometimes they get fixed, and then disadvantageous. Prefers admitting external air of regulated temperature to any preparation of it. Basement-room to prepare warm and cool air, indispensable in a good system. Could give useful hints to a willing listener for an unobjectionable system. Does not profess full competence in practical details. Never saw a perfectly ventilated room; some apparently, but not really so. A communication between upper part of ceiling and exterior of roof necessary, and the lighting (artificial) so high, as not to consume lower strata of oxygen. Never concerned in ventilating a new building of any magnitude. Witness's principles sufficient for Houses of Parliament,—as numbers increase, so would current—would provide for greatest number, say 1,000, and thus include all requisites. Air prepared in a basement-chamber at never less than 50° ; if much heat in house, perhaps lower. Should be lowest when house is hotest. Taking 40° to 70° as ranging temperature of houses in summer and winter, would have to heat for former, and cool for latter, and according to number of persons.—Benjamin Wyatt published on these subjects an account of Drury Lane theatre, and possibly Saunders on theatres also.* Proposes to prevent draughts by short tubes in small semicircular niches, formed within the wall, or through floor, or above the skirting, but difficult to decide best mode to avoid incommoding any one. Prefers large to small inlets for air, and judiciously situated. A strong current of air at any temperature playing on the body is objectionable. "Draught" applies to cold air in motion; motion of air at two to three miles an hour just perceptible; at four or five miles an hour, a breeze ; at ten or fifteen, a pleasant brisk gale ; beyond that a wind, and at fifty, sixty, and eighty miles an hour, a storm, tempest, and hurricane. Ordinary current in a chimney four and a half or six feet a second, or about three or four miles an hour. If air be admitted of an agreeable temperature and pleasant degree of humidity, there would be no disagreeable draught. In a good system, change of air should be imperceptible, and is a practicable condition. Thinks a perfect system attainable for a number varying from 50 to 1000 persons, though with difficulty; should prevent exterior atmospheric changes being felt within; therefore thickness of walls and all circumstances should be attended to. Variation must be regulated by inlet and outlet apertures. Inlets must be in or near the floor, but influenced by position of chairs, benches, &c. and architect's taste. Air not substantially affected by

* Neither Saunders or Wyatt treat on ventilation.—*Editor.*

material through which it passes; the injury would be excessive temperature, without relation to any quality imparted from the iron. Imperfect air might be completely corrected and purified, by passing it through lime-water or chloride of lime—both simple processes. Unnecessary, if air be brought through subterraneous tunnels at a distance from the river, or from an open space, and any need of correction problematical. Considers neighbourhood of the river improves atmosphere, excepting effect from fevers. Air brought under ground, from a large building like the Abbey, would be better, and perhaps subject to no *source of impurity*. Atmosphere can be occasionally improved or purified; generally that of London is sufficient for respiration; more said about bad air than bad habits of London. Never heard of disease being generated from noxious vapours exhaled from a river embankment, where employed to keep out water; but where water behind has been rendered stagnant, there fever has been produced: conceives that the only mode depends on state of land embanked. Unaware that any of the New Buildings' foundation was to be on an embankment. An embankment may simply contract and accelerate the stream. Should say, an embankment would be a bad foundation. No prejudicial effect to new houses would arise from the embanked soil when it was dry, which it would be in no long time. No fever in connexion with banks but what arises from decomposition of animal and vegetable matter by moisture. Puddling would completely prevent soakage. Doubts the fact of prevalent fevers at New York and some Italian cities on banks of rivers. When good system once established, may be conducted at small expense—almost self-acting: does not know that air would require to be acted on; but sometimes it might require to be cooled, warmed, dried, or moistened. Any quantity could be rapidly admitted or changed. Expense should not be considered when such eminent men are exposed to deleterious air. If good system provided, before building be begun, expense would not be great: the present system is terrible. His plan excludes ventilation of staircases and galleries from interfering with other parts; all ought to be ventilated; mines are ventilated by galleries and doors; the best mode is that devised by Mr. John Martin, the artist; he avoids chambers; but surrounds the coal by one great gallery, and this alone is ventilated (no other cavity)—his plan admirable. Believes proper ventilation prevents chimneys smoking, if constructed according to Hiort's circular plan.

JOHN SYLVESTER, Engineer,

Has attended to the subject. Ventilated Lunatic Asylum for Kent. Fresh air is introduced slowly and in any quantity, and flows through an apparatus to temper and render it fit for breathing at all times. Apparatus fit for fresh cold and fresh warm air. Channel communicates atmosphere with an under story of the space to be ventilated, and warmth and moisture given by apparatus; motion is given to external air entering through a shaft by a cowl directed to the wind. In hot, calm, and oppressive weather, cowl will not act; but warming surfaces above ceiling, at higher temperature than rooms, would extract foul air; from cavity of roof there is an outlet cowl, with reversed action to that of inlet. Rate of air's motion about four feet per second; rate of motion into Houses would be half a foot per second, or about one-third of a mile per hour. Inlet apertures over whole area of floor. Area of apertures about 665 feet, estimating house with staircases and corridors to be operated on at 200,000 cubic feet of air, which would be changed six times per hour. Sufficient surface of pipes, filled with steam, above ceiling, to raise foul air out of house. Temperature of air depends on quantity of surface of pipe exposed, and time it is in contact with heated surface. As respects his practice and the most advantageous temperature, witness has never operated on so great a surface, either in material or quantity. Ventilation has been usually effected by fires to heat columns of air in large chimneys connected with the room. Additional apparatus required from the great difficulty of operating on House of Commons. Air admitted should be 5° Fahrenheit (higher or lower) than temperature of House: air is heated by being divided into numerous very small streams, flowing against large surfaces of cast-iron apparatus in basement, under part of such surfaces heated by steam or water, equally affording moderate and varying excess of warmth required, and thence to flow under whole area of, and through apertures into, house. In some of witness's apparatus for warm air, metal surfaces are heated by direct radiation of fire. Prefers steam or hot water for house, because desirable to give very moderate degrees of warmth to a very large quantity of air; the air is brought to temperature required, by fixing the time for contact with heating surfaces, varying by the degree in which they are heated. If house be too hot, temperature might be reduced to any state required in ten minutes. Not easy to raise so much air to an inconvenient temperature. Air warmed by surfaces inclosing steam, may have (though witness doubts it) little difference between absolutely cold degree and that of boiling water; but witness's surfaces would be thick cast-iron, and great portion of the heat is conducted into substance of tube itself. Heat applied at under surface of plate only. Intermediate degrees of heat obtained by discharging the steam at intervals; has not determined whether steam or water affords easiest adjustment; thinks either would answer; if by water, might be adjusted by thermometer. Thinks air may be accurately attempered for house, without being previously prepared in a chamber (or reservoir). Advantage of steam is, easiness of controlling its action; is not certain water might not be equally so. Believes either could be easily and uniformly regulated to a required temperature, within five degrees, without a mixing-room. Does not know how hot and cold air mixtures could be attended to in such large quantities; easy enough for small quantities; and at excessive temperature. Does not consider steam and hot water necessary to avoid burnt smell or excessive dryness in air. Metal surface apparatus, heated by fires well arranged, should be free from this objection. Has heard of disagreeable feelings to the lungs by air from overheated cockles. Is not aware of a cockle in Portland place being removed for such reasons. Would avoid such evil in House of Commons. If cold air only be required, the metal surfaces would remain unheated, except those above ceiling, to produce motion. To cool air in summer and warm it in winter, it should be conducted under ground, sa from Palace-yard for 100 yards; such a channel would temper it about fifteen degrees above or below atmosphere. Cellars are hotter in winter and cooler in summer; but if air be passed through cellars, the temperature would be altered, unless it could remain long enough, as in a reservoir; it might be cooled by passing through channels with wet surfaces. Calculated area of cool-air channel required to be 83 feet, or about nine feet square; if long enough, such a channel would subtract in summer, or add in winter, sufficient water to cool that quantity of air fifteen degrees averagely. This witness states as fact, observed at Kent Lunatic Asylum, which is of common stone-work, 200 yards long and six feet square, as proof that the surface of cold-air channel does not acquire temperature of the air passing through it at speed of four feet per second. Calculations for apparatus, &c. for House of Commons at rate of 1,200,000 cubic feet of air per hour. Supposes area of floor to be 4000 feet; ventilation-flue, when house occupied, always in action; when empty, flue closed, which at usual altitude (say fifty feet high) affords 200,000 cubic feet of air, which rising in ten minutes or 300 feet an hour, is one-third of rate proposed for admitting current of air into house. Includes air for whole building; for *all* should be operated on. Cost of adequate apparatus, exclusive of ground chamber, £2000. Thinks it impossible to do it efficiently after erection of building, and must be BEFORE commencement: refers, as proof of all this, to the Kent Asylum. The warming surface there is cast-iron heated by fire; each stove having a distinct apparatus. At Trinity-house witness used a surface partly heated by water, but there no rapid ventilation required; no effluvia from the iron ; no oil used. Air, admitted at half a foot per second, scarcely moves the most sensitive flame. Inlets might be larger. Witness's apparatus would introduce air better tempered than if various tempered airs were mixed in a chamber, and better than if airs were mixed like water in a bath ; but such a mode not inconsistent with witness's mode. Could deliver drawings and dimensions of his plan ; it could be applied to any building provided a ready means of communicating from basement to roof existed, or by external flues if there were not. Is not prepared to say, as to applying it to present House of Commons; it would be very difficult and expensive from great cutting through walls, &c. It would require centre of basement under house nearly whole length, and a counter ceiling to basement generally, and at least ten feet in height. One air channel would do for Lords and Commons (but larger for both), with different branches. At the Kentish Asylum, air passes from day-rooms into sleepers' cells at 60° to 70° ; general fixed temperature is 64° for a regular number of persons (about twenty, sitting still). In winter time, to preserve this temperature, that of the inlet current must exceed that of the rooms. The air is not changed so quickly as for the House of Commons, which is calculated for the number of Members of Parliament. Cannot state what the temperature of 1000 cubic feet of air, passed through a pipe whose exterior was 212 degrees, would acquire in a given time ; but no difficulty in ascertaining. Such an experiment unnecessary for data for his apparatus, witness knowing what its surfaces will do. The temperature will depend on time the air is in contact with the surfaces ; and witness's surfaces are not 212 degrees ; but will ascertain it for the Committee. A large building, as reservoir for air to settle and cleanse it from smuts, &c. before its admission to the house, very desirable, like water in a large cistern. Westminster Hall an excellent place for such reservoir; air would lose much of its velocity there if passed through a grating. Admit it at the floor of the hall, and take it away through the floor again. The outlet cavity in the roof might be as a lantern; no other preparation required. The outer walls of the house should be hollow, or sheathed, and would secure the ventilation and prevent changes of the atmosphere. Air in a double wall should never be altered; the warm air should only be introduced in the manner stated by witness; for when of higher temperature than the house, it would not so well diffuse itself.

Michael Faraday, Esq., F.R.S., Professor of Chemistry, Royal Institution,

States, that his knowledge is theoretical. Not having considered the subject generally, his answers must be mere opinion, or speculation, rather than useful information. The lecture theatre of the Royal Institution his only practical study—Mr. Webster its architect. It is almost perfect for hearing a single speaker: often referred to as a model, and imitated with alterations; but none are equal to it. Its plan rather more than a semicircle: it is a square space inclosed with common brick walls, within which the theatre, nearly semicircular, is constructed entirely of fir-wood, which in some places touches the brick, in others leaves a passage-way. Its dimensions 60 feet from side to side, and 44 feet from back to front, and has a large gallery. Cannot say whether it would be a good room for speaking in from various parts, when more than fifty persons were assembled, which is not a criterion of its power. It holds 800 people: never yet been able to replenish its bad, by good air, without partial currents. Perkins's hot air apparatus the only one tried there: it is powerful: tubes 24 *inches in diameter;* but they produce draught, from difficulty of mixing airs of different temperatures. The air is warmed in the basement, and flows into the theatre 25 feet above the furnace; escapes at the roof or the windows, thirty feet higher. This is not good for parliament-houses: they should have full command of the temperature, without depending on admission of a given quantity of air, and also of any quantity of air, without being restricted by temperature. Hot and cold air does not suddenly mix; and it would require especial care to do so : and if previously admitted into an air-chamber, than directly into the house, from the heated surfaces, would be more under control. Prefers the air being admitted through numerous grated apertures, and generally diffused. If fresh air cannot be supplied from above the level of the chimney tops, then its source is indifferent, whether high or low, provided it be not near sewers, &c. The tide in the river is beneficial ; the effluvia from mud at low water is objectionable. It is worth consideration whether the air from the tower of Westminster Abbey be desirable, or from the inside of the Abbey itself, in connexion with the tower, as preferable to the exterior air. The supply for each person should be 10 or 20 gallons per minute : one man destroys a gallon per minute. The chemical effect on air in crowded chambers is yet unascertained ; its deleterious matter cannot be removed ; its oxygen may be restored. Impurities as soon settle in long passages as in a short, large chamber. Prefers atmospheric air to any artificially compounded. Great difficulty in ventilating and warming rooms subject to sudden and great variations in the number of occupants, and from draughts. A perfect system might be established if parliament would go to the expense of it, to produce a proper supply and current of air, with or without warmth, for a few or many persons, with equal control. Knows of no present building with these advantages, nor combining good hearing, &c. with good ventilation. Not having seen Sylvester's apparatus in practice, is unprepared to give any opinion on it. There is a risk of dryness in air from highly-heated metallic surfaces ; therefore prefers it warmed by steam or hot water, which gives lower temperatures : 65 degrees, by the latter mode, will not cause the air to lose any of its humidity ; but if by the former mode, the air requires vapour of water to correct it. Knows not the cause of this, nor why highly-heated air feels unpleasant : 60 or 65 degrees Fahrenheit is a good atmosphere for the houses ; but desiderata involve such complicated and various conditions that witness cannot be specific. In a large company feels oppressive sensations of closeness at

60 or 65 degrees, but not in a small company; probably from personal effluvia rather than absorption of oxygen, or evolution of carbonic acid; which sensation is much diminished by lowering the temperature. All noxious effects removed by good ventilation. If houses had two walls, (hollow wall,) of porous material, the space between might be importantly used. Not sure whether the walls should be porous or impenetrable to air. Observations and experiments for "*Data*," necessary both for the interest of science and human health, and particularly as bearing on the new Houses of Parliament, and should comprise hot and cold weather; a full or nearly an empty house; the temperature of the house before operations begin; quantity of air entering; its temperature; chemical condition; dryness; the sensation experienced by the members of parliament; state of the barometer; external temperature; direction of the wind; number of persons; quantity and position of lights (artificial); quantity of heat, in addition to that given by the apparatus, communicated to the air by the persons and lights in the room; exclusion of atmospheric air; materials and thickness of walls, &c.; whether porous or solid, exposed to the sun, external air, &c. If a scientific architect would undertake to investigate the subject impartially, it would be a great advantage; but a philosopher without building knowledge, or an architect unacquainted with natural philosophy, might fail. He should be acquainted with the subject in all its bearings on the Houses of Parliament. As to associating a scientific man with an architect, the Committee can best determine.

William Thomas Brande, Esq., F.R.S., &c.,

Has occasionally considered the ventilating and warming large public buildings two essential points; first, free escape of the warm foul air from above; and secondly, admitting compensating quantity of fresh air from below, to create a change of air from near the ceilings below, by a warm current sent into the foul-air chamber in the roof, whence a cowl turning from the wind gives it exit. Also necessary to create a fresh air current into the room to be ventilated. Would not apply heat for this latter. Ventilation ought to be distinct from warming for the new Houses, and quite practicable. Very essential that the foul air should be carried off near the ceiling, in such a way as to guard against descending currents of cold air. Where processes are united, there is often a source of failure, by attempting too much by one stove or other means. Thinks a fresh air chamber (hot or cold) under the whole of the House is necessary. Has calculated the supply for the number of persons and lights; but in practice must far exceed the theory: of ventilation on so great a scale, and such various conditions, must be guided by practice alone. Prefers a large quantity moderately heated, to a small quantity highly heated; say, in winter not exceeding 85 or 90 degrees, external atmosphere being 32 degrees; and in summer, thermometer ranging from 65 to 80 degrees, would put the heat apparatus out of the question, and admit fresh air from without. Very difficult in summer to admit air lower than the external temperature; but it might be somewhat cooled in summer and warmed in winter by a subterraneous passage. Fresh air should be admitted at or near the floor, and elsewhere, where persons are on different levels: there are various opinions on it, and it depends on size, form, and positions of the doors and windows. As to admission-apertures, a sufficient quantity tolerably large, so as to disperse the air, are better than sprinkled over the whole surface of the floor, which would be objectionable. Warm or fresh air admitted through a long line of apertures under the seats would be a good mode. The space under the seats should be lighted and ventilated, and kept clean. A few apertures would not produce draughts. In an oblong room, say 70 × 40 feet, like the present House of Commons, the apertures beneath the seats, or in the floor, equidistant from the sides of the room and each other; or, as witness considers, in a semicircular or elliptical room, the great bulk of the air should be admitted in the central line of the floor by a cluster of apertures, and others at th sides, in the floor or wall; lateral distribution (as under the galleries) would be by the construction of the apertures and large quantities of air: if by a small, or by only one aperture, it has a tendency to produce a current, which immediately rises to the ceiling, and does not mix with the air at the sides. Several apertures, and moderate temperature, diffuse it better, the difference of specific gravity being less. In a House like the present, with a deep gallery, and full of people, ventilation is almost impossible. A common-formed gallery is a great obstruction; a gallery much above the seats, and not too projecting, is admissible: would, if possible, avoid one, and substitute a corridor on level of upper tier of seats, or a kind of retreating gallery: if recessed, like boxes of a theatre, would absorb sound. Cannot state best velocity for an entering current, without referring to data; it would continually fluctuate. Little difficulty to avoid draughts in a semicircular room, with a domed ceiling surmounted by a lantern, which is nearly as the theatre of the Royal Institution, having a gallery and large flat ceiling, which impedes its warming and ventilation. Presumes the new Houses would be larger, and avoid these defects and include the merits: many efforts made to warm this theatre: first, by thin copper steam-pipe, one foot diameter, passing under the seats; the air warmed by it admitted through holes bored in front of some of the seats, and by six large apertures on each side of the four entries. With a thin audience in cold weather, temperature is scarcely high enough; when the steam not fully up, there are draughts and currents; the pipes difficult to keep tight; a noise and cracking from the admission and condensation of the steam: the plan abandoned. The present mode is a current of heated air, thrown into the centre of the room, which with modifications might answer tolerably, but it is not satisfactorily and equally distributed. Provision to pass the air from under the gallery to the roof not effectual, and disagreeably close under the gallery, with closed doors and a crowd. By referring to Notes, can state the rate of the entering current; but neither that nor the temperature constant, and apt to be incorrect. Complaints of draughts from persons on the front benches ; attributes this to the overheated air and mode of admission, which is nearly parallel to the floor, in front of the lecture-table. Does not consider this current a serious objection to the mode ; it might be got rid of ; the chief cold currents are from the passages of the outer entrances ; acts as cold air chamber when the doors are opened. Considers the lobbies, &c. of the new Houses should be likewise ventilated. Would use different stoves, and have no current, and lower temperature. The theatre is supplied from the basement open to the back yard. The supply of air should be from a distant open space through a tunnel, or descend by a lofty turret. Agrees with Mr. Tredgold, in the supply being from a space open to free currents of atmosphere ; and thinks a space below the House, appropriated to these objects, would be of the first importance. Air at different temperatures might then be mixed, but practically difficult, which possibly might be obviated ; the most prominent difficulty is to make so great a mass mix uniformly to a mean temperature, so as to be applicable by any means to the Houses. Thinks air warmed to the required temperature simpler than mixing hot and cold air. Change of temperature might be insured by a proper stove, and by regulated quantities. Great attention required to the dampers in the air flues ; and all to be opened or closed at pleasure. Thinks an air chamber previous to entering the House desirable, as affording regulation and observation, but not indispensable ; height of room necessary to good ventilation. Not aware of the proposed form or dimensions of the new Houses. Does not state proper height to a house 70 feet square. The theatre of the Institution is 60 feet in chord, 44 feet deep ; more correctly, it is a semicircle of 30 feet radius, applied to a parallelogram of 60 by 14 ; the walls 30 feet high to the ceiling ; cased with wood-work, which is very essential to perfection of hearing. Thinks it low with a gallery. Assumes the new House of Commons to be 80 feet chord, and 64 deep, and should be at least 40 feet high.

General purity of the atmosphere can be accurately tested; but an accurate chemical analysis of the air will not detect any difference between pure atmosphere and that of a room, with persons in a highly infectious disease; but probably some difference in a crowded room decidedly oppressive to respiration. Examined the air some years since, in the upper part of Covent Garden theatre; found three per cent of carbonic acid in it, produced by vitiation and imperfect ventilation. Was consulted when the large central gas chandelier was put up; much difficulty in having the foul-air aperture large enough to ventilate the upper part of the house; the dimensions of the funnel were quadrupled before it was enough to prevent the bad air accumulating and spreading over the ceiling. Chandeliers very powerful ventilators, and if well managed, supply the place of a warm-air chamber, which witness considers essential to good ventilation. Cannot accurately measure and correct vitiation of the House of Commons' atmosphere by supplying any element of which it is deprived. Air may be too hot, too cold, too moist, or too dry, and no chemically appreciable difference in its oxygen or nitrogen; trifling causes make the air agreeable or disagreeable. Not advisable to practice any chemical means of repairing or purifying the air. Thinks there are sufficient data, without experiments, for the new Houses, provided architects will consider the necessary arrangements previously, which they commonly disregard. Could not in five minutes change the temperature ten degrees of a house containing 300 to 600 persons. Air-chamber best mode; and to be supplied both from the stove, and directly from the external air. Prefers an air-stove, as simpler than steam or hot water. No burnt smell or excessive dryness from proper stoves; overheated air disagreeable from the burnt dust; difficult breathing occasioned by over dryness, and is corrected by vapour of water. Air not apt to over dry when many persons assemble, or lights are numerous. Is unable to answer from memory, or with useful precision, any experiment showing what surface of iron pipe, heated regularly to

212 degrees, will raise a quantity of air any number of degrees (Fahrenheit) passing at a given rate. Knows mode of heating air blowing through pipes on a cockle in contact with fire, and that a boiler may be substituted for the cockle. Thinks that air might be freed from soot and dust, by passing it through a wire gauze diaphragm, better than by its settling in a chamber. Witness would use a chamber as a reservoir between stoves and house, where the air *in transitu* could be examined, and hot or cold introduced to any temperature required. Does not agree in necessity of a chamber for the air to settle, nor by letting in steam, and condensing it, to get rid of the smoke. Generally, a room is imperfectly ventilated (as regards vitiation) if excess of carbonic acid be discoverable by chemistry. To reduce that to practice, what number of cubic feet of fresh air would you let into a room, in a given time, containing 100 persons, taking into consideration the lighting? I believe the quantity which would practically be found requisite to the comfort and convenience of the persons assembled would be in some great proportion above that which is theoretically required, or which is deduced from a calculation founded upon the quantity of air deteriorated by respiration and combustion. An individual may indeed be said to spoil a quantity of air, equal to that taken into his lungs at each inspiration, which amounts to about from fifteen to twenty cubic inches: I have at least found that, after emptying the lungs by a forced expiration, the expired air will generally extinguish a candle; and in that condition, though it might be safely breathed a second time, I should, for all practical purposes, pronounce it spoiled. In this view of the question, therefore, each individual may be said to spoil about eighteen cubic inches of air at each respiration; and, assuming that the average number of times that we perform this function per minute is twenty, the bulk of air hourly deteriorated would amount to 21,000 cubic inches for each person, or to 518,000 cubic inches=3600 cubic feet in the course of the twenty-four hours. The quantity of carbonic acid contained in the expired air varies at different times; but

I presume a fair average to be four per cent. The quantity of air deteriorated in any given time by combustion, as by the flames of gas, oil, wax, and tallow, is not very readily estimated, inasmuch as it is difficult to say what abstraction of oxygen, or addition of carbonic acid, may be considered as actually deteriorating the air, or rendering it absolutely unfit for respiration; but I have already observed that air differing very slightly from the general mass of the atmosphere, must, for almost all practical purposes, be so considered, and, consequently, that the requisite change of air in a well ventilated room must of necessity exceed any calculation founded upon the quantity of air rendered absolutely noxious either by respiration or flames. But, to give the Committee some general ideas on this subject, I may state that all the common combustibles consist essentially of carbon and hydrogen; and that one pound of carbon or charcoal, in burning, consumes two $\frac{6}{10}$ pounds of oxygen, which is that contained in between thirteen and fourteen pounds of atmospheric air; and one pound of hydrogen consumes eight pounds of oxygen, which is that contained in about forty pounds of atmospheric air. Now, tallow, wax, and oil, contain upon the average from seventy-seven to eighty per cent of charcoal, and from eleven to fourteen per cent of hydrogen; the remainder being oxygen; and 100 cubical feet of air weigh about 112 ounces avoirdupois, or seven pounds; so that from these data the approximate consumption of oxygen, by any given quantity of the above combustibles, is easily calculated; and as the atmosphere essentially consists of a mixture of four parts of nitrogen, with one of oxygen, the quantity of atmospheric air which may be said to be consumed, will be five times that of pure oxygen. The composition of coal-gas varies considerably, and consequently also its deteriorating quality; but I assume that it generally spoils thrice its bulk of oxygen, or fifteen times that of air.

David Boswell Reid, M. D., F.R.S.E., President of the Philosophical Society of Edinburgh,

Is a physician, and lecturer on chemistry. Has paid considerable attention to ventilating, warming, and acoustics in buildings, particularly ventilating large buildings, as 2000 experiments per hour are sometimes performed in his class-room; and unless every thing done with precision, students must retire from the disengaged fumes. Finds it essential to have an unlimited power perfectly under control, to carry off fumes. The mode is simply an artificial current determined by a column of heated air. A large furnace is kindled, and into its vent an aperture made from the room to be ventilated. The apparatus is on the floor, a few feet above it. Plays into a large vent. Artificial current into the vent is set in motion from any aperture made in it, fresh air entering at a different place to supply exit of heated air. Ventilating and warming-apparatus quite distinct, and would facilitate practical application to keep them so; additional expense is only a few shillings per diem for coke for ventilating furnace. The furnace had better not be in the House of Commons. In his class-room, this fire is used for experiments also: its position is of little consequence, except that witness wishes the air to feed furnace-fire, also to be drawn from house. If furnace be over house, it might create a little draught: the power of the furnace is by light air rising from its fire. Sometimes air warmer without the house than within; and currents might be reversed, if it were not for the heat of specific combustion. A tube from the house to the vent is the only essential for ventilation. So much, it is well known, has lately been done with warming by steam and water, witness has nothing peculiar to offer. Prefers air taken above ground-level, if situation be damp; has no local knowledge, and just come to London: if new House be in an open area very high level unnecessary; but if surrounded by buildings, air should be above chimney-pots; if open to winds and atmosphere, preferable. Ventilating apertures should be always ready for action, but not worked till wanted, or in ratio required ; bad air should not accumulate so as to need great power of the apparatus ; general and equal flow of air best ; not begin till Members begin to enter. In many buildings, entrance and exit apertures not enough, and induce cross draughts from windows. Great attention should be paid to their position, but never ventilate by doors and windows, which produce cross draughts, and some Members have no fresh air. Would wish all the establishment to have the same ventilating apparatus—one great vent, with a valve to each room. General difficulty has been, inadequate provision. Heated air is free from objections of mechanical ventilators, and gives power of introducing cold air when necessary, whose temperature may be lessened in hot weather, and give great relief. Arrangements for warm air in winter, and cool in summer, necessary. Architects and ventilators should work together, and even as to lights (artificial), which should have tubes, to carry away their bad air. His class-room eighty feet square ; (seats for 300) made for students experimenting ; holds 1000 total. It is divided into two by furnaces, rising several feet above the floor. Roof entirely supported on chimneys ; has about 100 furnaces ; and can all operate at same moment. His principle of ventilating universally efficacious, and adopted in other establishments, and has been carried on for years in noxious manufactures. Students vary in number from 100 to 400 in six or eight hours per day. Increases or diminishes exit and entry for air at pleasure, by turning a plug ; regulates by personal feelings ; by a thermometer better. Ventilation is put in action by heating furnaces, and regulated according to species of operations ; ventilation continued, though numbers go away. Doubts if it could be self-regulated ; generally, failures are from attempting too much. Variety of circumstances requires a regulating attendant and a thermometer to guide him ; and a check-thermometer open to inspection of Members of Parliament. Can work to any extent in five minutes ; one small power equal to work numerous ventilators. Prefers both Houses under one apparatus; but if flues extremely long, perhaps more economical to have two; but must adjust according to circumstances and plan of building, rapidity of current, height of chimney, number of people: has seen tubes conduct ventilation hundreds of feet. Ventilating tube not an inconvenient size; every thing depends on architect's primary arrangement; must be seen from the first, and not added. Flues do not interfere with building; may be underground. Air carried down as easily as up; movements induced by rarefied air easier carried up than down; if conveyed down, more liable to mismanagement from reverse current, but anticipates no danger of accidents. Prefers fresh air to be taken from one aperture, and admitted to house by a great many, and divided by tubes as much as possible; most effectual to temper air before admitted, and a little above floor, rather on or under floor; for if admitted through 10,000 little apertures, still Members might feel cold air unpleasant in frost, if admitted direct from exterior, and would mix with respired air, if not first tempered; but if previously tempered and introduced over body of floor, and a thorough ventilation, all respired air would be carried away, and sedative effect, head-ache, &c., often accompanying anxious attention, obviated. Would depend on apparatus used, whether, if air were admitted above level of floor, there was a stratum of cold air on it. Has considered effect of dry and moist air on the skin. Draught depends on temperature of air and rapidity with which it blows; generally termed a "current;" if of high temperature and proper degree of moisture, might be pleasant; and if colder, unpleasant, or produce evils. More important to divide current of hot air, because latter falls down and diffuses itself naturally; but hot air, introduced at one place, rises in a stream to the top without benefiting any one. Great sums thrown away in some buildings. Has seen, at twenty or thirty feet from floor, a stratum of air above boiling-water temperature, while below air was disagreeably cold. In admitting warm air, admissions should be as numerous and widely-distributed as possible. As respects heated air and radiant heat; when heated air is supplied in currents, it must be conducted; but if by stoves, heated by steam in various part of the buildings, or surfaces of iron heated by water or otherwise, may make a difference; unequal currents are an objection to stoves and plates, and return of respired air in a descending stream. In all lofty rooms, impossible to have sweet and fresh atmosphere, so easily commanded in less elevated apartment, when a stream of air rises slowly, but continually, from floor to top of inclined roof, to be there removed by ventilation. A lofty room generally preferred, because mass of air requires more time to be contaminated; but same cause renders it difficult to renew vitiated air. Velocity of air should not depend on its gravity; all should be under precise control; hot supply changed for cold, *vice versa,* or entirely cut off, at a moment's notice. A person in another room, by turning a handle, might open or close valves; but all under some general control, to insure harmony of action.

Has considered Sound, in public buildings; was on Committee, and gave hints for great room for Earl Grey's dinner at Edinburgh; Mr. Hamilton, architect; was aware of principles; differed with respect to using canvass, which was required to display ornament; was adverse to it. No room more advantageous for sound; tried it with and without canvass; employed people to read and sing in it, to study its powers, and tried comparative power of canvass and wood. Consulted Hertz, Messrs. Murray and Findlay Dunn, celebrated musical men. Hertz said, "the sound was not sonorous;" it was beautifully clear and distinct. Music never heard in a room so beautifully clear and melodious; but had not the strength and power observed when canvass was pulled down, and the sound was strengthened by reflection from roof: beauty of music on a lake or still water is proverbial. Witness attributes it to the same cause—to the purity of tone, where there are no prolonged reverberations interrupting each succeeding note. An essential condition for good House of Parliament, as bringing Members nearest together, is a square form, in preference to a circular (which latter is ill-adapted for sound); in such a building, walls should be as low as possible, and arranged so that no sound can be reflected repeatedly from one to the other; roof as low as possible, consistent with size of building; so that direct voice of speaker may be strengthened by reflection from roof; and lastly, having been strengthened by this single reflection, all further continuance of sound ought to be destroyed by throwing it on an absorbing surface, as an irregular and matted form: from a number of experiments, found no difficulty in conversing in open air from 100 to 1000 feet distance. Sir John Ross, in the still and silent atmosphere of the Polar regions, found no difficulty in conversing a mile apart. Lieutenant Bowen conversed a mile, or upwards, across a frozen lake; and Mr. Parkin, Royal Marine Hospital, Woolwich, says, that at a place near top of hill at Cawsand Bay, frequently heard conversation and laugh of sailors on board frigates and vessels at anchor one or two miles distant; therefore, difficulty of communicating sound in public buildings must be attributed mostly, not so much to want of power in voice of speaker, as to the interruptions from prolonged reverberation and other causes. In some rooms, the sounding continued for five seconds after ceasing to speak; and no doubt it was continued longer, though we could not hear a distinct sound: every instant that one sound is continued, after a new sound has fallen on the ear, renders it less and less distinct. In searching for facts in geological works, I found, in a government despatch, that a volcano has been heard 900 miles distant, and sound of cannon 300 miles, by Captain Stoddart, in the Baltic, and by the nearest vessels most distinctly; the sea not rough at the time; a gentle inclination of wind favored its transmission. Witness attributes facility of sound in high latitudes to a peculiar state of atmosphere, its perfect silence, and freedom from any agitation. Currents of winds assist. Knows of a powerful military band heard twenty miles off. Oars of a small boat, under favorable circumstances, heard many miles off. Witness recommends form of ceiling to be inclined, and meet in a point, as his class-room, both for ventilation and hearing. Same ceiling that allows heated air to collect at top will most broadly throw pulses of sound across greater portion of audience; object being to diffuse it equally over whole house; a broad reflective surface most conducive to it. "Question 461. But in that form, the person speaking from near the wall would be better heard than if he were speaking in the centre?—That may be; but it seems that in every part of a room constructed on that principle, whether the person speaking be in sight or out of sight; whether one or two be in the room, or several hundreds; there is no difficulty either in hearing, or in distinctness of articulation. Many rooms will produce a more loud and sounding noise; perhaps they will be better for the *premier coup-d'orchestre* in a concert room; but if it is distinctness of articulation that is wanted, or to experience melody in its purest form, strengthened however by a certain reflection from the roof, that is the form I would recommend. The difference between distinctness and purity of intonation, however low the tone may be, and confused and noisy sound that is produced in some rooms, has been very little attended to practically in the construction of buildings, and still less the effect of reflection upon the voice of the person speaking. Where, from any particular cause, many reflected sounds strike upon his mouth, it is impossible for him to articulate distinctly, however articulate under other circumstances his enunciation may be; a physical cause opposes the free action of the muscles that regulate those movements by which speech is produced; and any one who studies the subject practically, till experience makes him familiar with it, will acknowledge the great difference in the sensation produced upon the mouth, when he speaks in a well constructed room, and then in the focus of a large parabolic reflector—for example, opposed to a powerfully reflecting wall.

"Of what material would you propose to construct an interior? I would propose that it should be constructed of wood, and that it should, as far as possible, resemble the sounding-board of a piano-forte. In experiments in the open air, when we were in a valley, and the situation peculiar, I have repeatedly spoken to individuals 200 feet distant from me, when they did not hear a word, if they were in the line of the valley, so that there was a great hollow extending indefinitely behind them; while others, who were still more distant than they, at twice or three times the distance, but who happened to be at one of the sides, heard distinctly every word, without the slightest effort.

"Then they heard reflected sounds? They heard the primary united with the reflected sound; they were so close to the reflecting surface, the primary sound no sooner came to them, than the reflecting sound came up and strengthened the primary impression; so in the same manner the roof should be so near the Members, that the voice of the person speaking should be strengthened by the reflection. If we admit a certain height for ornament and ventilation, let that be as low as possible, and the more equal will be the communication of sound, in my opinion, not only from theory, but from direct experience in my own class-room and other buildings.—What is the height of your own class-room? The walls are nine feet high, and the roof is between twenty-three and twenty-five feet high in the centre.—It seems to follow, from what you have said, that you would recommend the Houses of Parliament to be without galleries?—I should strongly recommend they should be without a projecting gallery; but a retreating gallery would not be very disadvantageous.—You would have no place for a retiring gallery with so low a wall?—The retiring gallery should be made immediately behind a series of pillars, as will be shown by the annexed plan.

"With reference to the position of the Speaker of the House of Commons, would you propose to adapt what is called the Speaker's chair to the favorable transmission of sound, or trust entirely to the room itself?—I should have no hesitation in saying, I would trust entirely to the room itself, were it constructed on these principles. At the same time, if it was fixed that the Speaker's chair should have a place near the wall, which I presume may very probably be the case, it would be almost unnecessary to do any thing for the communication of the sound ; as, if that were made a good reflecting surface, and inclined in such a manner that no reflection were kept up between wall and wall, he would require no peculiar arrangement, either to hear or to be heard, without any effort, in any part of the room.

"In that case, the Speaker would always be directing his voice, in point of fact, towards an absorbing surface; for the Strangers' gallery must be opposite to him, and not in the side of the roof?—He would, under those circumstances; but at the same time the sound would be reflected, from the roof spreading from the situation in which he was placed on either side; the roof inclining on either side of the Speaker.

"Would you explain upon what principle you have a preference for a square to a circular form?—On this principle: whenever there are any concave surfaces, it is the same, generally speaking, with sound as with light; that is, from the angle which the sound makes as it falls upon the surface, it is necessarily collected into foci; and in circular rooms there are, accordingly, more or less points where the sound is heard with greater power, while it is comparatively deficient in other places. The object in the House of Commons being an equal transmission of sound, that is the reason why I give a preference to a flat surface.

"If you were understood rightly, you would depend principally on the ceiling for the reflection of the sound; and you propose to have walls of an absorbing surface?—The part of the walls that are brought more immediately into play would be so extremely low, and converted at the same time into a kind of gallery, that perhaps, with the exception of that part where the Speaker may be placed, they could scarcely be said to have any of the properties of ordinary walls in reflecting sound.

"By adopting the circular form, you would bring the Members closer together; and therefore, in that point of view, they will be able to make each other heard more easily?—I am not aware that the advantage gained in this respect would in any way balance the difficulties that would present themselves from the collection of sound in foci; and even, whatever materials are used, it is perhaps impossible to have a surface that is absolutely non-reflecting: it is more or less reflecting, merely in comparison; for even the very canvass we at times put up to destroy the reflecting power, which may predominate in some particular buildings, has been known in other cases, when stretched, as in the sails of a ship, to collect pulses of sound from bells that have been ringing 100 miles distant, and rendering them observable.—As to the position of the seats, have you any idea whether it is convenient, or not, for the transmission of the sound, that they should be raised one above another?—As the floor is considered to be an absorbing surface, on the principles I have alluded to, I should imagine that if they were elevated one above another, so as to allow the Speaker to see the Members distinctly, and Members to see one another, it would facilitate the communication of sound, and the perfect absorption of the reflected sound. In fact, the elevation of the back seats would tend to diminish practically, so far as sound went, the height of the walls?—Yes.—And to diminish the inconvenience of the circular form?—Yes: at the same time, it being admitted, that the power of sound is proportional to the intensity of the mechanical impulse made, the area through which it is to diffuse itself, and the manner in which it is strengthened by the reflection from the walls;—every space, every superfluous space, that can be cut off without interfering with the principles above alluded to, or rather with their applications, will be a gain to the Members in facilitating the communication of sound.

"As to the openings in the roof and walls, for light and air, should you propose to arrange them according to any past experience you have had?—I should consider that an object of very great importance. The first thing that led me to direct my attention to this subject was what occurred in a church, where it was almost impossible to hear the preacher, in consequence of the prolonged reverberation. After spending some little time in it, I left it, and was surprised, when I was totally out of sight of the preacher, to find that I heard every word distinctly. On examining into the circumstance, I could only attribute it to this cause:—viz., that the direct voice of the speaker was perfectly sufficient to be audible in every part of the building; but that, at those particular openings into the passage, it alone had come out, and there affected my ear alone; whereas, in the interior of the building, I not only heard the direct voice of the speaker, but also the confused noise produced by all the prolonged reverberation of preceding words. If, then, from one or two apertures alone such a body of sound can escape, as will render the Speaker's voice distinctly audible in separate apartments, we are entitled to infer, that if that portion be prevented from escaping, it would tend much to add to the power of the Speaker's voice within the House. Further, not only will the loss of sound be prevented, but also the entrance of all discordant sounds from without. In every large city there is a continual hum; and the noise of people walking in the street, of bells, of horses, of coaches, and the like, though on every occasion they may not be distinctly audible, still produces a certain amount of sound, which detracts from the purity of intonation. If, then, the loss be prevented on the one hand, and the entrance of discordant sounds on the other, there will be much added to the power of the room in communicating sound. In those rooms where I have seen all those openings arranged in such a manner, that while air was permitted freely to enter or to escape, yet the sound had to be reflected two or three times in passages, so that it was lost, as it were, and could not produce any specific effect if entering from without, or reflected back into the room if formed within, the intonation was more powerful and more distinct than when that was not attended to.

" Would you propose to light the new House of Commons entirely from the roof by means of a lantern?—I consider that many different plans might be adopted. I have generally preferred as equal a distribution of light as possible; so that I would regard it as more advantageous if there could be lights at many fixed places, than if there was one great and powerful central light radiating to every point of the room. A large window, with obscured glass, might be introduced at the gable, and a series of windows might also be placed in the interior roof, supplied through powerfully reflecting passages, connected with the exterior roof. Again at night, if on the pillars supporting the galleries, or between the different parts of the galleries, according to the plan laid before you, lamps were placed, then these would distribute the light very equally throughout the whole of the House, without being extremely painful or injurious to the eye at any particular point. I would further wish to mention, that whatever lamps are used at night, the bad effects arising from the combustion should be carried away by independent tubes to the ventilator.

"As to the lighting of the room by day, would you propose to do that by lanterns in the roof, or by side-lights?—I should prefer side-lights: there would not be any danger of interruption from heavy rains or hail, which occasionally makes such a very loud noise, even on a few panes of glass, as to interrupt the proceedings of an assembly. I should see no objection to having those arranged in the roof; but at the same time they might be formed in such a manner, that the light might be taken from the side, by making a projecting window, raised upon the exterior of the outer roof, in the same manner as many garret or storm windows, and not in the form of the common skylight.—You would not apprehend any interruption to its perfect operation by those breaks in it? —Those breaks might be arranged so as not to interfere with the effect of the roof to any great extent; for if there was a double window, then the glass would there supply the place of the boards."

Considers glass equally efficacious as wood for sound, and for reflecting sound. Prefers thick outer walls both for sound and temperature, as preventing disturbing causes. Prefers double roof: if only one roof, impossible to prevent heat in summer, or noise of hail and rain. To spare expense, has no double roof in his class-room. Would light outer roof with garret-shaped windows, and let in light from loft to interior by glass openings. No difficulty in lighting, and more equally diffused. Considers ornament on roof desirable, and advantageous for sound. Considers cross partitions on roof advantageous for sound. On ground of this experiment, "I made an impulse in water in a particular direction: instead of impulse extending throughout the whole of the water, as it is generally believed to do, a wave was made to roll along upon a particular surface, while the rest of the water was quiet and still: this I believe to take place to a certain extent in communication of sound: if the voice, for instance, be directed on an extremely plain surface, at a particular angle, we know that we can speak to people at a great distance if we both go nearer the side of a wall; now, if so much of the sound were to fall on the roof at this particular angle, my opinion is, it would run along the roof a considerable way, before any amount of it would be reflected on the ground: whereas, if surface be broken by cross-beams (or pilasters if on a wall), there is always a reflection at each part to the ground below." In a railroad (smooth-walled) tunnel, persons could not hear each other at a distance, until pilasters were put along the walls, when they could hear in any direction distinctly and easily. To a certain extent, they would effect progress of sound, but on the whole, diffusion more equal with pilasters. Ornaments may be admitted as much as desired; but let applications be made according to peculiar building adopted for House of Commons. So long as you bring up a reflecting power to act upon the air, while direct voice of Speaker is still sounding there, so long you strengthen voice of Speaker. I found every thing on this—that "The human voice of itself, when it does not meet with interruption, is sufficient to fill the most ample assembly that ever has been made, provided that there be no noise from extraneous sources; that you may dispense entirely with additional power of reflection, and have the walls crowded with ornaments, but taking care there is a perfect power of absorption, so that the audience hear solely by the direct voice of the Speaker; and in ninety-nine cases out of a hundred, if the room be moderately quiet, they will hear distinctly, but they will not hear that body of voice which they would have heard, had they also gained by reflection from the roof; and in a building such as the House of Commons, I consider it would not be desirable to take away this reflecting strength, which may be communicated to the voice. Performers on instruments, and singers, say, when they are in a room which has no reflecting power, that the sound escapes easily enough, but that they do not experience that resilient and sustaining power, which makes so many rooms so delightful to speak or sing in: those who pay much attention to the subject, feel the tone escaping easily from the mouth; but they do not feel the sound sustained and buoyed up, as it were, where there is too little reflection. In other rooms, where the reverberating power is so great, that it interferes with speaking, they are precisely in the reverse condition; when they sound a particular note, they feel there is something playing and working on the mouth, a mechanical power preventing the emission of the tone they wish to introduce: in some rooms, many of which I have been in, if any one stand in a particular position, the voice is returned to the focus if they are placed in it, and they feel as if some one was actually knocking them on the mouth. In one of the reflectors they use in a chapel, which I had been invited to examine, a preacher went up one day who had accidentally not been informed of its peculiarities: there was not only a focus for the emission, but also for the reception of sound; and when he had said two or three words, he suddenly turned round, believing some one was mocking him, but it was only the reflected sound of his own voice, which sounded loudly to him, but inaudible to any other person. In the adaptation of these parabolic reflectors, any part of the audience excluded from its influence hear as ill as the others hear well.

"You would not think it advisable to place the Speaker within a chair with a parabolic sounding-board ?—I should think it unnecessary with that construction of building ; and it would, to a certain extent, be liable to the objections mentioned.—Would it or would it not be desirable to maintain, as nearly as possible, a unity of atmosphere in the room, with reference to sound, quite apart from ventilation ?—I consider that one of the primary objects of attention ; but to what extent that does actually interfere with sound, I am at a loss to say : it is admitted on all hands, and it is known, that in an apartment, even a small apartment, we often have different strata of air ; and the sound, in passing from one to another, is much affected in the same manner as light : thus, when we look at any object on the wall, through a current of warm air, as when the sun is shining on any building, a current of warm air from a chimney being interposed between us and it, we see the tremulous motion of the air indicated by the unequal reflection of the light upon the wall ; so in the same manner I believe that, when sound passes through different strata of air, a similar disturbance is induced, but preventing it from being so clear and uniform as is desirable.

"Would you positively interdict the use of drapery,* particularly round about the windows or the cornices ?—I should not consider it necessary to interdict the use of drapery ; but whenever there was a powerful reflecting surface, and it was required to take advantage of that surface, then the drapery ought not to be used.

"You would not interdict drapery on the side-walls ; but you would from the windows above ?—From the roof, or from whatever part we wish a reflecting power.

"As to the smaller rooms connected with the House of Commons, you would scarcely propose to alter the ordinary ceil-

* Drapery is used in the Houses of the United States Congress.

ing perhaps ?—It would not be so necessary as in the larger apartment for the meeting of the House; but the same remarks, it must be remembered, apply to both. There is a great harshness and indistinctness often communicated to the voice, even in small rooms; and it is remarkable how sensitive some people are to the manner in which sound affects them. I have been in some rooms where it was impossible to converse even with a moderate party, unless with a considerable effort, from the power of reverberation. I have been in rooms where there were alcoves at one end; and whenever any individual happened to sing in a particular position, it made a great difference in the voice; and on trying it experimentally, a number of persons going to a distance, and shutting their eyes, while one individual, trying the experiment, walked across the room while speaking, I have seen the others raise their hands whenever he came to a particular part, indicating the change which they all perceived. The power of the voice may perhaps be such, as not to make it a matter of great consequence in these small rooms; but yet there is a very great difference in the unity and pleasantness in the tone of voice in different rooms, according to the form. I may state, with reference to the same subject, there is a room not larger than some of the Committee-rooms may be, in which it was found almost impossible to carry on a school, from the amount of reverberation; and when any individual sounded any note in a prolonged voice, it was quite like the sound of a trumpet, it was continued so long after he had ceased: that room was about forty-eight feet long, twenty or thirty broad, and sixteen high; the roof was arched, but the curve was not great. It was improved very much by suspending curtains and drapery from the cornice.

" Have you ever accurately examined the present House of Commons ?—I have been in it on several successive occasions; but since I came here, I have been one day at one Committee, and the next day at another; and having been up several nights before I arrived, I have not had an opportunity of examining it so minutely as I would wish.

"Do you think you have examined it sufficiently to be able to state that some alteration might be made at a small expense, with a view to improve the communication of sound?—Yes; I have no hesitation in stating that; at the same time, if I were asked to enter into detail on this, I should like a little further opportunity of examining the House during the debates."

Has inspected present Houses of Parliament. Considerable advantage would be gained by matting the floor; by double doors at the entrance; by a less noisy lock; by lowering the roof to base of present windows, and inclining it to meet in a ridge at the centre. Thin wooden boards give more body to the voice than canvass; Members would hear better, and voices be sustained at proper pitch with less effort; under side of galleries to be similarly boarded, and parallel inclination. Incline to commence about seven feet above gallery, and terminate near present roof; unless lowered considerably, no great advantage gained. Angle to be from 20° to 30°.

Other disadvantages are, large openings for ventilation; noise of bells ringing; noises from street. If air introduced through passages, so as to undergo several reflections, much noise would thus be excluded. The rooms behind Speaker's chair, Reporters' and Strangers' galleries, tend to diminish power of sound within the House. Members easily heard there when doors open. If this sound were confined to the House, its power would be increased. The voice speaking is heard there sometimes alone, and the noise of House is not heard. In Reporters' gallery, interruption from chair of Speaker is very great, so that frequently no one could hear what was going on. Recess behind Reporters' seat takes away power of sound in House. If their seat and roof be lowered, would hear better. Another interruption to sound is the great body of air rising from middle of House, when heating apparatus is in action (when atmosphere is in perfectly equable state, sound is most distinctly audible); from this cause Members cannot hear on the opposite sides, or the

Speaker, persons at the bar. He sometimes hears persons at a distance better than when near, which witness attributes to the same cause. The matting might be made open enough to let air pass through. If air be admitted from without, and unprepared, it should enter from above rather than below, to temper its descent; but if from below, it should always be brought to a fixed temperature, and minutely subdivided and admitted from the floor and openings left in risers to steps of seats, or whole space under seats so used, or in matting for its ingress: witness has used Mauritius sugar-bags, rush, bass, &c. Air might flow in a pipe the whole length, under seats, and escape in numerous small quantities; and apertures should be distributed over whole floor of House, and currents avoided. In an equable and very low temperature in northern regions, no unpleasant sensation is felt when walking about; but directly there is any wind, it becomes dangerous, and almost insupportable. Accordingly, if air be properly tempered, from the slow and gradual manner in which it must rise, it is impossible so much heat can be abstracted from human body as to create inconvenience. A great velocity in air, at comfortable temperature, may be borne with pleasure and health; or even very low temperature, with extremely slow motion. If half of the passage-ways and floor were covered with perforated matting (excluding the table and benches), and the remainder used for tempered air inlets, covered with wire-cloth, it would be sufficient. Does not consider it advisable to pass air through matting, as the meshes might close up.

As to ventilating apparatus now used in House of Commons, Dr. Reid never examined it in action: it is constructed on the principle he recommends; viz., to induce a current by introducing heated atmosphere at one point. The side ventilators do not appear to be fully under control, and windows are often opened, and interfere with ventilation.

Mode of heating is very different from that of witness's: a current of air is induced in upper part by means of steam; that used by Dr. Reid was produced in a furnace, when advantage was taken of a longer column of heated air than can be commanded by this apparatus, and more intense heat produced by combustion. If steam cylinder be moved down nearer ceiling, it would be more powerful, and a much more active current would be produced; the greater the height to which column of heated air is carried, the greater the power. Ventilators are now counteracted by openings near roof, to let in fresh air. In the recent hot weather, those windows being kept open, diminished the effective circulation of air in House, unless a strong current rose from House and escaped by them. Preferable to obtain ventilating surface from below, and would obviate objections; these windows sometimes aid ventilators. Thinks ventilation would be improved if apparatus were extended, and windows kept closed, and tempered fresh air admitted from below. Time so completely occupied in attending the Houses and Committees, that witness is unable to submit more than a very rough sketch, illustrative of his principles of a House most favourable for Sound and Ventilation.

Sir Robert Smirke, R. A. &c.

Having heard Dr. Reid's evidence as to present House, considers no practical difficulty as regards construction in making such a ceiling, though it would require attention to adapt it well to its situation, and would cause material alterations in parts of house not immediately connected with the ceiling. The end behind Speaker's chair and the Strangers' gallery, in which great inconvenience would arise from seats being so near such a ceiling, it would require a room to be built expressly for such a plan. If sufficient ventilation, strangers in gallery might not suffer, but difficult to supply air enough, or in the same mode as for Members' seats. Form of roof would not facilitate transmission of air from Strangers' gallery, nor interfere with their ventilation. Difficulties arise from House itself, not from theory of the subject. Air might be sent up by pipes to the gallery. The width of House is thirty-eight feet, of Reporters' gallery twenty-one feet. A slanting ceiling might be made from base of present windows, all round, without altering the galleries. Thinks there would be great difficulty in present House, in giving Dr. Reid's principles a fair trial, and nature of building cause great expense. Not remembering all the evidence, cannot specify these difficulties precisely; wishes time for consideration. Causes of defective hearing in present House, stated by Dr. Reid, are; —want of matting; noise of Members passing; opening and shutting lobby-doors; its heavy lock and admission of external noise; height of house, and means of introducing air. Of these, the first is readily obviated: noise would be lessened by removal of large lock (fixed by express order), and noise of doors and external sounds lessened by adopting double doors, though at some inconvenience possibly to Members. As to lowering ceiling, cannot take the responsibility, and has great reluctance in offering an opinion; probably, want of light and direct communication with open air might be objectionable, and extremely difficult in present House to introduce pure or tempered air from vaults below, sufficiently without inconvenience to Members, in so low a room as this would then be. If it were done imperfectly in any way, it would be a very serious circumstance during a Session, and desirable to try it elsewhere. Air is now introduced in seventy-eight different places, but a difficulty in regulating temperature and velocity. Members often complain, and close all apertures within their reach. Suggests that any propositions of Dr. Reid should be directed by him, as those of Sir H. Davy and Marquis Chabaunes were by them; and witness will see that the work be properly done. Height of old House of Commons twenty-six and a half feet; from floor to sill of present House windows twenty-three and a half feet (as proposed roof of Dr. Reid), which, to make in parts and easily removable, would be difficult and expensive. Knows not where experiment could well be tried, but afraid of making trial in present House; but supposing present House so altered, witness does not know how proper ventilation could be given without inconvenience to Members, and present mode must be altered, now it is complained of, and would *then* be worse, as the current will be greater, or the numbers of apertures must be increased, and air must be *forced* in. It is extremely difficult to state the rate at which air can be taken in and out in case in point; but witness observed with an air-gauge, that present House was emptied of its air in forty minutes: if greater velocity, knows not how to prevent troublesome current, as windows are now occasionally used, and then would be *closed*. If air apertures be increased, supply would be increased: if Members would not close them, more may be made under seats and under floor, but not without inconveniencing Members. Members near apertures always complain unless air admitted be of such regulated temperature as not to be sensible to any of them. Some enter the House chilled; some heated. Witness knows not how air can be regulated so as to suit diverse feelings; but if all air supplied be of equal temperature, these objections would cease. Thinks the light would be less in present than in old House, with Dr. Reid's alterations. Knows not the comparative area of light in old House; a large body of light behind Speaker's chair (towards east); present windows are a great height from floor; if placed as in old House, would give more light. House seldom sits in the morning. Present windows could not be reduced without great part of proposed ceiling: Dr. Reid's were glazed; which would be kept clean with great difficulty. Objections so great that witness prefers a trial made any where but in the House. Cannot say where all things would be similar to House of Commons; a lantern on the high roof of House would give little light below, and incompatible with Dr. Reid's principles. Present windows are the old ones, but not best method of lighting House. Sir R. Smirke is not aware, from Dr. Reid's evidence, that alterations he proposes are founded on alterations proved to be successful in existing buildings.

Dr. Reid again called in.

Cannot state any buildings which have been altered under precise circumstances of House of Commons: but large rooms have been built on similar plan in most respects. One church in Edinburgh has been (and witness has heard beneficially,) altered; another in Glasgow now altering on similar evidence. In no building has Dr. Reid ever arranged the ventilation and arrangements for sound, at same time where alterations were required. Considering the immense annual expense of public buildings, if £2000 or £3000 were spent on a model House of Commons, in which experiments on principles of sound, ventilation, &c. might be tried, and afterwards used as a hall, lecture-room, church, &c., Committee would have confidence in recommending any plan deserving special attention: not that witness has the slightest doubt of his recommendations; but does not press this point.

THE END.

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