THE SCIENCE OF VENTILATION.

First Part .. .. General Fundamental Principle

In order to convey a clear understanding of the method by which all inhabited interiors—including saloons, cabins, berths, engine-rooms, stoke-holds, etc., of steamships, as well as the compartments of railway carriages—may be thoroughly ventilated, wholly free from currents and draughts, it is needful to state, at the outset, the principles by which such effective Ventilation is regulated and controlled, which are universally operative.

The world is enveloped in a fluid, to which we give the name of air or atmosphere, permeating and filling every crevice, excepting only such as are filled by that other denser fluid, to which we give the name of water. Man chooses for his habitation a niche, not filled with water, and, therefore, permeated throughout by air, of which it contains, always, its full measure, neither more nor less, and which can neither be increased nor diminished, except to the extent to which it may be expanded or contracted by differing degrees of temperature, or to which its total ponderosity may be affected by the presence, under special conditions, of a greater or less proportion of the more ponderous of the gases of which it is composed, as, for instance, in a highly corrupted atmosphere, containing an abnormal proportion of carbonic acid gas; but, long before this element could be present in quantity sufficient to have any appreciable effect on the total density of the air or atmosphere, the occupants of the interior would be in a state of suspended animation, if not actually dead, by being starved for want of the oxygen which had been used up, or asphyxiated by the carbonic acid gas produced in the using of it.

The quantity of air within every interior may thus, for all practical purposes, be regarded as fixed and invariable, subject to the slight modifications already referred to, and to the, also slight, changes in the regulating power exercised by the weight of the whole superincumbent mass of the atmosphere, a weight sufficiently regular and clearly defined to be the recognised unit, in mechanical science, of all pressures, great or small, and designated "one atmosphere."

Now, it might be advanced that all that precedes consists of a series of truisms, being undoubted or self-evident truths, but as, with a proverb, "the force lies in the application," so with a truism. It is a truism that a house founded upon a rock will withstand the force of storms before which a house founded upon sand would succumb, but the builder of the stronger structure must clear away all debris covering his foundation before proceeding to build, and so is it necessary that I should expose to view the solid rock of universally admitted truth on which the structure I am about to build is to rest, that it may stand out clearly before the mind's eye of every beholder, because there is probably no sphere in which the perversity of indolence is more markedly shown than in the indifference and neglect bestowed upon "universally admitted truths," the whole benefit of which is thrown away by the ever ready phrases, "Oh, everybody knows that," or "that's nothing new," and so, although admittedly true or rather because universally admitted, they are deliberately relegated to the intellectual dust heap, and left, practically, a dead letter.

Failure to realize or apply the truisms referred to has led to the greater part of the essential error that enshrouds the subject of ventilation, and produced the empirical condition of the science. Persons, otherwise well-informed, will cry out, when suffering from the oppression of a stifling atmosphere in a crowded hall, "We must have "*more air*;" thus showing an absence of intelligence equal to that of the babe that cries for the moon, and who, pacified by some subterfuge, ends in the belief that it has got what it cried for; the continued resemblance, in this second stage of childish self-deception, is very striking, when the callers out for "more air" believe they have got what they cried for, by having the windows opened high up in the hall—as will be fully explained in its proper sequence later on; at this stage it is sufficient to mention that, at every moment, from the cradle to the grave, we are as truly *bathed* in air as we should be in water if plunged into the sea. But it is essential to bear in mind that this atmospheric air is a composite, made up of several gases in varying proportions, charged with vapour also in varying amount, and it is when the normal and

healthful proportions of the various gases, and the static charge of moisture, undergo abnormal changes, that the inconvenience complained of arises, accompanied by dangers greatly more serious, although much less complained of, because not appealing directly to the senses and not realized by the mind. What is really required, in such circumstances, is not an increase in the amount of air, which is impossible, but a change in the *constituents* of the air, that those elements or gases which produce vitality in man may be supplied, and those which poison his life may be removed. In the open air this adjustment of the constituent elements is regularly carried on, because the balance of nature is perfect, and, taking the most active and important elements—oxygen and carbonic acid gas —the first of these, oxygen, inhaled by men and other animals, vivifies their blood and produces in them fresh life and energy, yielding, at each respiration, as a waste product, the second, carbonic acid gas, which, in turn, is breathed by living growing plants, producing within them the health and vitality of vegetable life, and yielding, as their waste product, the oxygen, which is the breath of his nostrils and the source of vitality in man; whilst the adjusting regulator, in this process of beneficial interchange between animal and vegetable life, the fly-wheel to this great engine for the production of vital power, in the animal and vegetable kingdoms alike, is the ocean, whose property it is to adjust irregularities, and maintain a true equilibrium, in the due proportions of these two essential elements in the atmosphere.

But natural laws, thus obeyed in the open, where sun and sea and sky exert all their vivifying and regenerative influences, are ignored in the enclosed spaces used as habitations by mankind, wherein, in consequence, the irregularities continually arising are not effectively corrected, the true equilibrium in the component parts of a healthful and invigorating atmosphere is not maintained, the regenerative oxygen, necessary for animal health and vitality, is used up, and not efficiently renewed, whilst the poisonous carbonic acid gas, the deleterious animal effluviæ, surplus animal heat, excessive moisture, and other evil influences, continually evolved by the vital processes of the occupants, and by their surroundings, are not regularly removed, but permitted to accumulate in amount, in density and in power for evil, not infrequently seriously aggravated by the spasmodic, uninstructed or even vicious methods resorted to for relief when the pressure is felt unbearably severe.

How serious is the *incubus*, whose crushing weight is thus laid upon the health and life of the entire community, may be to some extent realized by the statistical fact, that the mortality in the small houses of one and two apartments in our crowded cities,

wherein such evils exist in a pronounced form, is 2½ times as great as in ordinary dwellings of five apartments and upwards, in the same cities, wherein better, although still very imperfect, means exist, for supply of oxygen, and for getting relieved from the worst effects of the deleterious waste products—largely by dilution with the atmosphere of the more spacious interior, rather than by any scientific method for carrying them freely off, as produced. But this is far from being the deepest deep, because, in bringing out these deplorable figures, the whole of the small houses are classed together; but a very large proportion of these houses are inhabited by a superior class of skilled workmen, with tidy and capable wives, who do not suffer from this excess of mortality, which is therefore enormously higher in the worst class of these small houses. Here are the authoritative figures, produced by the devoted labours of a gentleman who stands in the front rank amongst the vital statisticians of the country, who, working in a city where the crowding of insanitary dwellings together, and the heaping and piling of them one upon another, have been carried to their utmost limits, has collected, analyzed, and tabulated the facts, with such ability and care, as to give to his conclusions the very highest value—Dr. Russell, Medical Officer of Health of the City of Glasgow. Mortality in houses of one and two apartments, 27·74 per thousand; three and four apartments, 19·45; five apartments and upwards, 11·23. In the best of the 24 districts, into which the city is divided, the average rate of mortality, in all the houses, small and large, is only 16; in the worst district it is 42. What must it be in the worst class of the small houses in this worst district? Such a house, with its fœtid gases and animal effluviæ, not infrequently impregnated with disease germs, suspended in an atmosphere robbed of its oxygen and surcharged with moisture and animal heat, is a very hotbed of infection, producing in its inmates the fearful excess of mortality shewn to exist, with the most harrowing accompaniments of pain and weariness and suffering and disease, and is, besides, a source of danger to the entire community.

I do not overlook or ignore the many factors which co-operate in the production of effects so deplorable, but, of all these factors, atmospheric pollution is the most potent, and, as I hope to show, the easiest to remove. I have dealt at some length with these extreme cases, in order to place in the strongest relief the dangerous consequences of atmospheric pollution, as illustrated by its results, when found in its worst form, in places where the means of ventilation are wholly awanting, and to remind you that evils, the same in kind, although, happily, vastly differing in degree, are universally

prevalent, in all inhabited interiors, on land or sea, more especially wherever and whenever human beings are assembled together in considerable numbers for considerable periods of time; nor have events been awanting to show that the mansions of the wealthy, even the palace of the Prince, have been deeply tainted thereby, to the danger of health and life.

That such atmospheric pollution is easily preventable, and that all this resulting excess of human misery and suffering may be brought to a speedy end, are propositions the demonstration of which will be found simple and conclusive, by giving thoughtful attention and consideration to natural laws to which the atmosphere is obedient; and if, in stating these, I am found once more guilty of uttering truisms, my defence is, that they are valuable truths, which, instead of being left to moulder in neglect, should be brought out of their obscurity, and set, polished and bright, before the eyes of all men, that they may remedy the evil and effect the good for which they are adapted.

The laws which govern the denser fluid, water, and the rarer fluid, air, differ in respect of their density and rarity, but coincide in respect of their fluidity, and one law to which all fluids are subject, whether that filling the room in which we are now assembled, or that in the bed of the ocean, or in the tiniest tea cup, is that the part of the fluid which is rarest and lightest is found at the top, that which is densest and heaviest at the bottom, and where, from any cause, the operation of this law is disturbed, whether by rarer and lighter fluid being produced or admitted at the bottom, or heavier and denser fluid at the top, this irregularity will at once correct itself by the lighter fluid rising or the heavier fluid falling to its proper level.

In proceeding to apply this law to the ventilation of human habitations, we may dismiss, with a mere passing allusion, the transcendental question of the rarefaction produced in the atmosphere of the higher heavens, by the gradual lessening of pressure, as the superincumbent mass of the atmosphere, from the blue cerulean to the earth's surface, becomes reduced in amount, and restrict ourselves to the manner in which the law acts at the level at which we dwell, and, more especially, its action on the atmosphere of our dwellings, whether on land or sea. It will thus be made clear to every one, that the facilities placed within our reach, almost thrust upon us, by the unintermittent operation of this most beneficent law, for securing the continuous, thorough, healthful and invigorating renewal of the atmosphere, within these dwellings, are complete, leaving nothing to be desired, whilst the neglect hereof-

fore bestowed upon them is another instance of the indolent indifference to "universally admitted truth," which not only deprives us wholly of its life-giving power and energy, but, as has been shewn, substitutes therefor suffering, disease and death.

The one factor which governs the rising or falling of any part of the air within our dwellings, by causing density and resulting ponderosity, on the one hand, and rarity and consequent lightness, on the other, is temperature, the air which is highest in temperature rising to the ceiling, that which is lowest in temperature sinking to the floor level, if not already there. Now, the elements which cause deterioration in the atmosphere of our dwellings, and which are produced, without intermission, by the vital processes of the inmates, the products of combustion of gas, etc., immediately ascend to the ceiling, by reason of their relatively high temperature, and thus, by the continuous operation of this beneficent natural law, the greatest possible distance is at once placed between the occupants and those poisonous gases and dangerous effluviæ. It is manifest that if their continuous upward movement, to the ceiling, were continued, from the ceiling, upwards, and if they were constantly and completely discharged into the open air, the occupants would be wholly freed from the bad effects produced by their remaining and accumulating, coming gradually lower and lower, till they saturate the atmosphere breathed by the inmates; and that this can be easily and thoroughly effected, by obedience to another atmospheric law, I will presently show.

Before proceeding to do so, I must take notice of a most pernicious heresy, which, setting at naught the law just explained, has turned upside down many men's conceptions of the movements of the atmosphere of rooms, and produced many topsy-turvy and worse than useless notions for effecting ventilation. The constituent elements of atmospheric air differ in specific gravity, some being heavier, some lighter, carbonic acid gas being the heaviest; on that account, the persons referred to have arranged to take off the bad air near the floor level and introduce the fresh air near the level of the ceiling. But to deal with the composite atmosphere of our rooms, as though the several elements, of which it is composed, were not merely constituents of one body, but separate bodies, to be found at different levels, according to their individual ponderosity, is to ignore the very existence of a composite atmosphere. In making a chemical analysis, of the air of inhabited interiors, the chemist finds all the elements present, at every level, and has to separate them, before giving his results, the greatest amount of impurity being found at the highest level. There is always carbonic acid gas present in the purest atmosphere, but in infinitesimal propor-

tion to the other gases, and even when it is found to have increased, to a dangerous degree, it is still only infinitesimal, compared with the other gases or elements composing the atmosphere. But if the carbonic acid gas and other heated waste products, regularly produced in human habitations, which rise to the ceiling, and remain there, as component elements of the atmosphere, accumulating lower and lower, as they continue to be produced and to rise, without being taken off, but, all through, remaining as component elements only, were, as the advocates for taking off the bad air from beneath ignorantly imagine, either to remain at, or to fall down to, the level of the occupants, no method for removing them thence could ever be of any avail to prevent the asphyxia or death of the inmates, for human life would be impossible if condemned to breathe such undiluted poison. The crucial error of arranging Ventilation, with the view of taking off the waste gases from the floor level, has arisen from observations made in the morning, after a crowded night meeting in unventilated interiors, when the greatest impurity is found at the low level, but this is as precisely in accordance with the natural law, with which I am now dealing, as that they should fly to the ceiling when produced, and remain there during the whole time of the meeting, unless regularly taken off at that high level, because their high temperature is maintained, continuously, and even increased, during the meeting, by the unintermittent rising up of the like products, so that the law of the highest temperature at the top, the lowest at the bottom, keeps them suspended at the high level, whilst, after the meeting is over, and a night has intervened, a vast cooling-down process has set in, and, in the morning, the relative position of the less and more impure is found to be reversed.

I shall deal with the remaining branch of this heresy, that, namely, of introducing the fresh air at a high level, in its own proper sequence, and show how, by that and other crucial errors, there does occur, at times, a certain amount of refrigeration of the waste gases, causing a certain proportion of them to descend to the level of the occupants, not by the natural operation of the atmospheric law, but by violation thereof. Meanwhile, I return to the question of the continuous and complete discharge, into the open air, of the waste gases, from the high level to which they rise, without intermission, by reason of their relatively high temperature: and this can be secured and maintained by means of another atmospheric law, as powerfully and universally operative as that already described, all that is required to secure the desired result being a mechanism constructed in accordance with the law. As engineers you are familiar with the upward velocity of an upright column of

air, or other gas, rarefied by heat, the rate of velocity being conditioned by two factors, (1) the height of the column, (2) the degree of rarefaction and resulting expansion of the air or other gas contained in it. The most familiar illustration is a Factory Chimney, taking off the products of combustion from steam boilers, where, the heat being great and the height considerable, whilst any entrance of cold air, which would cool down the chimney, and *pro tanto* destroy its efficiency, is carefully avoided, the upward velocity is very high ; and the same law operates in an ordinary household chimney, as in every other upright flue or tube, the air or gas in which is rarefied by heat. We have here the most simple, effective, and continuous means for completely carrying off the waste gases constantly rising to the ceilings of our rooms, whether by properly utilizing the ordinary chimney for that purpose, or specially providing the requisite tube or flue, as may be most appropriate and convenient in any case in hand.

It is unnecessary, at this stage, whilst still engaged in the consideration of the fundamental principles of the science of Ventilation, applicable to all human habitats alike, to make reference to the detailed specialities failing to be considered when we come to deal with the specific subject of Ventilation on board ship ; these will receive due and detailed notice in the second paper, to which they more properly belong. I shall therefore continue still to use, in illustration of the true working of these principles, and of the errors or misconceptions which mar or destroy the working, the arrangements commonly found on land ; and no illustration is more useful or instructive than that of the ordinary household chimney. I have already mentioned the care with which any entrance of cold air, into a factory chimney, which would cool it down and *pro tanto* destroy its efficiency, is avoided, thus producing a very great upward velocity within it, because only the highly heated products of combustion are permitted to enter it. But no care whatever is given to this point, so essential to efficiency, in the case of the household chimney. There, the entire products of combustion require a sectional area of passage into the chimney of from 16 square inches as a minimum, for small fires in small rooms, to 32 square inches as a maximum, in the case of larger fires in larger rooms. But the sectional areas of the chimneys themselves are many times greater, ranging from 72 square inches as a minimum to 144 as a maximum, so that by far the greater part of the chimney—more than three-fourths—would be available for carrying off the waste gases from the rooms themselves, if proper arrangements were made for utilizing it, and proper precautions aken to prevent its power being dissipated and lost. But such

arrangements and precautions are alike conspicuous by their absence. There is a great wide open throat at the entrance to the chimney, immediately above the fire place, of as large, generally much larger, sectional area than the chimney itself, into which the outer air, coming into the room, enters and mingles with the ascending products of combustion from the fire; with the treble disadvantage of (1) drawing off this cool fresh air and depriving the inmates of its benefits for their respiration and the resulting vivifying of their blood, (2) cooling down the chimney and thus *pro tanto* destroying the velocity of its upward current (3) rendering the chimney unavailable for taking off the waste gases from the room at the high level, because it is completely filled with cool pure air, at the low level, and can take no more. There is thus no ventilation whatever, above the level of the entrance into the chimney at the fire place, which uses up and wastes the fresh air, causing currents and draughts on the occupants' feet and legs, but leaving the atmosphere, at the height of their breathing, wholly unrelieved, saturated with the dangerous gases and animal effluviæ of the inmates, for which there is no escape. By restricting the aperture above the grate to what is just sufficient for carring off the products of combustion, a high heat and a consequent high upward velocity are produced and maintained in the chimney, and by having a connecting tube or flue from the room into the chimney, with its opening in the room at the ceiling and its communication with the chimney at the floor level, the whole of the waste gases continually produced in the room will, without intermission, pass down the tube or flue and up the chimney, thus continuing the process, by which atmospheric law placed the greatest possible distance between these gases and the occupants at the moment of their production, and completing it by carrying them off regularly and continuously into the open air. The reason for taking the tube or flue down to the floor level and there passing it into the chimney is twofold; (1) to pass the escaping air over the heating surface at the hottest part of the chimney and so increase its upward velocity; (2) to take the full advantage of the height of the chimney as an upright column of air, because the greater the height the greater the velocity.

Before proceeding to the next department of the subject, it will be instructive to draw attention to a perverse ingenuity which has been manifested in the construction of house chimneys, to the further deterioration of their value as upright exhaust flues for taking off the waste gases from our rooms. (1) They are frequently not upright at all, or upright only in part, with turns and angles and bends, every one of which detracts from the velocity

whilst, as the part which is upright does all the work, all the other parts, instead of adding to the power of the exhaust, act as drags upon it and sometimes destroy it altogether. (2) There are not infrequently roughnesses and irregularities in the structure of the chimney, from the ignorant impression that any kind of wall is good enough for a chimney and will serve the purpose, but smoothness and regularity of surface are of the first importance in promoting velocity in upright flues, the friction caused by roughness and irregularity constituting a serious drawback and sometimes rendering the flue useless. (3) The exit at the top is stopped at a lower level than some neighbouring commanding chimney or gable-end or turret, and so, when the wind is against it, it simply sits down on the chimney exit, as effectually stopping the escape of smoke or gas therefrom, as in the erewhile Scottish schoolboy's famous trick, of ascending to the roof of the lowly thatched cottage, and placing a flat stone, or slate, or other covering, directly over the chimney top.

When it is discovered that the chimney won't draw, the extraordinary expedients resorted to, and the grotesque and preposterous fittings put on the top, beggar description, and render a near view of London housetops a remarkable sight to the instructed eye. Now the only form of cowl which can effect the purpose is the open-faced revolving cowl, provided it is in perfect equipoise, turning easily and accurately with every change of direction of wind, because, its back being always turned to the wind, no "sitting down" on the chimney top is possible. To remedy such defects is often difficult, sometimes impossible, but, in a chimney in the smoking foyer of the Gaiety Theatre in the Strand, which I have utilized for ventilation purposes, but which, when I got it, would not draw at all, by contracting the entrance as described, fitting a revolving cowl on the top, and doing everything possible to clear away internal obstructions, I have got a velocity of 500 feet per minute down the tube that opens into the room at the top, and into this chimney at the floor, and, from having been the worst ventilated place of the kind in London it is now the best.

Wherever the correct atmospheric principles just explained are intelligently applied, with proper and appropriate mechanisms suited to the case, the waste gases of any interior can be taken off regularly and with certainty, and this can be effected equally by the simplest chimney in the poorest house, as in the mansion of the wealthy, the assemblies of beauty and fashion, or the crowded theatre, ball-room or supper room, as also the various interiors within steamships, and in fact every interior inhabited by mankind. The essential requirement is an upright column of air,

rarefied by heat, having sufficient free sectional area to carry off the full volume of waste gases as they are produced, whether this column be the chimney of a room, a tube from the centre of the ceiling of a hall or theatre, a funnel or other upright tube in a steamer, or any other form. There must be heating surface to rarify the air and produce the needful velocity, and the waste gases must always be taken from the top of the room. There are innumerable refinements which can be brought into play, in the working of such an apparatus, for giving power of control, and enabling the ventilation to be increased or diminished, or wholly cut off at will, by the simple act of turning a tap. There must be effective insulation, that the heat may be wholly conserved within the upright column, for performing its work, and neither wasted, nor permitted to become a source of danger by communicating heat to outside fittings; but these more elaborate details will come in with more appropriateness in my second paper, in which I propose to show the application of the method to every department of a steamship, from the luxurious saloon or state cabin of the Atlantic greyhound to the stoke-hold of the trader in tropical seas. When I come to that more specific subject I will be able to show that ships, sailing the ocean, possess special and great advantages, in the matter of getting the effete air thus thoroughly and continuously removed, over and above those which I have now described, and that their atmosphere, more than all others, may easily be made pure and wholesome.

But, as I stated at the outset, the quantity of atmospheric air within any interior is practically fixed and invariable, so that, if the effete and noxious air is thus regularly removed, it will be replaced by a supply from the outer air, which will come in by the readiest channels, no power on earth can keep it out; indeed, in strict theory, it may be said that it is not the working of the outlet exhaust that brings the outer air in, but the entering cooler air which forms the driving power that sends the effete warmer air up the exhaust column. The two processes are inter-related and balanced; they act and re-act, as cause and effect, and this essential never-varying inter-relation and balancing must be kept, throughout, clearly in view, in any scientific system of ventilation.

Now, the two chief essential points in the needful arrangements for the admission of the fresh outer air, are (1) that it must be admitted at a low level, where it will mingle with the purest and coolest air already in the room, and yield its oxygen, uncontaminated, for the respiration of the occupants; (2) that it must be admitted wholly free from impinging currents or draughts.

These two essentials are very simply and effectively attained, by preventing the immediate direct entrance of the air, from the outside into the room, and causing it first to fill a receiver or reservoir; and—whether it may be introduced into this reservoir by a direct communication from the outside at that level, or brought down to that point by ducts from a higher level, as may be most suitable or convenient in differing circumstances—it is, at its entrance to the reservoir, baffled, and sent in, in a lateral direction, by which means it loses its initial velocity of entrance, spreads itself slowly over the interior of the reservoir, gently percolates through innumerable interstices in a grating, wire gauze, or other perforated fitting on the top, which is about three feet from the floor, and insensibly permeates the atmosphere of the room, by imperceptible diffusion, at the low level at which it immediately yields an abundant supply of oxygen to be breathed by the inmates. It is absolutely free from the current heretofore found to set in, from the point of entrance of air to the point of exit of air, which has been so invariable as to have come to be erroneously designated an "atmospheric law."

The air admitted in the heats of summer may be cooled, by means of a frigorific mixture, inexpensive as to cost, and vastly more powerful than ice, in its action, contained in a vessel, which is placed, when desired, in a space provided in the inlets or ducts, by which means the entering air passes over, beneath and around the refrigerator, before entering the reservoir. The extent of cooling can thus be regulated with ease and precision according to the varying conditions of the outer atmosphere.

In winter the entering air may be warmed by a heating surface of pipes fitted in the reservoir. This heating process is under equally easy and simple control.

During fogs, or where the outer atmosphere is impregnated with "blacks," means are provided for purifying the air before it enters, and an interior so fitted would remain with a clear atmosphere, whilst the outer atmosphere might be thick and opaque.

Valves are also provided for reducing or closing the entrances for air when desired. In cases of dry oppressive heats, where the static charge of moisture becomes abnormally reduced, means are provided for restoring it.

The atmosphere of any room, hall, theatre, saloon, assembly-room or other interior, having the before described doubly arranged apparatus for removing exhausted air and admitting fresh air, fitted with the valves or taps of control (already mentioned) and with the other appliances referred to, can be kept continuously

not only fresh and pure, but always at an equable and agreeable temperature, at all seasons, and the degree of change of atmosphere is under such immediate and simple control that it can be regulated to whatever is desired at any time and at all times.

I will now make reference to the heresy of introducing the cool fresh air into an apartment at a high level, from which level it is bound, by reason of its ponderosity, to fall down on the heads and shoulders of the occupants, in its descent to the floor. But it does not come down in its pristine condition of purity, on the contrary, coming into direct contact with the warm, impure air found at that high level, it exercises a cooling influence, and thus restores to the carbonic gas its natural ponderosity, and reaches the level of the occupants highly charged with this poisonous gas, in solution with the other deleterious atmospheric elements found at the top of the room, so that, to suppose that there can be any refreshing or healthful effect, whatever, produced by this cool descending current, is wholly delusive, because the descending showers are not only cold but impregnated with impurities, which, over and above the draught, are a source of vital danger to the persons seated beneath. Again, the idea that such direct openings to the outer atmosphere, at that high level, are a proper and effective means for taking off the impure air, is one which will be rejected as absurd by all who have clearly before their minds the atmospheric laws we have been considering. That a certain amount of impure air escapes outwards is quite true, but how is this accomplished? The cold air tumbles in and down, and its progress downwards causes a commotion in, and churning up of, the entire atmosphere of the room, a part of which, in accordance with the law that the room will hold its fill of air, and no more, escapes by the high openings, displaced by that which has fallen to the floor. But to bring down upon the occupants the impurities which a beneficent natural law carried away from them, the instant they were produced, and to mix and churn up the whole mass of the atmosphere, impurities and all, and thus cause an atmospheric *tourbillon* in an apartment, is certainly the furthest removed from comfortable, healthful, scientific ventilation that could well be conceived.

In concluding this first paper, I regret to say that you possess, here, in your own hall, one of the most pronounced examples and illustrations of this crude and vicious method, which consists of the absence of all method, for purifying the atmosphere, and I retain a vivid recollection of the action, at a former meeting, of those opened windows, high up at the back of the hall; the only comfort I can give you is that it would not be a difficult matter to correct the evil.

MR. J. McF. GRAY'S REMARKS.

Mr. Hoey has given a most interesting and instructive lecture upon his favourite subject—Ventilation.

Recognising that the Almighty has given us a heaven of pure air upon earth, he has been telling us how to maintain the air in our dwellings also pure, as that air of heaven. We have all enjoyed the agreeable manner of his address to us, and we observe how, even to his spirit, Ventilation is the very breath of life.

He has pointed out how the air is changed in the atmosphere by the winds in their circuit, and the part played by the evaporation from the sea; and then, how, by imitating nature, we can cause the vitiated air, in clouds near the ceiling in our rooms, to descend and rise again in an exit pipe by increase of buoyancy, while pure air of greater specific gravity is passed in through dado perforations, as invisible waterfalls, on to the floor, spreading out in a layer, gradually lifting the whole air in the room, as the air in a dry dock is lifted when the water is let in, as if it were a solid block, without draughts, until it is squeezed against the ceiling and forced into the exit pipe.

He has referred to meeting currents of air being mutually retarded. This is an important principle to be always remembered when arranging ventilation pipes, uptakes, and exhaust passages. Two streams of air, smoke or steam, ought not to be allowed to commingle until they have been deflected so as to have motion in the same direction. The same principles hold good all through nature, the air-fall from Mr. Hoey's dado, may have a head of pressure equal to only one-sixteenth part of an ounce upon the square inch, while Niagara's head of pressure is 66 pounds upon the same area, yet both are falls of the same character, equally definite in form.

We are all greatly indebted to Mr. Hoey for his present address, and we will look forward to his Second paper as a coming pleasure.

MR. JAS. ADAMSON'S REMARKS.

The racy style which Mr. Hoey has introduced, not only into the Paper itself, but the manner of its delivery, has greatly tended to make the subject-matter highly interesting. The importance of the subject is manifest, and there is, without doubt, very great need for a reform and a Reformer in the direction of providing ventilation—real and efficient—in buildings on shore.

Mr. Hoey having gone to work very energetically, in the direction indicated, we may wish him all success in his crusade; but we look forward in anticipation of his promise being fulfilled, as regards the ventilation of steamships; in the words of Virgil, "*Hoc opus, hic labor est.*"

I thank the author for the interesting Paper he has given us' as an earnest of the one to follow in the course of the autumn.

CHAIRMAN'S REMARKS.

(Mr. G. W. Manuel.)

You had, at a former meeting, the pleasure of an introduction to Mr. Hoey, who has kindly consented to read us another Paper on Ventilation as applied to Steamships, as he has now read one with special reference to Houses and Halls, the principle and practical working of which he has had much experience, and, having heard this paper, I have no doubt we will learn how to enjoy life better by a freer use of the air that surrounds us, and be better fitted for the duties of the day.

The Ventilation of Ships especially interests us as regards cabins and saloons, where so many people are confined in narrow spaces, and I hope these will engage a paper from Mr. Hoey at no distant date.

I have listened to the paper with much interest, and endorse the author's views on the subject so graphically put; a subject so little attended to by builders and architects in the construction of halls and dwellings, and by some *not at all*, that I think it will have to be dealt with ere long by compulsion, and I hope that no house will be *passed* without proper means for ventilation.

I must confess that, brought up in the country where the air is exceptionally *good*, one feels so little inconvenience from want of ventilation, or from confinement in small spaces, that the consequences are heeded but little, for it is only when we are confined in *Cities* where the air is contaminated, that we are forced to pay more attention to these natural laws, on which our happiness so much depends.

I have no doubt we are undergoing a process of *slow poisoning* in *many* ways, both in air, food, and drinks, but the process is *so slow* that we entirely disregard it. In future we may hope it will not be the case as regards air, and the remainder I trust will be dealt with in a similar manner by other reformers.

From the system as explained by Mr. Hoey, so dealing with the admission of fresh air, by bringing it into rooms at a very slow velocity—although in sufficient quantity—and spreading the discharge over a large area, thus avoiding draughts, which are often hurtful, and also raising the temperature of the air in cold seasons, thereby preventing colds, &c., and this method of withdrawing the heated and foul air, from the upper part of the room in such a manner that it does not get mixed with the fresh air, seems to me to be what is required.

We have all learned something to take home with us and apply to our daily wants, and from my own experience (for I have lately had a little experience of house ventilation) I am quite in agreement with Mr. Hoey, and have to thank him personally for calling my attention to the subject, and I trust his system will meet with the success it deserves. It remains for me to ask you to accord a hearty vote of thanks to the author of the paper we have heard.

MR. HOEY'S CLOSING REMARKS.

I have much pleasure in expressing my deep appreciation of the great attention given to the reading of the Paper, and the cordiality of the observations made upon it I had often desired to have an opportunity of dealing with the subject, in the manner adopted to-night, starting with first principles, and building up the argument from the foundation, and rejoice to have been afforded that opportunity. From what I have gathered to be the nature of the Institute, as partaking largely of the character of a Technical College, wherein the elder members constitute a body of professors, with Mr. McFarlane Gray as one of the Principals, I have been encouraged to approach my subject in the manner adopted, by the example set by Mr. Gray, in the observations I have been privileged to hear made by him at former meetings. I hope to be able to devote sufficient time to the preparation of the second part of the subject, dealing with the practical application of the principles now set forth, to the ventilation of every department of a Steamship, in a manner to show my warm sense of the appreciative observations which have fallen from those gentlemen who have spoken to-night, and to exhibit plans that should render the matter clear and plain, for which purpose I have been favoured, by the Honorary Secretary, Mr. Adamson—whose labours in the cause of the Institute are so unwearied and valuable—with a considerable variety of important plans of steamships in actual working.

EXPLANATION OF DIAGRAMS.

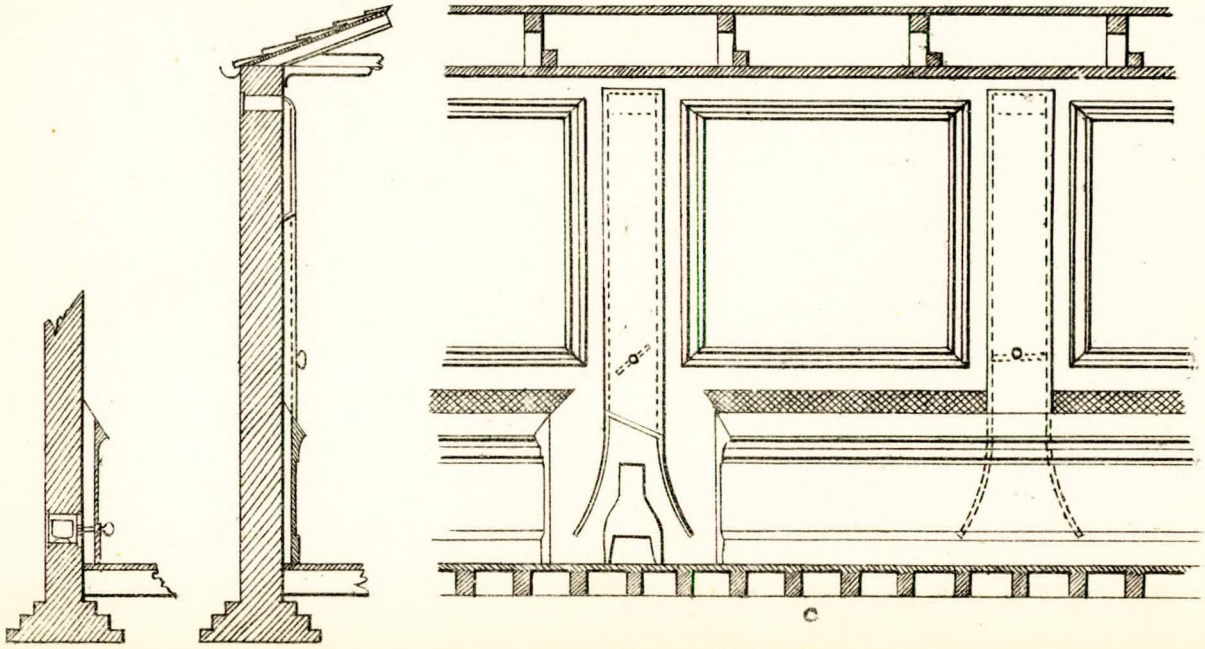
FIG. 1 shows transverse and longitudinal vertical sections of the original application of the system in the Glasgow International Exhibition of 1888. The fresh entering air has ingress through ports, either direct at a low level, as shewn in **A**, or, as in **B**, at high level, leading into vertical ducts, by means of which it is conducted down into the "dado" or reservoir which is shewn most clearly in **C**. This dado or air reservoir is fitted at conveniently available places round the walls, having a narrow space between it and the walls. The air is admitted into the dado or reservoir near the bottom, and where ducts are used they are carried down to this low level, as shown in **B**. The top of this reservoir or dado is covered with wire gauze or perforated sheet metal, which is placed in an inclined position. The air is then conducted by lateral openings into the dado space, over which it spreads. The initial velocity of the entering air is thus destroyed, it fills the space and afterwards percolates through the almost innumerable interstices in the covering gauze and enters the apartment without sensible current, by the operation of the natural law of the imperceptible diffusion of fluids. A vessel is placed in the entrance or at the bottom of the duct, when required, containing a frigorific mixture for cooling the entering air, or it may be warmed, when necessary, by means of hot pipes within the reservoir. It may be purified from smut, &c., or have the normal charge of moisture restored, in sultry weather.

FIG. 2 Besides giving another view of the dado or reservoir, the tube or funnel for taking off the vitiated air is shown, receiving its velocity from a Bunsen Burner, placed at the lower end, and covered on the top by a revolving cowl to maintain regularity of action, and prevent inconvenience in bad weather.

FIG. 3 Is a vertical section of the Glasgow Stock Exchange, shewing the great outlet tube, 45-feet high, driven in like manner and covered in the same way as in the former case. In both cases complete insulation is secured to prevent condensation and loss of upward velocity.

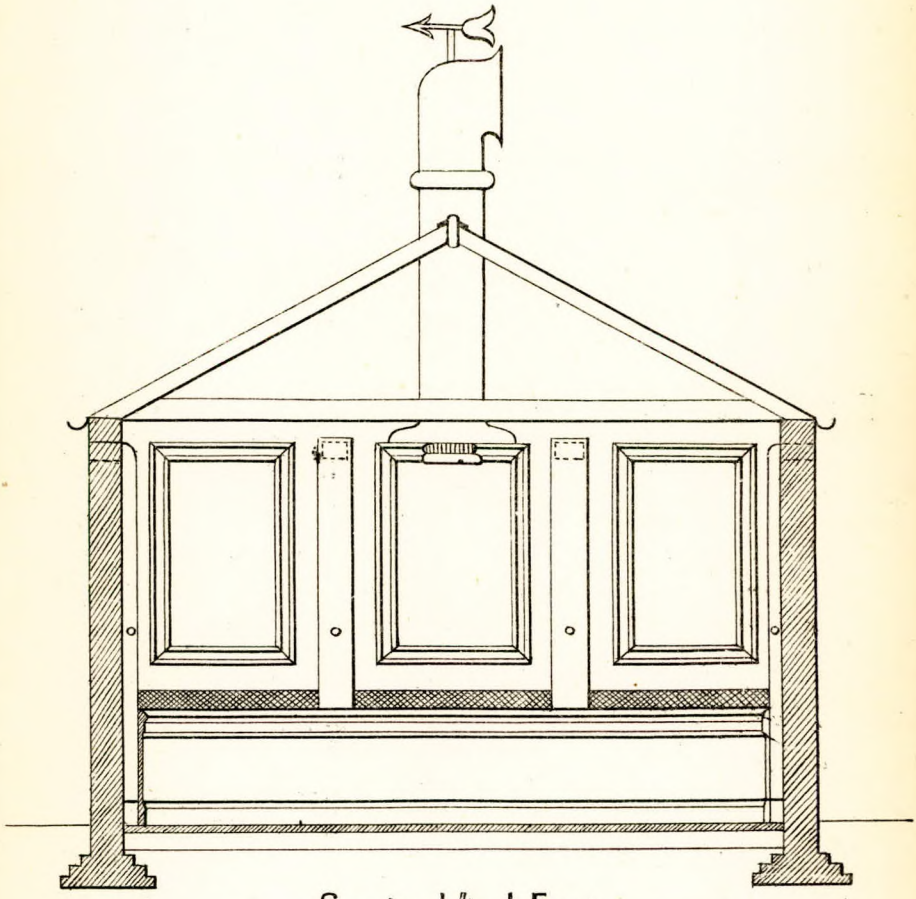
FIG. 4 Gives details of the patent revolving cowl, which turns (1) on a central pivot, accurately adjusted, and (2)—in the event of a deflection of an eighth-of-an-inch—on roller balls or wheels, running on a race fitted along the outer circumference.

Fig 1.



Scale $\frac{1}{4}$" = 1 Foot.

FIG 2.



Scale $\frac{1}{6}$" = 1 Foot.

Fig 3.

Section of Glasgow Stock Exchange with D.G.Hoey's Ventilating Apparatus.

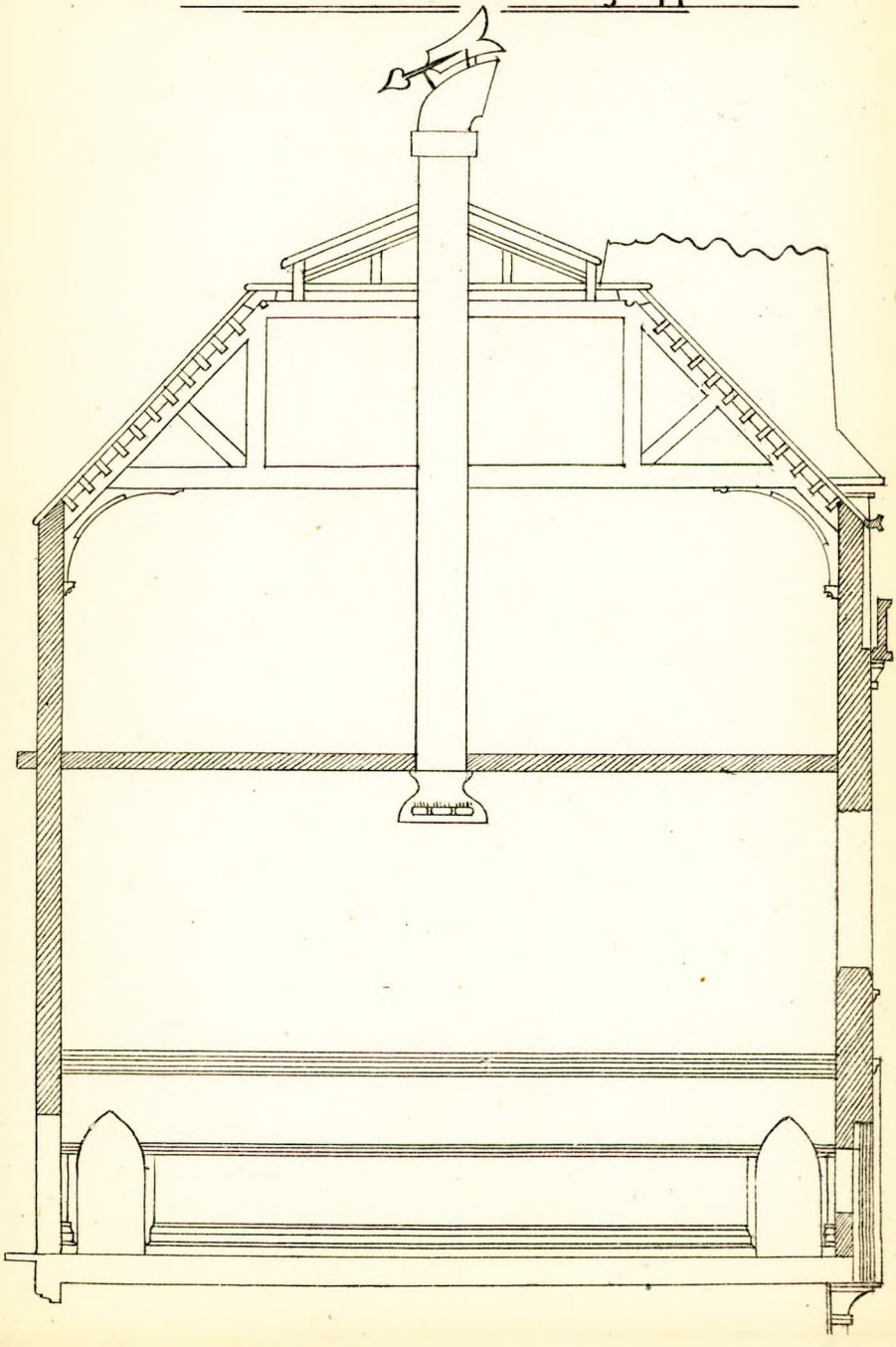
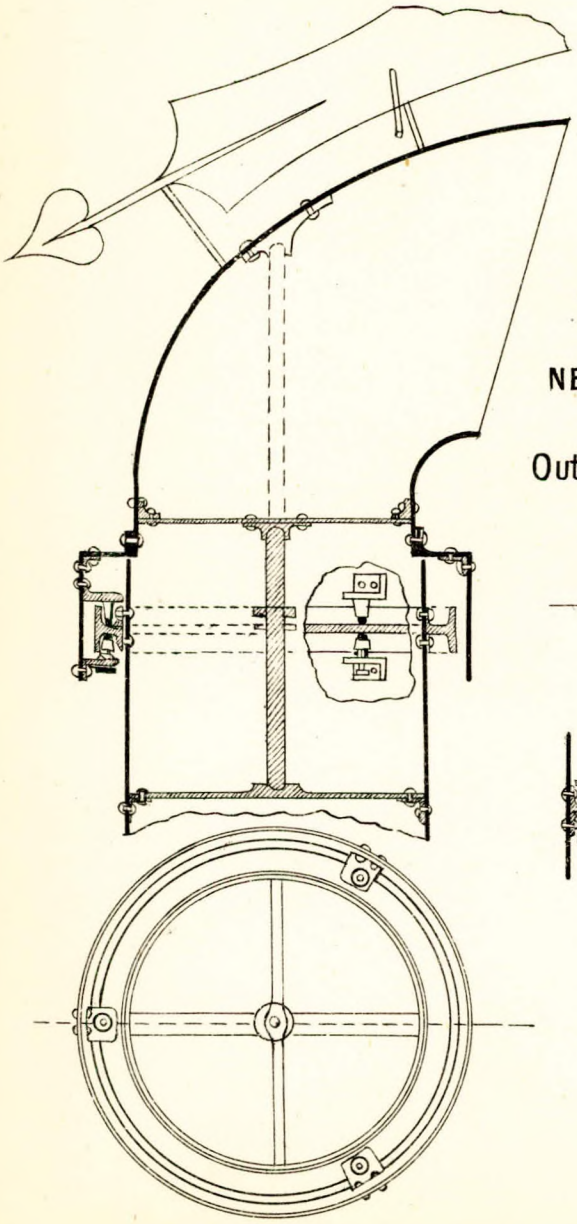


Fig 4.



Diagram

OF

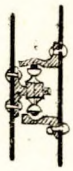
NEW REVOLVING COWL

FOR

Outlet Ventilating Tubes.

BY

D. G. Hoey.



The Langthorne Rooms,
Broadway,
Stratford, E.,
14*th October*, 1890.

PREFACE

A Meeting of the Institute was held here this evening, when a Discussion ensued on several points, raised in the Address delivered by the President at the re-opening of the current Session, after the summer recess, on Friday, September 5th.

The meeting was presided over by Mr. J. H. Thomson.

The Remarks made on the questions, brought forward by Mr. Manuel, will be found in the pages following the Address.

The Quarterly Business Meeting was also held on the 5th September, presided over by Mr. Manuel, when Reports were submitted by the Conveners of the different Committees. A Minute of the proceedings will be found in the pages following the Remarks on the Inaugural Address.

JAS. ADAMSON,
Honorary Secretary.