The ventilation of public buildings / by Robert Boyle.

THE VENTILATION OF PUBLIC BUILDINGS

"A People's Health is a Nation's Wealth."

—FRANKLIN.

"*Air is the prime supporter of life; health, even life itself, is dependent upon its purity.*"—PARKES.

"The two best preservatives of health are sunlight and fresh air."—PASTEUR.

COMPILED from Reports of Royal Commissions and Select Committees on Ventilation appointed by the Houses of Parliament, and from other authorities.

The Ventilation of Public Buildings

by

ROBERT BOYLE

"*Health is the soul of life.*"—DESCARTES.

ROBERT BOYLE & SON
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"Statistical inquiries on mortality prove beyond a doubt that of the causes of death which are usually in action, impurity of the air is the most important."—PARKES.

Foreword.

THE respective merits of natural and of artificial methods of ventilation may be said, perhaps, to have been definitely determined by the decisions obtained at the international ventilation tests carried out in London and in Paris, when natural ventilation, in each instance, was pronounced to be the most efficient.

The names of the eminent scientists, engineers, and medical men who made the tests are a sufficient guarantee of the value to be attached to their decisions, which have been confirmed by the reports of various Royal Commissions and Select Committees on ventilation appointed by the Houses of Parliament.

Lord Kelvin's experiments at Glasgow University endorse these findings, which have also been approved by well-known scientists such as Lord Rayleigh, Lord Lister, Sir William Crookes, and others, the results of whose investigations have led to the practical abandonment of mechanical ventilation in this country.

Though the balance of evidence may be in favour of natural ventilation, that method, clearly, also has its limitations; indeed, it would appear to be more than doubtful if any form of ventilation will ever be devised that will achieve "perfect" ventilation under all conditions, or that will satisfy all idiosyncrasies. R. B.

London, *June 1st*, 1923.

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"Anything which has passed through the human body ought to be treated as excreta and rejected; just as sewage is thrown away into the drains, so air that has passed through the human lungs should be got rid of at the earliest possible moment without allowing it to go through the lungs of someone else. It is as unreasonable to breathe the same air twice, or twelve or twenty times over, as is the case in many places, as it would be to go to the sewer for drinking water."

Volume of Air Supply.

"The commonly adopted basis of calculation of so many cubic feet of space in each room per person meant that the object aimed at was the slowing down to a standard time-rate of the vitiation of a stationary quantity of air. From this idea was derived that of supplying per hour between 30 and 200 times as much as was actually inhaled by the inmates of the room.

". . . . In order to keep down the percentage of pollution to a non-dangerous degree, under this system [mechanical] arises, therefore, the necessity of admitting for ventilation fresh air in quantities many times greater than that actually used [about twenty cubic feet per hour per person]. The true idea of perfect ventilation is evidently to supply and extract only a moderate excess, say five to ten times as much, over that actually used, and to do so in such a manner that (1) the exhalations do not mix with the fresh air supply, and (2) the inflow is properly diffused and does not pass direct to the outlets in merely local currents or draughts.

"Thus the only ideally perfect ventilation consists in a natural up-current from a level about that of the human head to the extraction outlets at the ceiling. Under this system the bulk of fresh air required to be admitted is immensely reduced."—PROFESSOR R. H. SMITH.

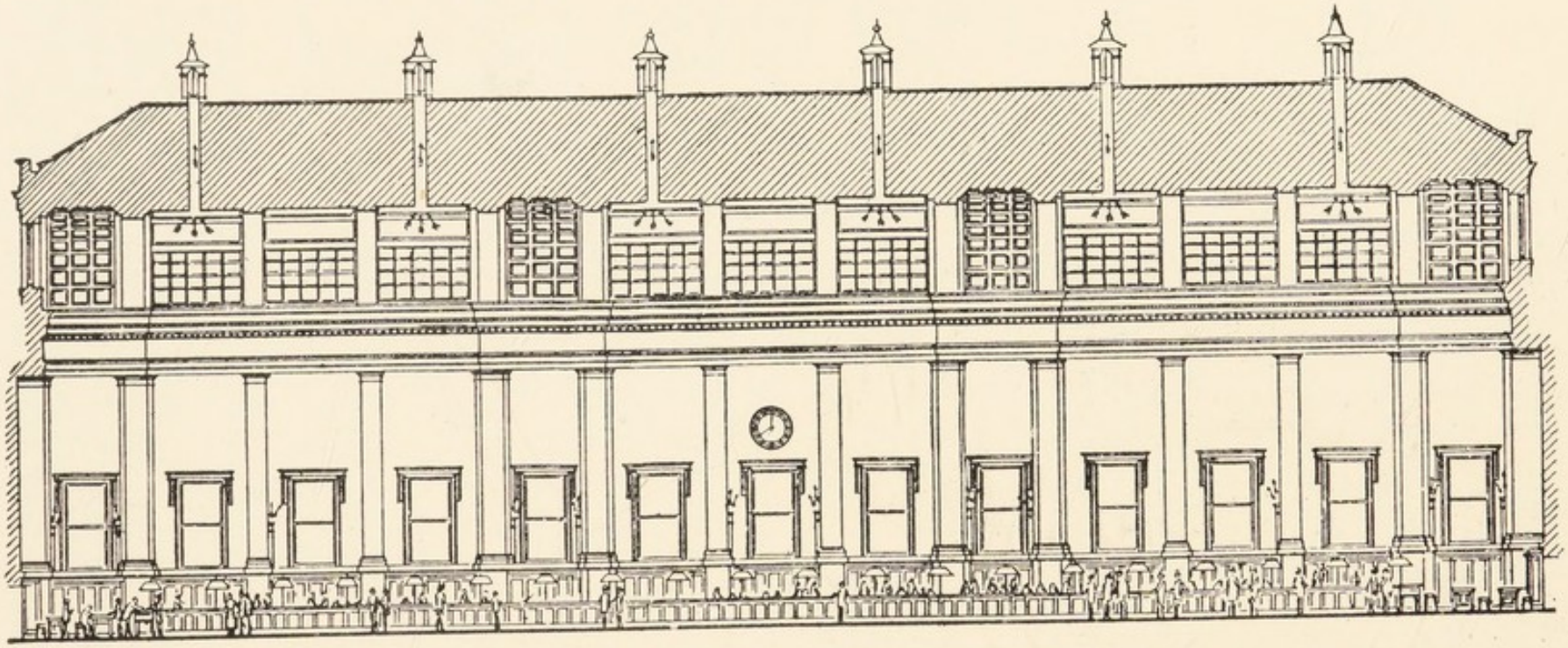
"Each individual in a room is a source of warmth to the air which surrounds him, and he does, as a matter of fact, distribute the air largely for himself. He warms the air that surrounds him; it rises above his head, and its place is supplied by cooler air from somewhere or other—he is himself a ventilating machine. I think it is an extremely satisfactory way of assisting the automatic distribution of air which the individuals themselves produce."—PROFESSOR SIR W. NAPIER SHAW, F.R.S. (*Director of the Meteorological Office*).

"As the warm air expands it ascends; as the warm air ascends the air around rushes in to fill its place. If the fresh air supply has free access, and the warm columns of air arising from the body and from the lungs are drawn off at the roof, to which they naturally ascend, 100 cubic feet of air per hour per person would be amply sufficient, and ideal ventilation would be achieved."—SIR DOUGLAS GALTON, F.R.S.

NATURAL SYSTEM OF VENTILATION

As applied to The LONG ROOM"—LONDON CUSTOM HOUSE.

under the direction of H.M. OFFICE OF WORKS



"I have conferred with the other members of the Long Room Ventilation Committee, and beg to state that we are unanimously of opinion that the Natural system of ventilation applied has been a success. I confidently assert that we have enjoyed, since the system has been in action, a purity and clearness of atmosphere to which we had long been strangers."—H. HANCOCK HOOPER, *Chairman*, Long Room Ventilation Committee.

"Clerks engaged in the room state that under the old arrangement (Artificial), before the day was half over, they suffered from severe headaches and general prostration, caused by the vitiated atmosphere; but that since the application of this Natural system of ventilation they feel almost as fresh when they leave in the evening as when they came in the morning, and the fact that they do not now suffer from headaches is certainly convincing proof of the efficiency of the ventilation."—Report on the Ventilation of the "Long Room."

Mechanical Ventilation
as applied at the
Houses of Parliament.

"Once more the periodical complaint about the bad ventilation of the House of Commons is the subject of discussion. This time Sir John Baird has promised that more elaborate scientific tests are to be made at the House of Commons, and inquiries are to be made about 'the psychological effect' on Members of Parliament. There are, however, to be no 'drastic alterations,' as to change the system completely would cost £40,000, so it is said, and the Office of Works has no money to spare. Tinkering with the inlets and outlets will, we venture to predict, be of little benefit."—*Building News*, March 23rd, 1923.

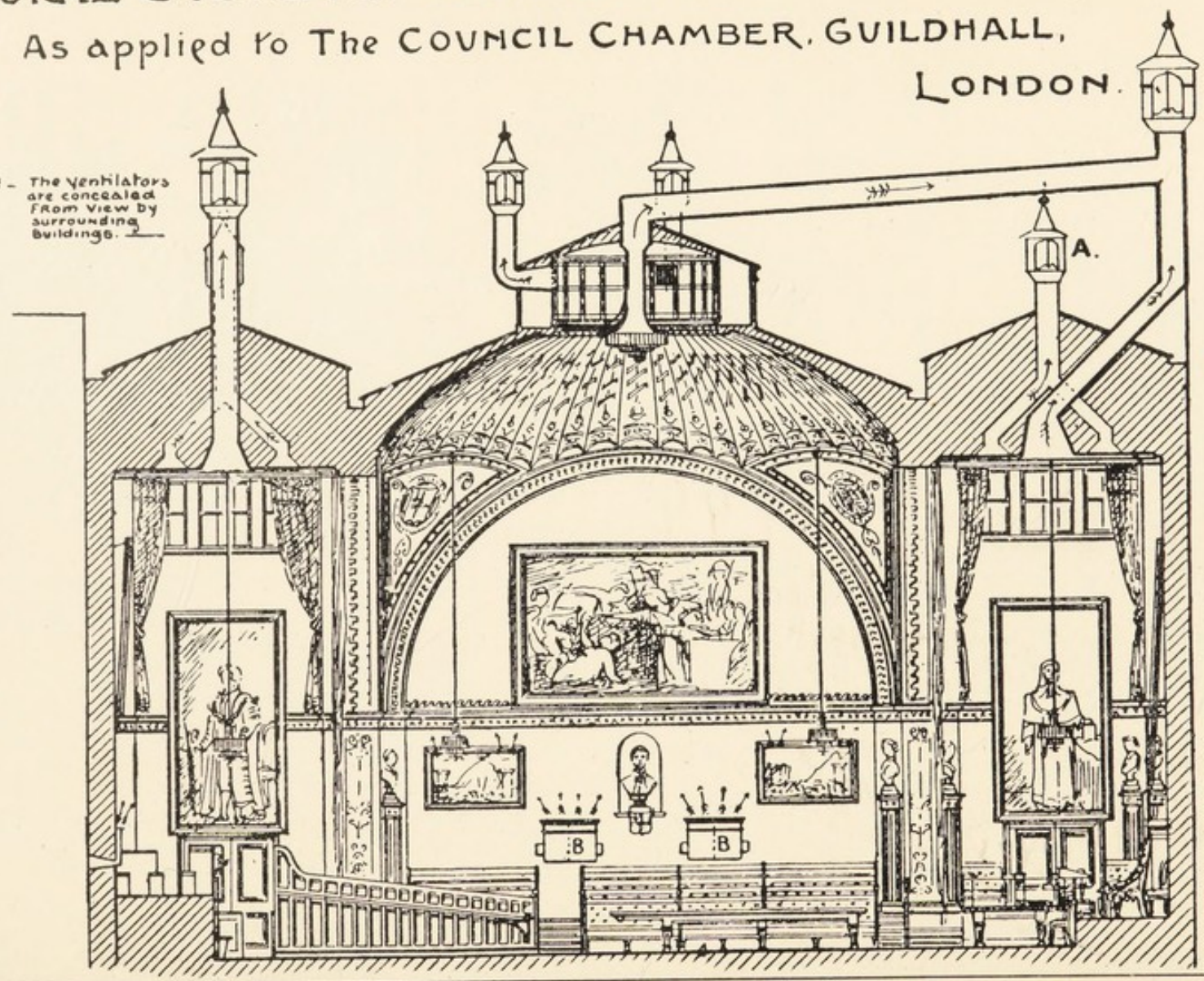
"It is the experience of many Members that the air of the Chamber lacks 'freshness,' and that there are some qualities possessed by it which lead to a stay for a length of time in the Chamber causing in the Members a lassitude and a feeling of heaviness which tend to interfere with the due performance of their duties."—*Select Committee on the Ventilation of the House of Commons.*

"When one considers the enormous volume of air, equal to ten times the cubic capacity of the House of Commons, which is passed through it every hour, and that the elaborate tables of air analysis are apparently all that can be desired, yet that the ventilation is so notoriously bad, it is clear that there is something very radically wrong with mechanical ventilation by impulsion, and that tables of analysis and of volumes of air passed through a building are not to be accepted as correctly indicating either the general purity of the air or the efficiency of the ventilation.

"I never yet knew of a system of propulsion that effected an efficient and satisfactory ventilation of any large building. . . . So long as architects employ this system, colossal buildings like the Houses of Parliament, the London Law Courts, the National Liberal Club, etc., will continue to be notoriously badly ventilated in every sense of the term."
—*Report on the Ventilation of the Houses of Parliament.*

NATURAL SYSTEM OF VENTILATION

As applied to The COUNCIL CHAMBER, GUILDHALL, LONDON.



"The ventilation at the Guildhall has proved completely successful, and satisfactorily fulfils the guarantee given in respect to the efficiency of the application of the system to the Council Chamber."—SIR HORACE JONES, *City Architect.* Report endorsed by the Guildhall Ventilation Committee.

Natural Ventilation

as applied at

The Guildhall, London.

"I am asked to state my personal experience of the recent ventilation of the Council Chamber. I can do so in very few words. Until the present year I never knew what it was to leave the Guildhall on a 'Common Council day' without a headache. I now do not know what a headache is. In fact, the alteration for the better in the atmosphere, even on crowded days, is obvious and very satisfactory, and it appears to me—a non-expert—that this system is eminently valuable and practicable."—Sir John Monckton, *Town Clerk.*

"It has long been notorious that, in spite of many attempts to remedy the evil, the Council Chamber at the Guildhall has been one of the worst ventilated halls in the metropolis.

"The natural system that has recently been introduced has, however, changed all that, and, after very severe tests, has received the approbation of all concerned.

"On the completion of the official tests, the City Architect has certified that all the conditions of the guarantee given, which were very stringent, have been fulfilled, and that the ventilation is completely successful.

"This report has been endorsed by the Ventilation Committee, and, in addition, the officials of the Court and many members of the Council have gratefully testified to the benefit they have derived from the application of the system. We also have much pleasure in adding our testimony to its success."—*Architect.*

"Being aware, from personal experience, of the bad state of the atmosphere which used to prevail on Court days, we are in a position to say that a marked improvement has been effected—so decided a change for the better, in fact, that we can quite endorse the favourable opinion of it which has been given by Sir John Monckton, the Town Clerk."—*Builder.*

Natural Ventilation.

"Nature's ventilation! a beneficent law! illimitable, and immutable!"—Sir William Crookes, F.R.S.

"I can testify to its efficiency."—Lord Kelvin.

"Three forces act in natural ventilation, viz., diffusion, wind, and the difference in weight of masses of air of unequal temperature."

"Incessant movement of the air is a law of Nature; we have only to allow the air in our cities and dwellings to take part in this constant change, and ventilation will go on uninterruptedly without our care. . . . In this country, and indeed in most countries, even comparative quiescence of the air for more than a few hours is scarcely known. Air is called 'still' when it is really moving 1 or 1½ miles an hour. Advantage therefore can be taken of this aspirating power of the wind to cause a movement of the air up a tube.

"In temperate climates natural ventilation is the best."—Parkes.

"Natural ventilation is certainly much to be preferred to any and every artificial system, no form of which can be made as efficient or nearly so pleasant and healthy in operation as the former.

"If the inlets and outlets be properly proportioned, the ordinary atmospheric pressure will carry on the ventilation quite efficiently, and the air will be kept fresh and comfortable by natural forces alone.

"This will be evident by reference to the natural laws of atmospheric pressure, and of the expansion of air by heat. The idea that the atmosphere cannot be caused to pass through a building automatically at a rate of emptying and replenishing every twenty minutes, by having sufficient and skilfully arranged openings at the bottom and top, is absurd to anyone familiar with dynamics."—Professor Hayward.

"There is no time throughout the whole year when there is not a sufficient movement in the atmosphere to secure effective ventilation."—Professor Macquorn Rankin.

"Acts in strict accordance with the laws of Nature, and cannot fail to operate."—Professor Grant.

Natural v. Artificial Ventilation.

"Having regard to the temperate character of the British climate, we have yet to be convinced that it is desirable or necessary to introduce artificial ventilation.

"At Guy's Hospital (new building) the artificial system can be compared with the natural system in the older wards, and the result of the comparison certainly does not make for the superiority of the former method."—Sir Henry Burdett.

"One need not go to England to search for means of comparison between the two systems (mechanical and natural), for the two hospitals in Paris where the mortality is greatest are precisely those in which artificial ventilation is employed."—Report on Hospital Hygiene by Dr. Le Fort, Paris.

"Ventilation can only be successfully accomplished at all times when it is effected without assistance from mechanical contrivances. However perfect these may appear, they can never achieve results superior to those insured by judicious and intelligent adaptation of natural means; and they necessarily suffer from the very serious disadvantage that they are liable to interruption without warning, and with possibly disastrous consequences."—Professor Wade, *Oxford University Lecturer on Hygiene.*

"I have inspected many mechanical systems of ventilation, including those at the Houses of Parliament and the Law Courts, but have never seen one that was approved by those who used it."—Dr. Fardon (*Chief Resident Physician, Middlesex Hospital*).

"The only safe and sound means for the supply of air is the natural one."—Surgeon-General Sir Thomas Crawford.

"Artificial methods are not to be recommended."—Professor de Chaumont.

"Experience would seem to justify the hesitation which has been felt with respect to artificial ventilation. It is far better to trust to the ventilation of nature—natural ventilation—than to the artificial pumping in of air."—Sir Douglas Galton, F.R.S.

"Mechanical ventilation was tried experimentally, under the direction of Lord Kelvin, at Glasgow University, but abandoned as 'inefficient and unhealthy,' and replaced by natural ventilation."—*Building News.*

Natural v. Artificial Ventilation.

"As a significant instance of the change that is taking place in ideas regarding the respective merits of artificial and of natural methods of ventilation, the results of the new Odessa Hospital competition are distinctly instructive, this hospital being one of the largest in Russia, if not in the world.

"As the efficient ventilation of the hospital was considered to be of the first importance, very special attention was given to the subject, the leading ventilating engineers in Europe and the United States being invited to submit plans. It is stated that thirty-four schemes in all were sent in, nineteen of which were from this country, four being American systems. All were mechanical with the exception of one, which was a natural system. The decision arrived at in respect to these plans was that a mechanical system should be adopted.

"It was resolved, however, that before selecting any particular plan from amongst the number submitted, a committee should be appointed, consisting of engineers, architects and others qualified to judge, to investigate the merits of the respective systems, as applied to buildings in different countries. This committee commenced its labours in Odessa, where several public buildings are mechanically ventilated. It seems that in none of the buildings inspected was the mechanical system found to be in operation, though of the latest construction, the committee being informed in each case that the ventilation was better and less objectionable without it, and that it had therefore been discontinued.

"The committee paid a visit to this country and made exhaustive investigations into the different systems in use here, including the natural system. Upon the completion of their investigations, the report of the committee was laid before the Municipality of Odessa, which had also received reports from other quarters, the result being that it was unanimously resolved that mechanical ventilation should *not* be employed, and that the natural system should be adopted.

"This is one of the largest ventilation installations in the world, and one of the most effective, having been pronounced, after rigorous tests, to be completely satisfactory in all respects. By comparison the ventilation problem of our Houses of Parliament appears insignificant."—*Building News.*

Upward v. Downward Ventilation.

"The relative merits of the upward and of the downward systems of ventilation may be estimated from the following considerations :—

"The direction of the currents of air from the human body is upwards, owing to the heat of the body. This current is an assistance to upward and an obstacle to downward ventilation. . . .

"With a downward current perfect ventilation would not be obtained, for this would only provide for the *dilution* of the impure air, while in perfect ventilation the impurities are not so diluted, but completely removed as fast as formed, so that no man can inspire any air which has shortly before been in his own lungs or in those of his neighbour.

"For these and other reasons the Board are of opinion that the upward method should be preferred."—*Report to United States Congress by Government Commission on Ventilation.*

"In downward ventilation the air breathed must, therefore, necessarily be that of the ascending currents of vitiated air reversed by and diluted in the descending mass of air used in the downward movement. In well-planned upward ventilation, the individual currents rise to the ceiling and there escape."—*Report to Congress on the ventilation of the Capitol, Washington, by* PROFESSOR S. HOMER WOODBRIDGE.

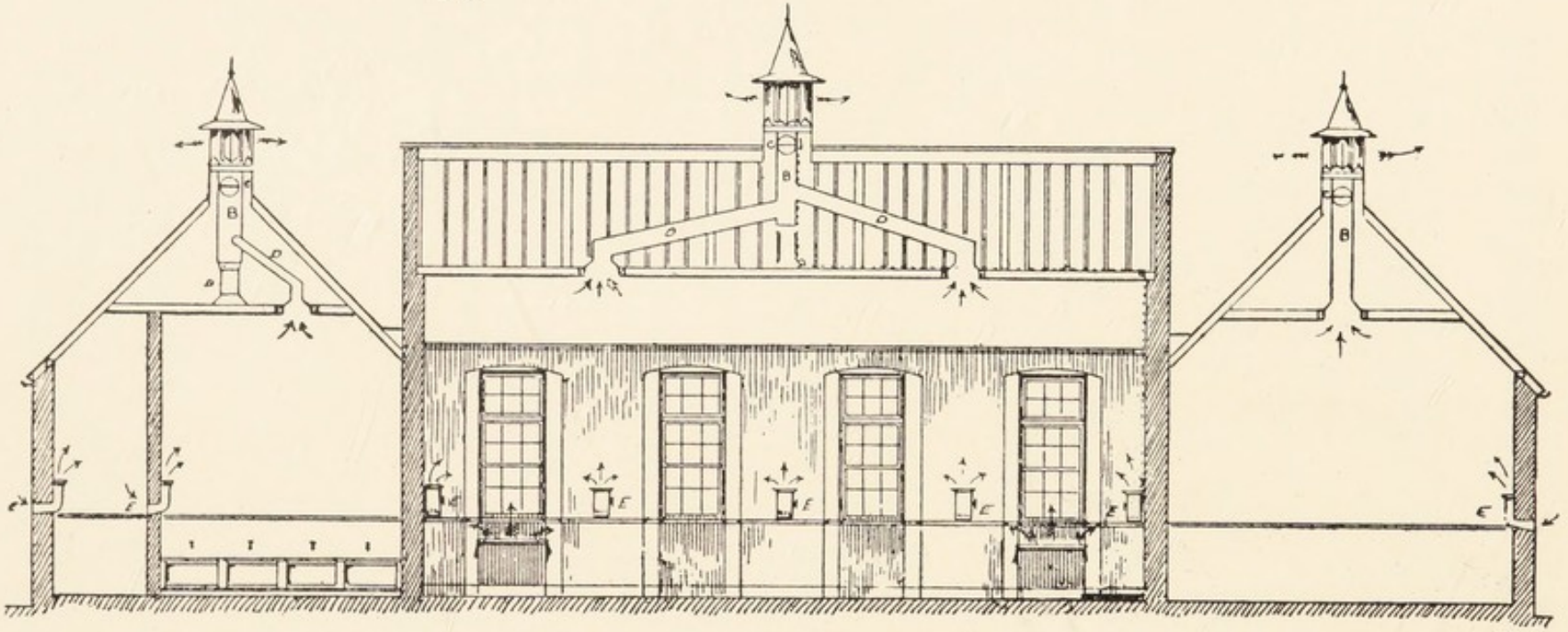
"The air is delivered by fan propulsion at the ceiling, and is taken out at the floor, giving a downward system of ventilation. . . . the air vitiated by respiration is brought back to be re-inhaled."—*Report on the ventilation of the Chamber of Deputies, Paris, by* M. EMIL TRÉLAT.

"For the ventilation of rooms, exits should be provided for the spent air near the ceiling. . . . The method of low ventilation (extraction near the floor) should be avoided on various grounds."—ROYAL COMMISSION ON VENTILATION (Blue Book).

"A descending current means mixing the used air with the fresh air, and bringing the mixture down to the floor and passing it over the members."—PROFESSOR SIR W. NAPIER SHAW, F.R.S., *Director of the Meteorological Office.*

NATURAL SYSTEM OF VENTILATION

As applied to a NATIONAL SCHOOL.



— LONGITUDINAL SECTION —

"This School was in a very insanitary condition, owing chiefly to defective ventilation. Various methods were tried to remedy the evil, with but partial success. A natural system was then given a trial, and there was an immediate change for the better. I am glad to say that this state of things has been maintained, and the School, instead of being one of the worst ventilated in the district, now ranks amongst the best. It seems little short of marvellous that so great a change should have been made at so little expenditure."—J. B. BAILEY, *Head Master*, National Schools, Maryport.

Fan Ventilation.

"You say that the chairman and other members of the committees have complained of the draughts caused by the fans?—I had in my mind one honourable Member in particular—the chairman in the police and sanitary committee-room stops the fan immediately he comes into the room."

"Complaints are made of noise and draught, and that the ventilation is by no means satisfactory.

". . . Improved regulations and arrangements required so as to obviate the great draughts sometimes experienced where the Members sit.

". . . General condemnation of the principle of extracting air from buildings by fans."—SELECT COMMITTEE ON THE VENTILATION OF THE HOUSE OF COMMONS.

"Draughts existed in every room ventilated mechanically by extraction fans, while the halls of such buildings were generally full of draughts."—*Paper on "Ventilation," read before the Society of Arts.*

With regard to the discomfort of electric fan ventilation, the following extract is suggestive, and would seem to confirm the complaints which have reached us from time to time with respect to that method of ventilation:—"The application of the electric fan has up to now done little more than substitute a through draught, the least tolerable of all discomforts to an Englishman. I could take you to a large smoke room in town where a fan is at work on one side of the room, where it is so draughty that no one will sit there. At the other side of the room it is suffocatingly hot, with no apparent movement of air."

"Mechanical ventilation is apparently not appreciated by the members of the Bristol City Council, where, according to the *Western Daily Press*, the city fathers have had to ask the Mayor's permission to wear their hats as a protection against the 'insufferable draughts' caused by the new electric extraction fans. One councillor pathetically pleaded to have the fans stopped, protesting that he 'would rather stifle than be killed by these terrible draughts.' If the choice is really between stifling and 'draughts,' the ventilation of the Bristol Council Chamber is a problem still unsolved."—*Building News.*

Warmed Air Supply.

Its Unhealthiness.

"The Committee received valuable evidence from Dr. Shaw as to the alleged enervating and other undesirable effects of air artificially warmed. . . . It is evident from what has been said above that the lack of 'freshness' in the air of the Chamber, which seems to be the cause of the feeling of lassitude produced by a lengthened stay there, appears to be always met with when air is supplied to a room by artificial means, and especially when it is heated. Those who know that system only, complain of the air being oppressive and giving rise to lassitude.

"Professor Shaw (Sir W. Napier Shaw, Director of the Meteorological Office):—One may suppose that possibly the lassitude or discomfort that arises in many cases from using artificially warmed air may be due to the effect of the heated surface producing actual deterioration of the air."—*Select Committee on the Ventilation of the House of Commons.*

"To warm the air supply artificially is to reduce its invigorating and wholesome qualities. . . ."

"If air was previously warmed, it would lose a portion of its oxygen, and if we got air short of oxygen, we had to breathe a greater number of times to supply the required amount, and that meant more effort."—PROFESSOR CORFIELD (late Professor of Hygiene and Public Health, University College, London).

"The temperature of the warmed air is raised beyond what is healthy for breathing."—SIR DOUGLAS GALTON, F.R.S.

"The premature loss by Americans of the freshness and bloom of youth may be attributed to the enervating effects of the warmed air systems of ventilation used in the United States, which are now being discarded for less pernicious methods."—DAVID GROVE (Eminent American Engineer).

"A most instructive historical fact is the abandonment in the States and in Canada of the warmed air system which was for so long popular."—PROFESSOR SMITH.

"Unhealthy, and a source of considerable physical discomfort."—*Report to United States Congress by Professor Homer Woodbridge.*

"An unhealthy, enervating, and costly process."—THOMAS BLASHILL, F.R.I.B.A. (late Architect to the London County Council).

Filtered Air Supply.

Its Danger.

"The Committee would like to know whether it is dangerous to filter air too free from non-pathogenic germs which may have the property of attacking and destroying the pathogenic germs when they come into contact?—Sir Michael Foster (Chairman of the Select Committee on Ventilation).—The removal of the pathogenic bacteria will take place *pari passu* with the non-pathogenic.

"There are very many qualities of air, in spite of our chemical knowledge, that we know little about at present?—Professor Shaw (Sir W. Napier Shaw, Director of the Meteorological Office)—That is perfectly true.

"And we may be altering these very considerably in our artificial apparatus?—Yes; that is a very serious consideration.

"Is it not better to avoid hyper-purification of the air which causes lassitude and oppressiveness?—If that is the result in the end, it would be.

" . . . Making every allowance for the play of prejudice, the testimony thus given does seem to the Committee to militate seriously against the system, and they cannot recommend that it should be adopted."—*Select Committee on the Ventilation of the House of Commons.*

"These health-giving qualities seem to be lacking in air pumped into a building, and to be present in methods of natural ventilation. The value of fresh, not filtered or pumped, air is obvious, and all recognise its exhilarating effects."—Dr. Christopher Childs.

"I have had considerable experience of screens for cooling and purifying the fresh air supply, but my experience is not in their favour.

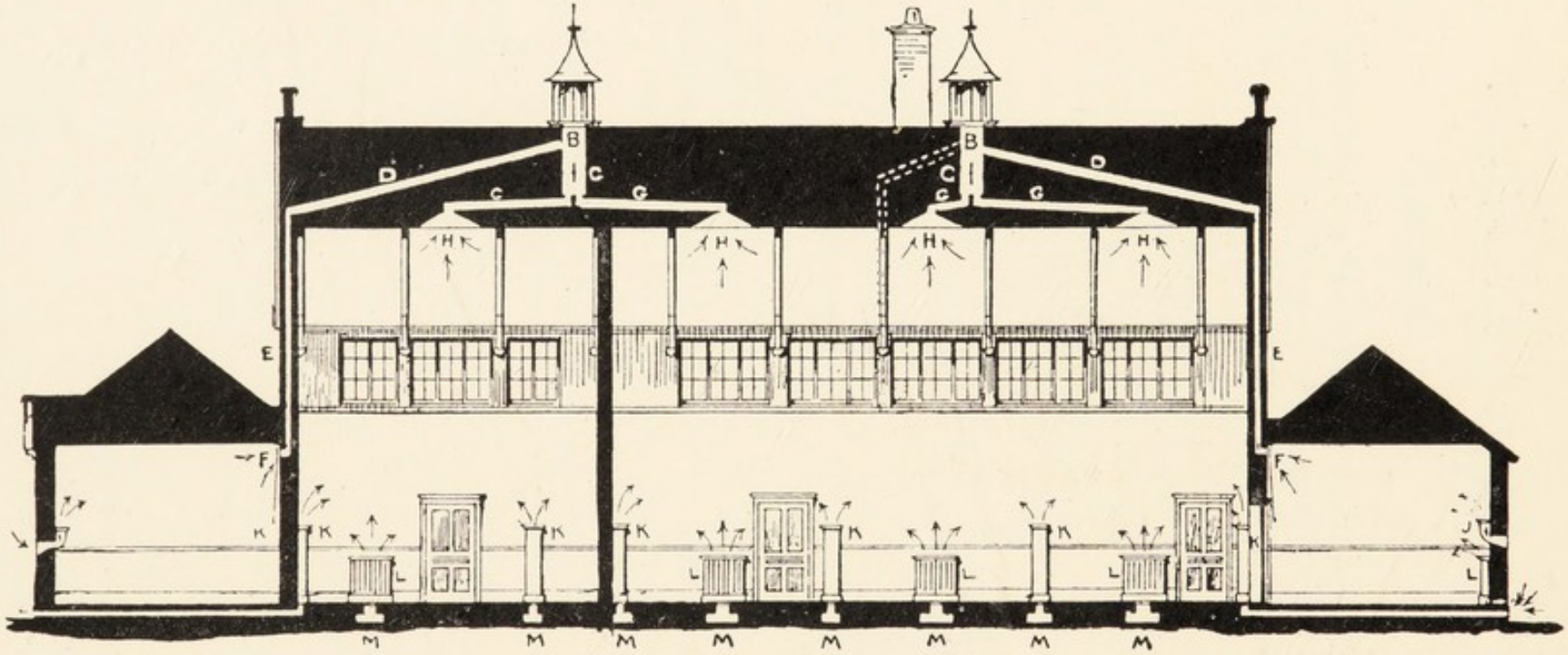
"They tend to devitalise the air, and to render it unfit for healthy respiration."—Surgeon-General Sir Thomas Crawford.

"Knowing its danger, people will not submit to cooled air being forced in upon them."—C. W. Mountford, F.R.I.B.A.

"The deleterious effects of washing and filtering the air supply are evidenced by the complaints made by the occupants of buildings so ventilated."—Sir Douglas Galton, F.R.S.

NATURAL SYSTEM OF VENTILATION

As applied to a SCHOOL with CENTRAL HALL



LONGITUDINAL SECTION

"The Natural system of ventilation has been most efficient. It was applied to these Schools a year ago, and has given perfect satisfaction. The rooms used to be unpleasantly stuffy, and H.M. Inspector and others complained of the vitiated atmosphere. Since the system has been introduced, the effect has been wonderful."—THOMAS CHAPMAN, *Head Master*, Beddington Central School, Croydon.

"Cross-Current" Ventilation

As Applied to Schools.

"When mechanical ventilation ceased to be employed in schools—apparently banned by the Board of Education—there was adopted in many schools a very primitive form of natural ventilation, consisting of adjustable openings in the upper parts of the windows, through which the wind entered and descended upon the unprotected bodies of the children underneath.

"Is it to be wondered at, that, subjected to such conditions, in cold weather, with a bitter 'nor'-easter' blowing, so many school-children should be laid up with colds and other more serious complaints caused by the icy downward currents from cross ventilation, which consists exclusively of a down-draught and a through-draught, no provision being made for the extraction of the vitiated air?

"Where there are openings in opposite windows, the evil is accentuated, owing to the increased through-draught. The descending currents of air also cool and precipitate the ascending vitiated air, returning it to be rebreathed. Nothing could be more unhealthy.

"A method of ventilation that consists of draughts, all draughts, and nothing but draughts, cannot but be detrimental to health and destructive of comfort.

"A high authority on the subject, Professor de Chaumont, says: 'Any form of ventilation that permits of a downward current of cold air is an unhealthy one, and a fruitful source of both physical and mental discomfort.' Royal Commissions on the ventilation of schools have specifically drawn attention to the manifold evils of this pernicious form of ventilation, and the Board of Education would undoubtedly be justified in restricting its use for classrooms.

"Glass hoppers in the *lower* parts of the windows may safely be used for the admission of air, where provision is made at the upper parts of the room for the effective extraction of the vitiated air, which naturally ascends to the higher levels from whence it should be withdrawn, and not returned by downward cross-currents to be rebreathed, as invariably happens when such provision is not made for its extraction."—*Unhealthy Schools.*

Authorities on
Natural Ventilation.

"Nature provides its own aeration, and with a lavish hand."—LORD RAYLEIGH.

"May be correctly described as an automatic aerial scavenger."—LORD LISTER.

"I can testify to its efficiency."—LORD KELVIN.

"Seems to be perfect."—LORD CLIFFORD.

"Natural ventilation certainly seems the proper plan."
—PARKES.

"Nature's ventilation is infinite."—HUXLEY.

"A perfect method of ventilation."—SIR B. W. RICHARDSON, F.R.S. (*Founder of the Royal Sanitary Institute*).

"A valuable aid in the prevention and cure of disease."—SIR JOHN MARSHALL (*ex-President of the Royal College of Surgeons*).

"Assures an automatic and continuous change of air."—SIR HENRY BURDETT, F.R.S.

"Most effective."—SIR JOHN FOWLER (*Engineer of the Forth Bridge*).

"The healthiest and most desirable system."—PROFESSOR CORFIELD, F.R.S. (*late Professor of Hygiene and Public Health, University College, London*).

"Effectively removes the vitiated air."—
SIR DOUGLAS GALTON, F.R.S.

"Highly efficient."—THE RIGHT HONOURABLE ACTON-SMEE AYRTON (*ex-First Commissioner of Works*).

"The best system of ventilation known to sanitary science."
—THE RIGHT HONOURABLE C. SEALE-HAYNE.

"One point worth noting was that doctors, for a wonder, did not differ in their recommendation of natural ventilation."—ADDISON HUTTON, *Architect* (U.S.A.).

Authorities on Mechanical Ventilation.

"Inefficient and unhealthy."—LORD KELVIN.

"Anything more pernicious I cannot imagine . . . Such a system is abominable."—DR ARMSTRONG (*Royal Commissioner on Ventilation*).

"Worse than a delusion . . . a positive danger to health."—*Royal Commission on Ventilation.*

"Not desirable."—SIR W. NAPIER SHAW, F.R.S., *Director of the Meteorological Office.*

"Unhealthy and a probable cause of much sickness."—SIR HENRY BURDETT, F.R.S.

"Experience would seem to justify the hesitation which has been felt with respect to mechanical ventilation."—SIR DOUGLAS GALTON, F.R.S.

"A dangerous fallacy; unhygienic; unscientific."—SIR EDWIN CHADWICK, F.R.S.

"Disastrous in practice. . . Not to be recommended."—PROFESSOR CORFIELD, F.R.S. (*late Professor of Hygiene and Public Health, University College, London*).

"'Plenum' ventilation is not wanted."—DR. LEONARD HILL, F.R.S. (*Professor of Hygiene and Public Health, University College, London*).

"A positive evil. The application of such a system is a mistake that may be followed by very grave consequences."—D. KEITH YOUNG, F.R.I.B.A.

"A huge mistake."—A. SAXON-SNELL, F.R.I.B.A.

"A menace to health."—ALFRED FRAMPTON, F.R.I.B.A.

"I am pleased to hear Mr. Young condemn mechanical systems, for I have never heard of one that was successful in action."—ALEXANDER GRAHAM, F.R.I.B.A.

"I endorse all that Mr. Young has said in condemnation of mechanical ventilation. Mechanical ventilating arrangements are generally utter failures."—P. GORDON SMITH, F.R.I.B.A. (*Architect to the Local Government Board*).

"Such a mode of changing the air is inimical to health."—*Report to Parliament by the Local Government Board.*

Instruments for Testing Ventilation.

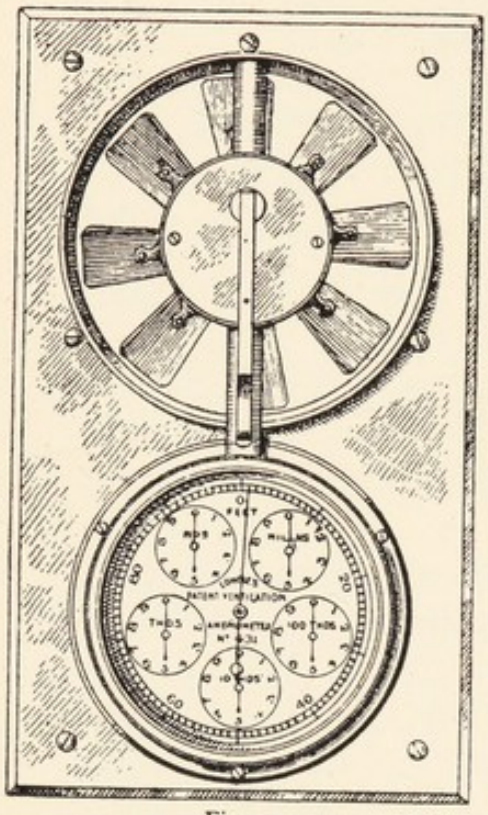


Fig 1.

Anemometer.

For registering the velocity of air-currents.

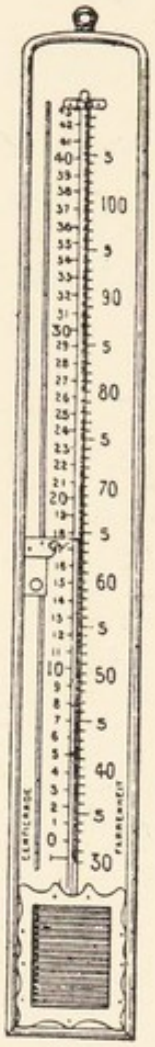


Fig. 2

Highly Sensitive Gridiron Bulb Thermometer.

Fitted with sliding index for observing difference of temperature between any two localities, or in any given interval of time. Can be read to 1-10th of a degree by direct observation.

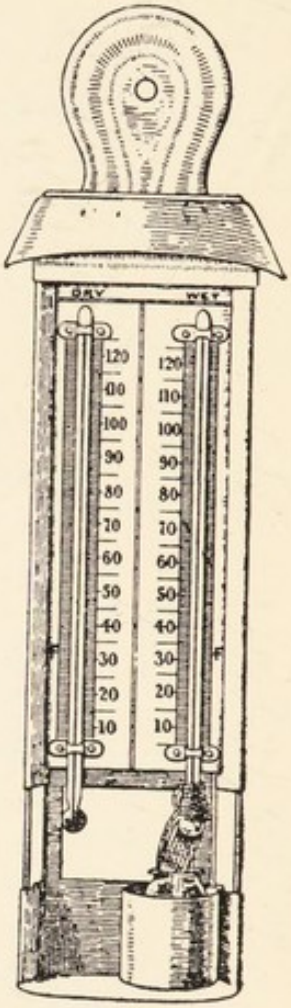


Fig. 3.

Hygrometer.

For registering the humidity of the air.

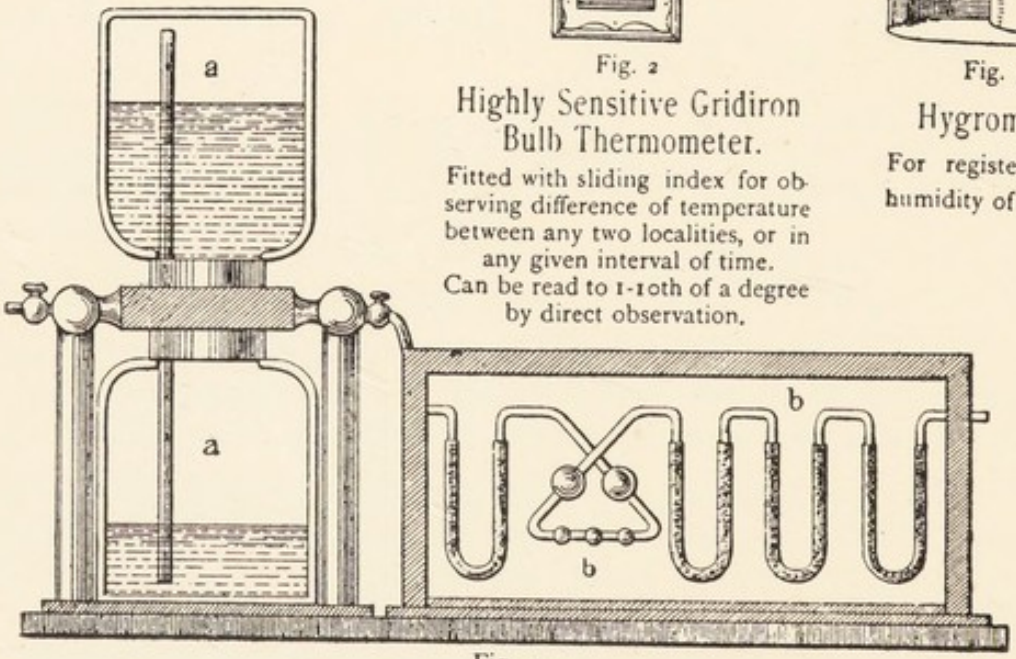


Fig. 4.

Carbonacidometer.

For testing the proportion of carbonic acid contained in the air.

The Ventilation of Public Buildings.

(*Appeared in the Building News, Jan. 19th and Feb. 9th, 1923.*)

PART I.

"Ventilation is a science, and it requires the study of a lifetime to master properly all its intricacies. The greatest engineering skill is necessary in the arrangement of tubes and the supply of fresh air."—PARKES.

It is now becoming more fully recognised that pure air is really "the breath of life," without which health, even life itself, cannot be maintained.

Parkes says: "Health is only possible when to other conditions is added that of a proper supply of pure air. . . . Statistical inquiries prove beyond a doubt that of the causes of death which are usually in action, impurity of the air is the most important."

There has, perhaps, been no other question in connection with health which has excited greater controversy than that of ventilation, and how to achieve it satisfactorily. Happily these controversies, often rather heated, are now ended; at least one hopes so, the much-disputed problem having, at long last, been solved by the chain of scientific and practical tests which have been made by eminent scientists and engineers with the various systems of ventilation in actual operation.

These experiments have extended over a number of years and have embraced some of the most important public buildings in this and other countries. The great value of these tests, and the correctness of the tabulated results, has been fully confirmed by the reports of the Royal Commissions on Ventilation, which dealt with the evidence of the experts, the evil effects of artificial ventilation being more particularly considered.

The following is instructive :—

"We have a striking instance at the Congress of the Sanitary Institute of how an assembly of scientific experts, having an intimate practical knowledge of ventilating systems and their respective values, unanimously condemned what they knew to be a dangerous system, but which non-experts, having no, or at most but a superficial, knowledge of ventilating arrangements, impressed by the working of elaborate machinery, accept as efficient. The system was condemned as being a retrograde step, which the Sanitary Institute ought not to endorse ; exception was also taken to the system on the ground that all mechanical arrangements of the kind were apt to get neglected and fall into disuse."

The Select Committee on Ventilation appointed by the House of Commons reports :—

"It is the common experience of many Members that the air of the Chamber lacks 'freshness,' and that there are some qualities possessed by it which lead to a stay for a length of time in the Chamber causing in the Members a lassitude and feeling of heaviness which tend to interfere with the due performance of their duties. . . . The Committee received valuable evidence from Dr. Shaw as to the alleged enervating and other undesirable effects of air artificially warmed. . . .
"It is evident from what has been said above that the lack of 'freshness' in the air of the Chamber, which seems to be the cause of the feelings of lassitude produced by a lengthened stay there, cannot be attributed to those chemical changes in the air which are easily recognised by primary methods, or to any excess of micro-organisms ; it appears to be due to some recondite causes not as yet accurately determined, which seem to be always met with when air is supplied to a room by artificial means, and especially when such air is heated. . . . Those who know that system only, complain of the air being oppressive and giving rise to lassitude."

" Professor Shaw (Sir W. Napier Shaw, F.R.S., Director of the Meteorological Office):—One may suppose that possibly the lassitude or discomfort that arises in many cases from using artificially warmed air may be due to the effect of the heated surface producing actual deterioration of the air."

Professor Corfield :—" If air be previously warmed it will lose a portion of its oxygen, and if we get air short of oxygen we have to breathe a greater number of times to supply the required amount, and that means more effort."

Sir Douglas Galton :—" The temperature of the warmed air is raised beyond what is either comfortable or healthy for breathing ; discomfort in one form or another can with difficulty be avoided."

A well-known American engineer, Mr. David Grove, attributed the premature loss by Americans of the freshness and bloom of youth to the enervating effects of the warmed air system of ventilation used in the United States, which, he says, is now being discarded for " less pernicious methods."

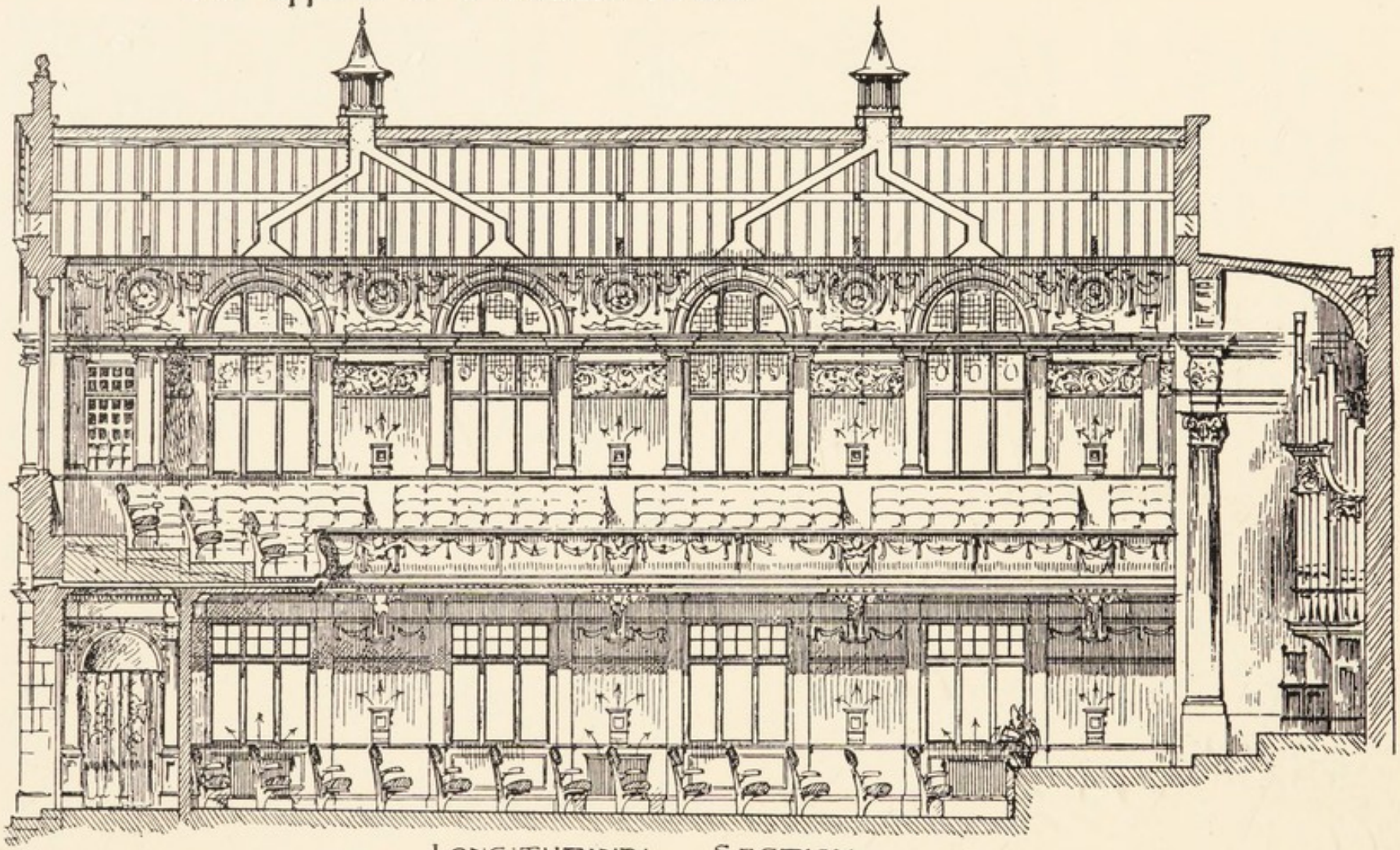
This is confirmed by Professor Smith, who says :—" A most instructive historical fact is the present gradual abandonment in the States and in Canada of the warmed air system which was for so long popular."

Professor Woodbridge, in a report to Congress on the ventilation of the Capitol, Washington, also strongly condemned this method of ventilation.

The employment of this out-of-date form of ventilation at the new Council Chamber of the London County Council constitutes one of those surprising and inexplicable happenings which are very hard to account for, especially in view of the Council's disastrous experience of mechanical ventilation as applied to other of its buildings (Claybury Asylum, for instance) recently referred to in these columns, from which the following is taken :—

" The Commissioners in Lunacy complained in their report that the system of ventilation used was dangerous. The London County Council Asylums' engineer reported to the Council that ' the principle of this system causes very large working expenses compared

NATURAL SYSTEM OF VENTILATION
As applied to a PUBLIC HALL.



LONGITUDINAL SECTION

"It has been fitted in several of our Public Buildings, including the Corporation Halls, Picture Galleries, &c. In every case it has given perfect satisfaction, and I have no hesitation in recommending it as one of the most efficient and economical systems of ventilation of the day."—JOHN CARRICK, *City Architect*, Glasgow.

with other methods, whilst its magnitude will entail an expenditure for upkeep unknown in our other asylums. Very excellent results are necessary to warrant such large expenses.' . . . The Medical Superintendent reported :—' The system is a vexatious and unreliable one. . . . Everything is apparently done to control this system. . . . No reliance can be placed upon it. . . . The system of ventilation is probably the cause of much sickness.' "

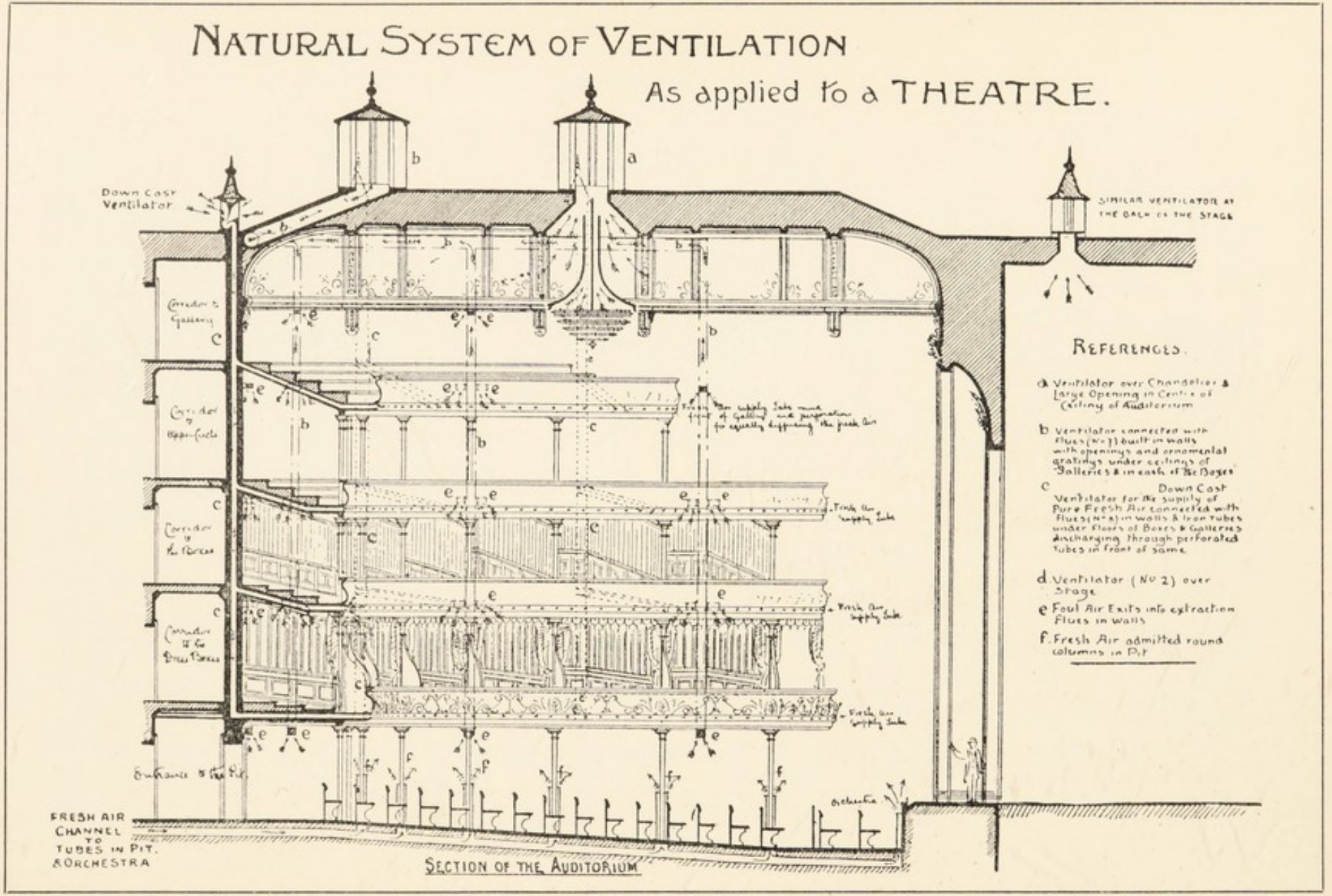
Mr. Keith Young, F.R.I.B.A., reported :—" The application of such a system as this is, in my judgment, a mistake, and a mistake that may be followed by very grave consequences."

One Royal Commissioner said :—" Anything more pernicious I cannot imagine. . . . Such a system is abominable."

The London County Council appears to be singularly unfortunate in the selection of ventilation systems, and if its recent ventures are no more successful than they have been in other buildings, a large expenditure of money will have been as uselessly made. Criticising these " experiments," the Editor of *The Lancet* says :—" We are called upon to believe that the day is near when we need only to telephone to be supplied with the climate of Sahara or of the Alps." That is to say that, with the system in question, one may be either roasted or frozen as and when desired.

Shortly stated, the system applied to the London County Council chamber consists of two air inlet tubes fitted to each of the desks provided for the councillors.

These tubes are connected with air channels underneath the floor, through which the fresh air supply is driven by powerful fans and up through the tubes into the chamber, the air being warmed in cold weather, and cooled in warm weather. One of the two tubes is a straight tube, the air forced through it ascending in a practically unbroken column direct to the ceiling, where it is extracted by fans. The second tube is formed with a bend so that the air forced through it is deflected at an angle across the desk directly on to the body of the occupant of the desk. Air exits are also provided at the floor level fitted with extraction fans to draw the foul air downwards.



"The notoriously unhealthy state of the air in nearly all theatres, and the intolerable draughts which usually exist, are a discredit to our boasted nineteenth-century progress in matters sanitary. It is well known to medical men that the impure air generally found in theatres is a prolific source of illness and disease, and many people stay away for that reason alone."—VENTILATION.

The possible effects of this arrangement are :—(1) The air supply being previously warmed is, as a consequence, deteriorated, rendering it unfit for healthy respiration, and—according to the Royal Commissioners—" inducing a feeling of oppressiveness and lassitude." (2) The air supply being mechanically propelled through the vertical tubes ascends in columns straight to the ceiling, and is there extracted by the fans, the occupants of the chamber deriving little or no benefit from it. As a high authority says :—" Engine-driving columns of air through a building is not ventilating it." (3) When the air supply is driven at an angle through the bent tube across the desk on to the body of the occupant, it blows the effluvia arising from the body, along with the expired air, directly on to the occupants of the desks behind, so that impure air only is breathed by them, not pure air. (4) In warm weather, when cooled air is pumped through the bent tube at an angle directly on to the body, for which purpose this tube is specially provided, the possible results might be pleurisy, pneumonia, peritonitis, etc., the extreme danger of playing a jet or spray of cold air on to a heated human body being well known to all medical men, who also know that the consequences may easily be fatal.

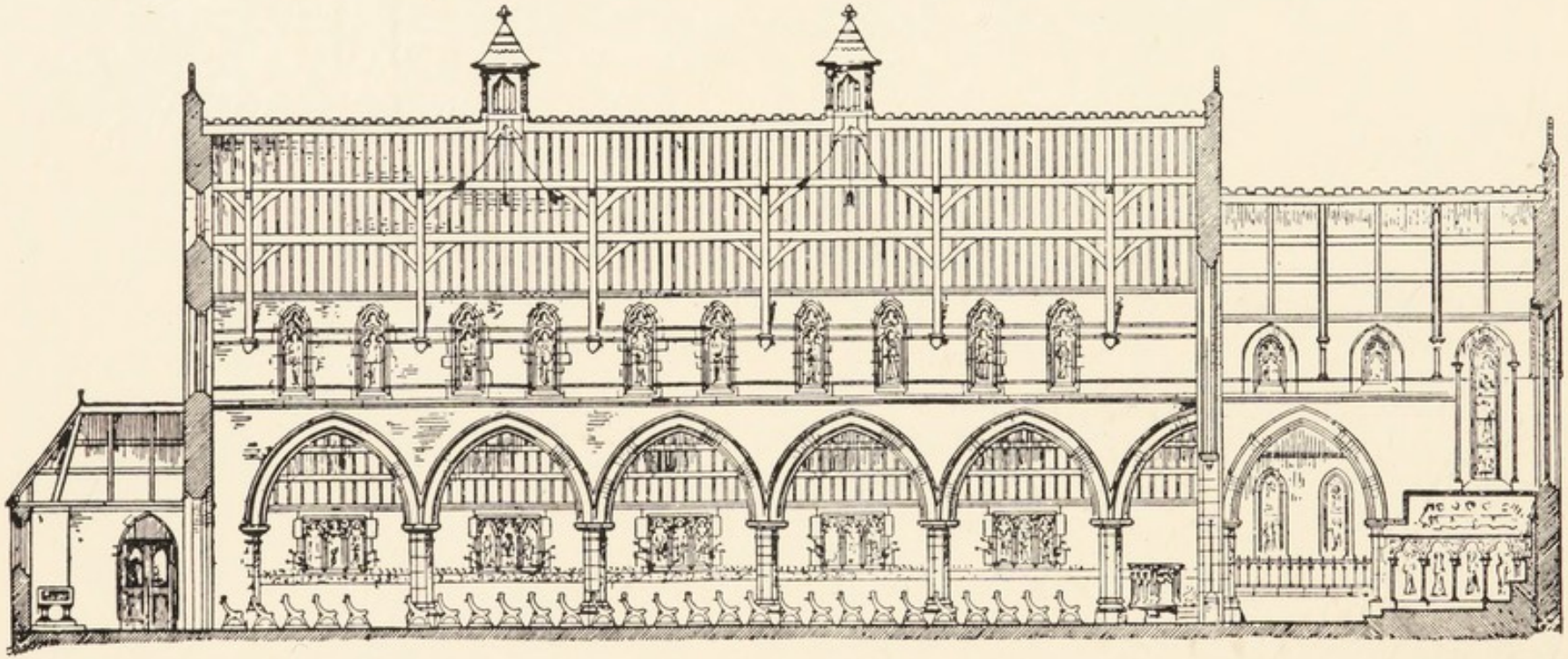
(5) This combined extraction from both floor and ceiling levels is a unique example of the " pull devil, pull baker " principle, the fans at the floor level creating a downward current in the lower strata of the atmosphere of the chamber, and returning the ascending expired air to be re-breathed, along with the exhalations from the body. This downward current would not, however, materially affect the ascensional force of the columns of air driven through the vertical tubes, as these columns, being mechanically propelled at a specific velocity, would continue to ascend aided by the upward suction of the extraction fans at the ceiling.

The net result of this arrangement would, therefore, be that the occupants of the chamber would be submerged in a strata of foul air, though immediately above existed a reservoir of pure air, from which, however, they would be unable to derive any appreciable benefit.

NATURAL SYSTEM OF VENTILATION

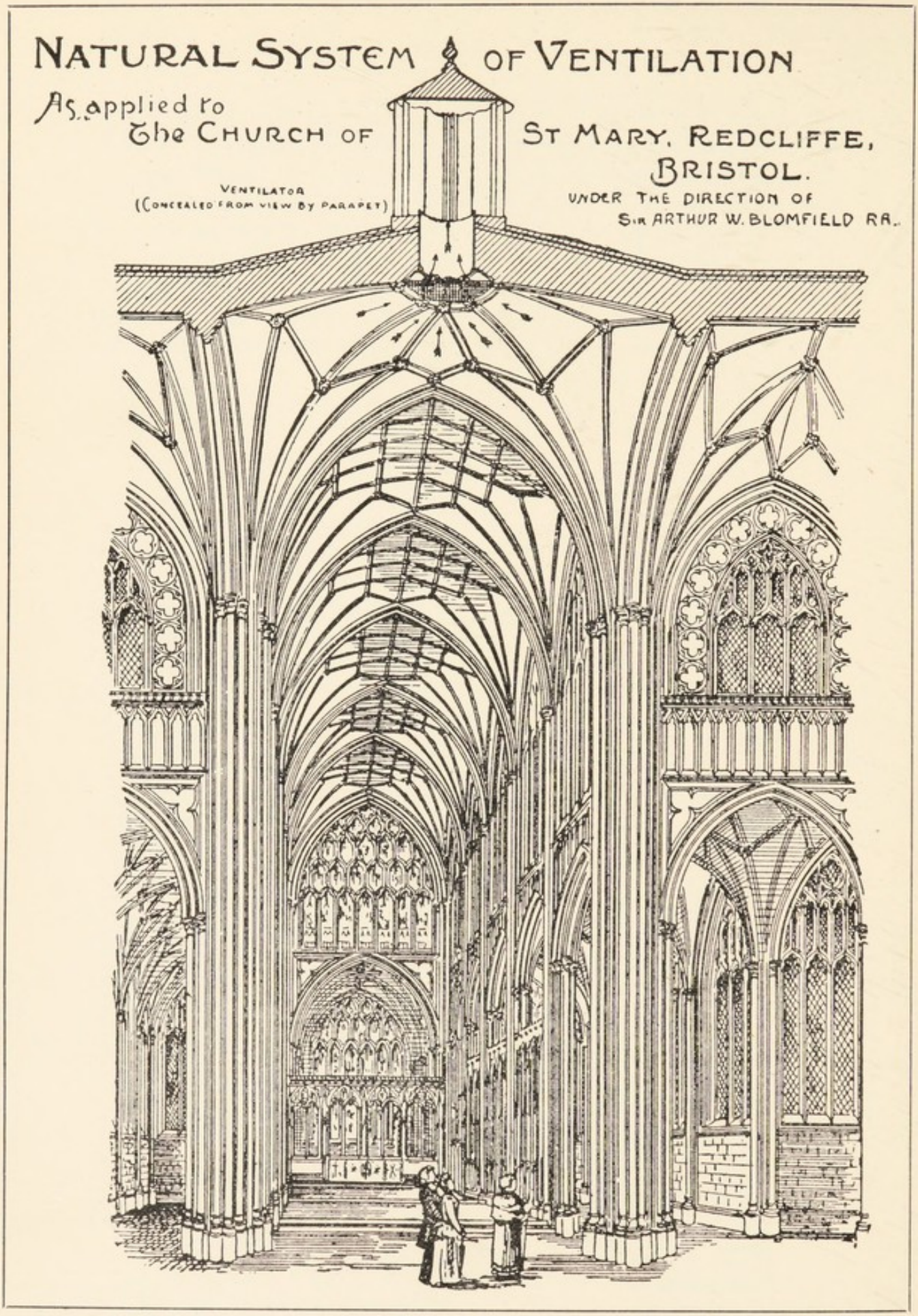
As applied to S^T JOHN'S CH., S^T Leonards on Sea.

under the direction of SIR ARTHUR BLOMFIELD. R.A



"The system is most valuable. We would not on any account be without it. It acts well, and keeps the church sweet and pure as regards air, without subjecting us to any draught."—Rev. HENRY D. JONES, *Rector*.

Professor Shaw, in his evidence before the Select Committee, referring to this form of ventilation, said :—" A descending current means mixing the used air with the fresher air, and bringing the mixture down to the floor and passing it over the members. The air supplied would be less fresh when it reached the floor than the existing air is at present, in consequence of the fact that the products of respiration and so on have to go upwards in the first instance, and to bring them down again would mean bringing them down past the members."



"The system of ventilation has answered admirably in the Church of St. Mary, Redcliffe."—Rev. CHARLES E. CORNISH, *Vicar.*

PART II.

"It is essential to the success of a natural system of ventilation that both the outlet and inlet ventilators be of correct scientific construction and skilfully applied."—PROFESSOR DE CHAUMONT.

Various contrivances have been employed in connection with mechanical ventilation with the object of purifying the air supply, the usual arrangement being to pass the air through filtering screens sprayed with water, and then over heated surfaces to dry and warm it.

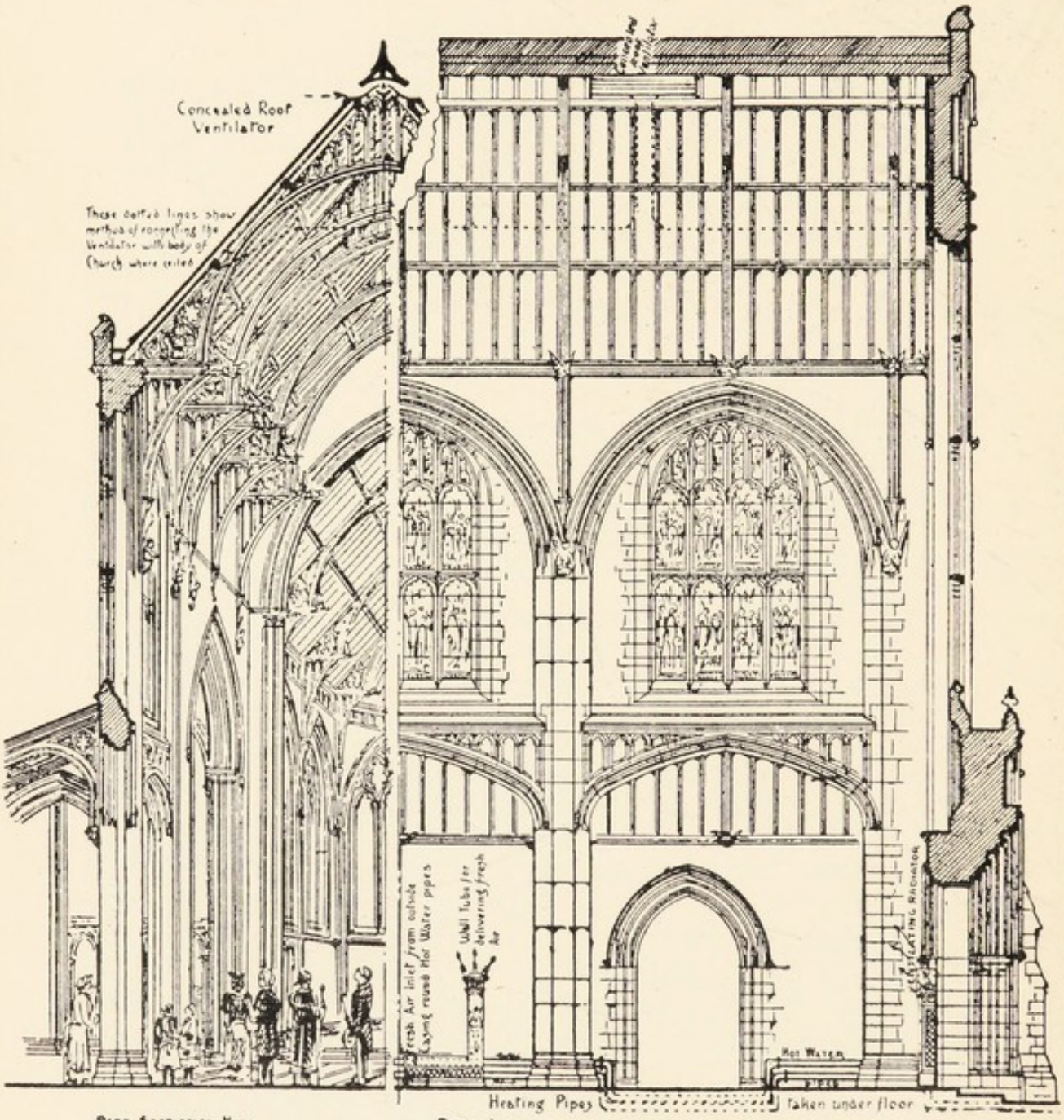
As showing the unhealthy effects of this washing and filtration of the air, the evidence of Sir Michael Foster, Chairman of the Select Committee on Ventilation, is instructive :—

"The Committee would like to know whether it is dangerous to filter air too free from non-pathogenic germs which may have the property of attacking and destroying the pathogenic germs when they come into contact ?—I should say, in the first place, it is exceedingly improbable that we should be able to remove all the bacteria ; there will always be some left ; and, in the second place, the removal of the pathogenic bacteria will take place *pari passu* with the non-pathogenic, so that the diminished bacterial supply will be equally good or equally bad in the same proportion as was the original supply.

"Do the non-pathogenic germs do people any harm when breathed ? If they are not pathogenic, what harm can they do ?—We have no evidence that they do harm at all so long as they are not pathogenic."

This was confirmed by the evidence of Professor Shaw (Sir W. Napier Shaw, Director of the Meteorological Office) :—

NATURAL SYSTEM OF CONCEALED ROOF VENTILATION



PART SECTIONAL VIEW

PART LONGITUDINAL SECTION OF NAVE

"Since the system has been applied to St. Margaret's Church, Brighton, I am assured that medical men recommend their patients to attend this church because of the purity of its atmosphere."—JOHN OLDRID SCOTT, F.R.I.B.A.

"There are very many qualities of air, in spite of our chemical knowledge, that we know little about at present?—That is perfectly true.

"And we may be altering these very considerably in our artificial apparatus?—Yes; that is a very serious consideration.

"But the difference between artificially supplied air and the natural air may be due to occult qualities which at present are beyond our knowledge?—Unknown, certainly.

"Is it not better to avoid hyper-purification of the air, which causes lassitude and oppressiveness?—If that is the result in the end, it would be.

". . . Making every allowance for the play of prejudice, the testimony thus given does seem to the Committee to militate seriously against the system, and they cannot recommend that it should be adopted."

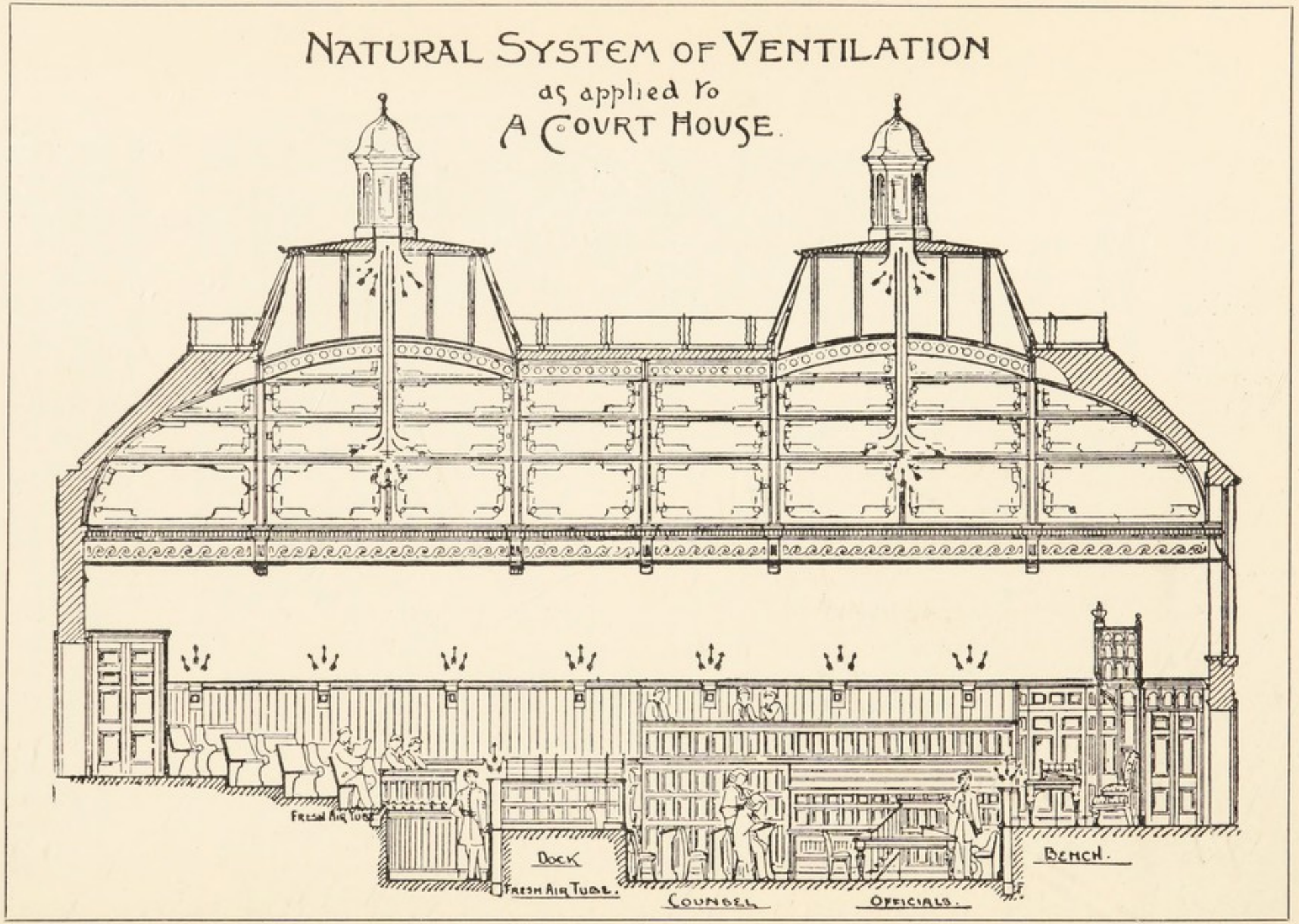
The well-known medical scientist, Dr. Christopher Childs, in a paper on ventilation read by him before the Royal Institute of British Architects, said:—

"These health-giving qualities seem to me to be lacking in air pumped into a building under a 'Plenum' system, and to be present in methods of natural ventilation. The value of fresh, not filtered or pumped, air is obvious, and all recognise its exhilarating effects."

Mr. Saxon Snell, in expressing, with other architects present, disapproval of this system, stigmatised it as "a huge mistake." The views of Sir Aston Webb on the subject, particularly in relation to the undesirability of warmed air for ventilation and heating, are well known.

An artificial atmosphere, mechanically supplied, can never be a healthy one, and it is not surprising that Royal Commissioners on Ventilation should have so emphatically denounced it as "pernicious and abominable" and "worse than a delusion."

The following extracts from a report on the ventilation of the Houses of Parliament are enlightening:—"I never yet knew of a system of propulsion that effected an efficient and



"Since the Natural system has been applied, the ventilation of this Court has been quite satisfactory."—TEMPLE C. MARTIN, *Chief Clerk*, Lambeth Police Court, London.

satisfactory ventilation of any large building. . . . So long as architects employ this system, colossal buildings like the Houses of Parliament, the London Law Courts, the National Club, etc., will continue to be notoriously badly ventilated in every sense of the term.

" This trouble of inefficient ventilation in large legislative buildings—notwithstanding the enormous amount of fresh air that can be passed through them ' without ventilating them ' —is not at all confined to the Houses of Parliament in this country.

" When one considers the enormous volume of air, equal to ten times the cubic capacity of the House of Commons, which is passed through it every hour, that the elaborate tables of air analysis are apparently all that could be desired, and yet the ventilation is so notoriously bad, it is clear that there is something very radically wrong with mechanical ventilation by impulsion, and that tables of analysis and of volumes of air passed through a building are not to be accepted as correctly indicating either the general purity of the air or the efficiency of the ventilation."

" Engineering columns of air through a building is not ventilating it."

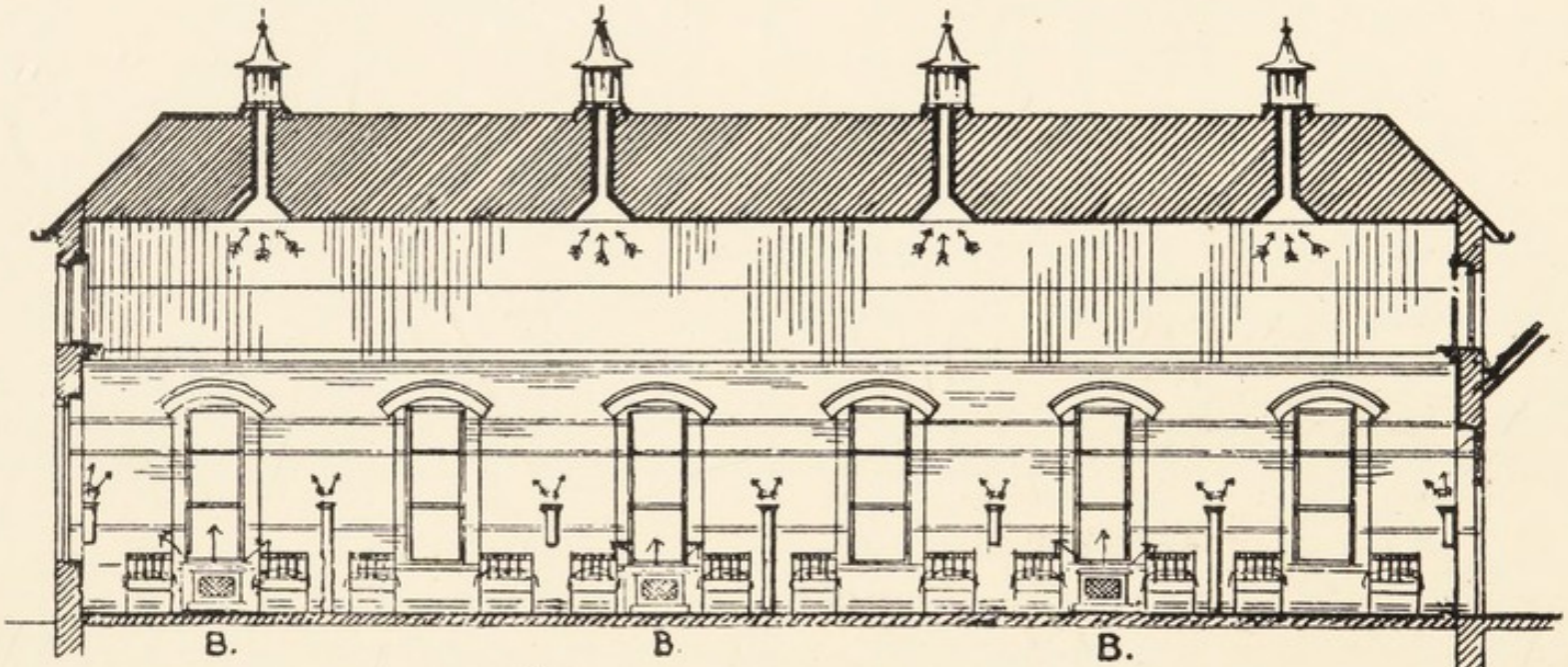
Apologists for the failure of mechanical ventilation usually seek to camouflage the issue and impress the ignorant by a specious flow of quasi-scientific jargon, reminiscent of Panurge's famous lecture at the Sorbonne, and of equal value. When the cold light of science is shed upon mechanical ventilation, its fundamental defects are all too apparent and cannot be burked.

Dr. Fardon, Chief Physician, Middlesex Hospital, says :— " There is absolutely no excuse for adopting an artificial method of ventilation. I have inspected many mechanical systems of ventilation, including those at the Houses of Parliament and at the Law Courts, but I have never seen one that was approved by those who used it."

Sir Douglas Galton confirms this :—

" Experience would seem to justify the hesitation which has been felt with respect to artificial ventilation. It is far better to trust to the ventilation of nature—natural ventilation—than to the artificial pumping in of air."

NATURAL SYSTEM OF VENTILATION
As applied to an INFECTIOUS DISEASES HOSPITAL.



LONGITUDINAL SECTION.

SHEWING INLETS FOR FRESH AIR _ and EXTRACTION TUBES

"There can be small doubt of the efficiency of this system."—DR. J. C. STEELE, *Medical Superintendent*, Guy's Hospital, London.

"The Natural system of ventilation fixed in the new building fulfils its purpose in a completely satisfactory manner."—DR. F. FOORD CAIZER, *Medical Superintendent*, South Western Fever Hospital, London.

Sir Henry Burdett says :—

" Having regard to the temperate character of the British climate, we have yet to be convinced that it is desirable or necessary to introduce artificial ventilation into our hospitals. . . . At Guy's Hospital (new building) the artificial system can be compared with the natural system in the older wards, and the result of the comparison certainly does not make for the superiority of the former method."

A distinguished Paris surgeon, Dr. Le Fort, in a report on hospital hygiene, says :—" One need not go to England to search for means of comparison between the two systems (mechanical and natural), for the two hospitals in Paris where the mortality is greatest are precisely those in which artificial ventilation is employed."

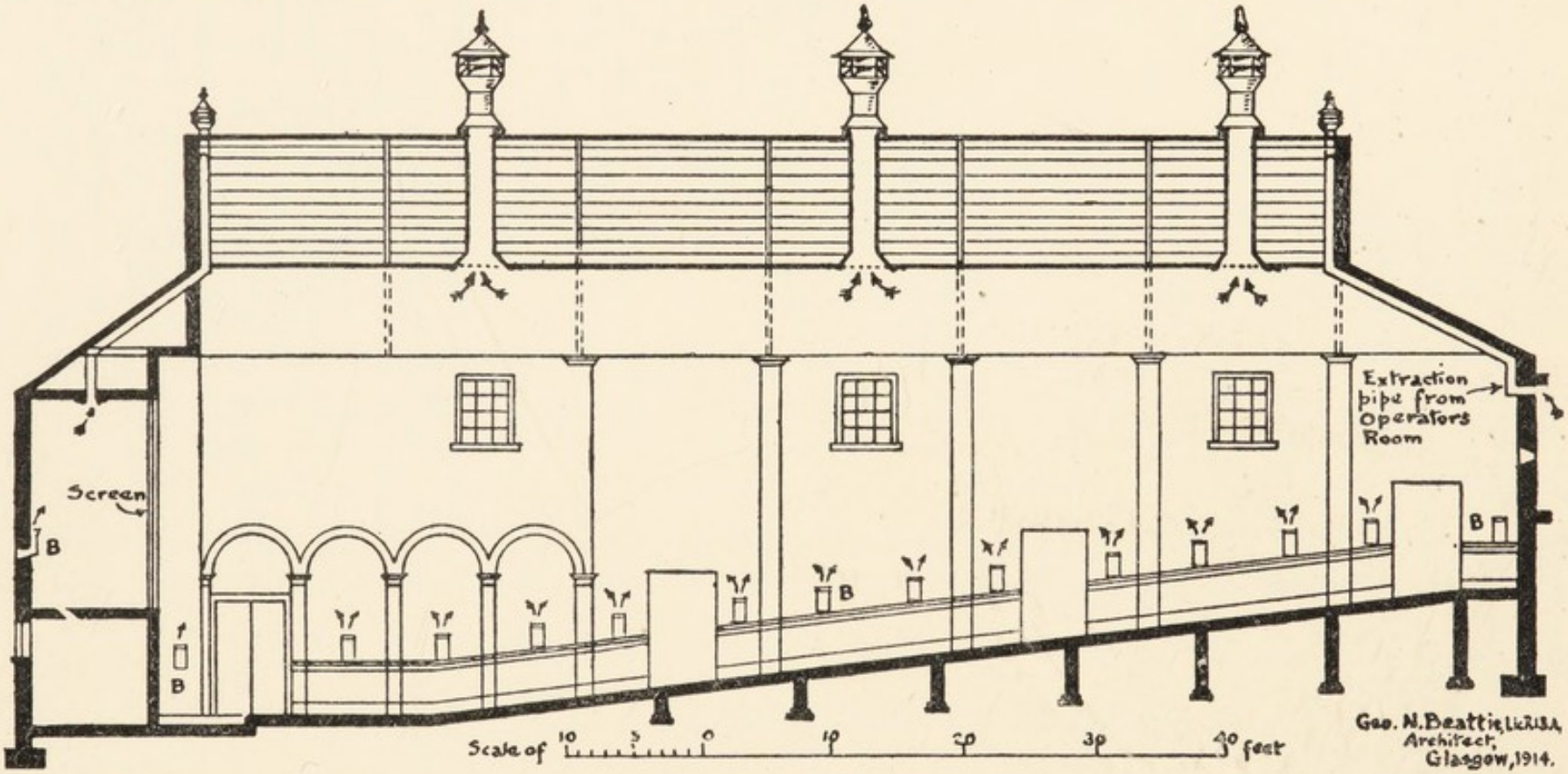
Mechanical ventilation was tried experimentally, under the direction of Lord Kelvin, at Glasgow University, but abandoned as " inefficient and unhealthy " and replaced by natural ventilation.

Professor Wade, Oxford University Lecturer on Hygiene, says :—" Ventilation can only be successfully accomplished at all times when it is effected without assistance from mechanical or artificial contrivances. However perfect these may appear, they can never achieve results superior to those insured by judicious and intelligent adaptation of natural means ; and they necessarily suffer from the very serious disadvantage that they are liable to interruption without warning, with possibly disastrous consequences."

A high authority, Dr. John Hayward, whose publications on ventilation are standard works on the subject at the Universities, says :—" Natural ventilation is certainly much to be preferred to any and every artificial system, whether on the ' Plenum ' or ' vacuum ' principle, and it is, of course, much less complicated. It is, indeed, comparatively speaking, simplicity itself. It also involves very little original outlay and comparatively no permanent cost for maintenance. On the other hand, all artificial systems involve costly original plant of machinery, as well as heavy permanent expense for maintenance in engines, engineers, fuel, etc., yet they cannot be made as efficient or nearly so pleasant and healthy in operation."

NATURAL SYSTEM OF VENTILATION

Applied to Picture Hall,



"The Natural system of ventilation, applied under my direction to the Maryhill Picture House, Glasgow, has proved a great success. It effectually extracts the foul air and tobacco smoke, and keeps the atmosphere of the hall cool and pure to a remarkable degree at all times and in all states of the weather, even when there is seemingly no wind. . . . . I consider it is undoubtedly the 'last word' in picture house ventilation."—GEO. N. BEATTIE, *Architect*.

Regarding the great cost of mechanical ventilation, Sir Henry Burdett says :—

" The really important point to be kept in view in regard to ventilation is that before any system depending upon mechanical contrivances can be pronounced worthy of adoption, it must be demonstrated beyond dispute that it is not only as good as ordinary methods, but appreciably better. Nothing but a substantial improvement would justify the largely increased cost, both of construction and maintenance, necessarily consequent on the adoption of mechanical ventilation."

In relation to the use of electric fans, the report of the Select Committee on Ventilation states :—

" You say that the chairman and other members of the committees have complained of the draughts caused by the fans ?—I had in my mind one honourable Member in particular—the chairman in the police and sanitary committee-room stops the fan immediately he comes into the room."

The decisions arrived at by the Committee in respect to fans were :—

" Complaints are made of noise and draught, and that the ventilation is by no means satisfactory.

" Improved regulations and arrangements required so as to obviate the great draughts sometimes experienced where the Members sit.

" General condemnation of the principle of extracting air from buildings by fans."

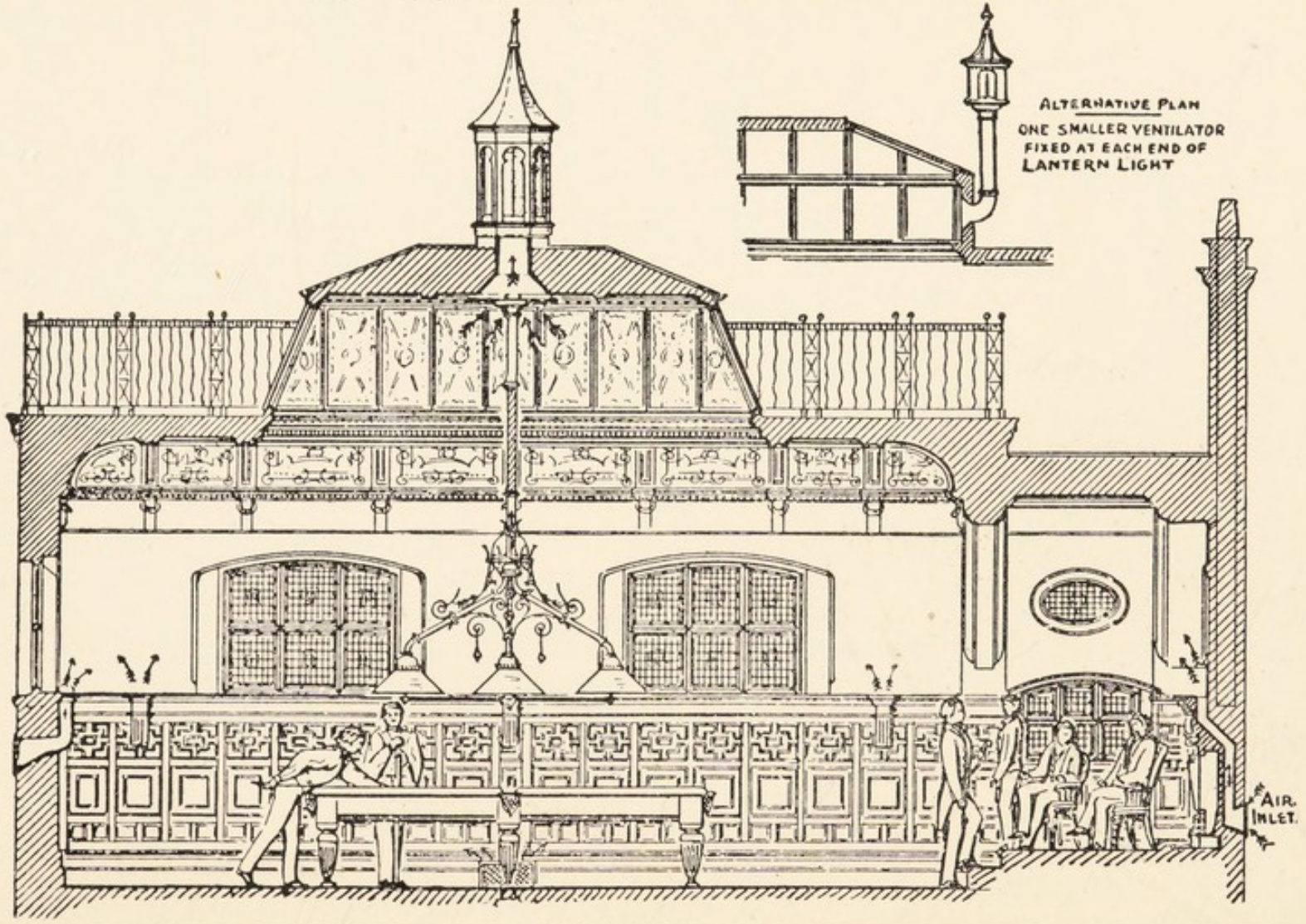
Another report states :—

" Draughts existed in the upper levels of every room ventilated mechanically by extraction, whilst the halls of such buildings were generally full of draughts."

The Council Chamber of the Bristol Corporation may be cited as a case in point ; there the city fathers have had to ask the Mayor's permission to wear their hats as a protection against the " insufferable draughts " caused by the new electric

NATURAL SYSTEM OF VENTILATION

As applied to a BILLIARD ROOM.



"Since the system has been fitted to our large Billiard Rooms, the ventilation has been perfect."—JAS. BEBBINGTON, *Manager*, Conservative Club, Nantwich.

extraction fans. One councillor pathetically pleaded to have the fans stopped, protesting that he " would rather stifle than be killed by these terrible draughts."

Dr. Leonard Hill, Professor of Hygiene and Public Health, University College, London, in a paper recently read by him before the Royal Institute of British Architects, concisely and accurately sums up the value now attached to mechanical ventilation when he says :—" ' Plenum ' ventilation is not wanted."

On the collapse of the mechanical ventilation craze, when it was realised that the vast sums of money that had been expended upon it were wasted—the system being a very costly one—a blind and unreasoning stampede took place to the very opposite extreme—ventilation faddists are usually extremists—and what is called " cross-current " ventilation was one of the forms that replaced (particularly in schools) the discarded mechanical installations.

A cruder or more unscientific attempt at ventilation than this could not be found, consisting as it does merely of an opening in the upper parts of the windows, through which the wind blows directly into the class-rooms, descending in a shower upon the unprotected bodies of the children underneath. The baneful effects of this cold douche, in winter especially, with an icy "north-easter" blowing, may be imagined. "Deadly" is the only name for it. Its essential features being a through-draught and a down-draught, the descending currents cool and return the ascending expired air to be re-breathed, along with the poisonous exhalations arising from the body. No provision whatever is made for the extraction of the vitiated air, which is supposed to find its way out through windows or elsewhere as best it can.

There is the wisdom of age-old experience in the Spanish proverb :—" The two greatest evils in life are a through-draught and a scolding wife." " Methods of barbarism " such as these are hardly creditable to twentieth-century intelligence, and sadly belie our vaunted progress in sanitary science.

Surely the intervention of the Ministry of Health and the Society for the Prevention of Cruelty to Children is called for here, as well as that of the Board of Education !

An important question is whether all such so-called "systems" of ventilation should not, in the interests of the community, be dealt with under the Public Health Act, Royal Commissioners and the accepted authorities on ventilation having pronounced such methods to be "a danger to health" and "a social menace."

Franklin says :—"A people's health is a nation's wealth"; no other interests should therefore be allowed to endanger it, nor the crude fancies of irresponsible, ill-informed faddists and "fresh-air-at-any-price" cranks.

It is truly said, "A little learning is a dangerous thing," and this is especially true in relation to the vital matter of ventilation, upon the efficiency of which, as Parkes says, "Health, even life itself, depends."

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"The evidences of injury to health from impure air are found in a large proportion of cases of ill-health.

"Health is only possible when to other conditions is added that of a proper supply of pure air."—PARKES.

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INVENTOR AND SANATARIAN

By LAWRENCE SAUNDERS.

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