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AIR CONDITIONING IN HEALTH AND DISEASE

By

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INTRODUCTION

According to P. E. Fausler, an engineer, no group of men should be better qualified to define the atmospheric conditions under which the greatest health or comfort may be secured than those innistering to the physical welfare of man. He continues that it would seem logical procedure for the medical man to define the conditions desired and for the engineer to produce, if able, the desired results.

Air conditioning is of interest because it has much to do with health and the prevention and control of various diseases. It is a universal problem of which the physician should be well informed. He will be asked time and again what the proper air conditions should be, for instance, in the home, office, hospital, etc., and he should be able to give an intelligent answer. These are the reasons why I have chosen this topic for my senior thesis.

More and more attention is being paid to this important subject as time passes and at the present time it is becoming quite an industry in the business world. More and more people are demanding that their homes and offices be air conditioned. In time this new industry will assume larger and larger proportions and will constitute an important business in the future. From a medical standpoint air conditioning is of the greatest importance. The industry itself is based upon medical theories as to health and comfort.

It seemed logical that the history of air conditioning should

include a brief review of the history of fire, heating devices, windows, ventilators, temperature and humidity, and air, since these are the subjects concerned in air conditioning. The order of their discovery is about as listed above and all with the exception of ventilators and the knowledge of temperature, humidity and the composition of the air have been known and used for thousands of years. All have advanced with the development of civilization and in many cases have been the cause of that advancement.

The physical effects of different air conditions are considered as well as the many therapeutic uses of air conditioning.

HISTORICAL

Fire.- During historic times it is doubtful whether any race or tribe was completely without knowledge of fire. Traces of fire appear among the earliest human relics as far back as the beginning of the Paleolithic Age. (16) To be sure, traces of fire, especially in the form of burnt flints, have been found in connection with habitation levels even antedating the lower Paleolithic, for example, in the Pliocene of East Anglia; they have also been reported in Pre-Chellean horizons, but no well defined hearths have been recorded from deposits earlier than the middle Paleolithic Age. (34)

Conflicting with the above statement regarding man's omnipresent knowledge of fire we have stories such as those told by the missionary Krapf, and other earlier travelers to the effect that a tribe in southern Shoa lived like monkeys in bamboo jungles and were totally ignorant of fire. These stories were reported in the middle of the nineteenth century, but no competent observer has yet seen such a tribe. (16)

As to the origin of fire Lippert states that fire enabled man's ape-like progenitor to descend from the trees and walk erect because it gave him protection from other animals. One of man's very earliest discoveries must have been that he could make profitable use of the fire engendered by lightning, falling meteors, the materials ejected from volcanoes, friction developed from avalanches, boulders and other natural occurrences. He probably soon realized the value of a blaze not only for warmth, but for cooking food, warding off beasts and driving game from the jungle.

Thus the use of fire has been known for ages but it was quite sometime later before man was able to control fire. (16)

The relative frequency with which charcoal and other evidences of localized fire maintainance are encountered in the Mousterian horizons points to at least a beginning toward the control of fire. The first steps, however, did not include ability to produce a fire at will. For example, the Tesmanians knew no way of kindling fire but they took great pains to keep it always burning, and if by chance it became extinguished, new fire was borrowed from a neighboring tribe. Similar practices no doubt were in vogue among early Paleolithic peoples. The keeping of the fires was the duty of the daughters. Extinguishing of the fires was an ill-omen and when this happened the daughters were no doubt fully punished. Then, as now, the female of the species had her little "niche" in society. (34)

The first indubital evidence of producing fire by artificial means is afforded by relics from the upper Paleolithic period; these relics include scarified lumps of pyrites and flints suitable for "strike-a-lights." One of the earliest discoveries of this sort was a deeply scored nodule of pyrites found by Dupont in Magdalenian deposits of the Chaleux cave at Furfooz, Belgium. (34)

The uses of fire were perfected and multiplied during the Neolithic period. Methods of curing meats and of cooking were perfected; and among coincident acquisitions must have been hot water for bathing, cooking, and cleansing purposes. Fire tended both directly and indirectly to encourage community life and give

permanency to the home. Without it, for instance, the manufacture of pottery would have been impossible, and the use of pottery is an effective check to nomadism. (8) The transition from the stone age to the age of metals would have been impossible without fire since it is necessary in the reduction of metallic ores. Thus the development of the use and control of fire has paralleled in history the mental development of man.

Heating Devices.- With the development of the knowledge of use and control of fire, the next logical step was the development of heating devices for use in the home.

F. H. Garrison's "History of Heating, Ventilation and Lighting" (20) and J. P. Putnam's "The Open Fireplace in all Ages" (44), have been referred to for the history of heating devices a brief review of which articles follows:

The Assyro Babilonian house was evolved from without inwards, with the idea of defense from nomad enemies and wild beasts; the high wall and courtyard first, then the quadrangular house with fireplace in the middle of the floor. As the fire from the old Greek tripod or brazier sometimes killed by monoxide poisoning, the Romans hit upon the device of a ventilated, extramural, underground heating plant (fornax-furnace) of log embers, leading into a hollow space underneath the floor of the house which was supported by uprights and connected with the walls in all four corners by hollow tiles communicating with similar spaces in the adjacent rooms and upper stories and eventually discharging smoke and gases by an outside vent. This invention attributed to Sergius Orata, 100 B. C., is mentioned by the younger Pliny and

Senica (who also mentioned window panes) and while first applied to public bath houses, became common in the dwellings of the wealthy in 10 A. D.

The oldest specimen excavated was found in the sweating room of the old and new thermae of Pompeii. Others were discovered in the baths of Caraculla, in a villa at Herculaneum, in the Emperor Hadrian's palace at Treves and in the Thermae of St. Barbara in the same city. (circa 286-388 A.D.) Actual smoke pipes are found in the remains of the Saalburg. Hypocaustal heating then penetrated to the northern marches (Germany) and became common in Britain, as evidenced by Roman remains at Dover, Chester, Cirencester, Lincoln and other towns, but died out in Italy during the decline of the Roman Empire.

Although Ctesias (400 B.C.) mentions the burning of natural gas by five worshipers in Asia Minor and although bathhouses in Byzantium were heated by oil from the Caspian Sea Region (about 140⁰ A.D.) heating in the middle ages was effected mainly by the open fire, which in Anglo Saxon houses, was usually in the middle of the room. In Spain, charcoal braziers were wheeled about like the viands in hotels. In Italy, China and India, it is still carried about the person, to become a source of monoxide poisoning or even of cancer.

Porcelain stoves or "cockle ovens" were known in Sweden in the ninth century and during the thirteenth century spread to Germany, where iron stoves were well known by 1500. Chimneys, a necessity of the inset or walled fireplace, and which we have already noticed existed in Pompeii, were not revived in Italy

until the fourteenth century. In medieval France, the fireplace, with highly ornate mantelpiece and chimney, became the motif. The most important type for reflecting heat was the high vaulted fireplace of the Turks and Persians. The original cooking stove was a pit of stones heated by fires underneath, like an army incinerator. From these stone ovens or furnaces were evolved. In the castle of the Teutonic Order at Marienburg, a number of subterranean furnaces of this kind were employed for central heating during the thirteenth to seventeenth centuries.

The seventeenth century is remarkable for the correct proportioning of the fireplace, chimney and mantel by Dr. Louis Savot, who in 1624, cut down its width and added a smooth flue for smoke abatement.

In the eighteenth century, the discovery of the gases of the atmosphere by Black, 1757-1772, Priestly 1771, Scheele, 1771, and Lavoisier, 1775, the physiology of respiration begun by Boyle, 1660, Hooke, 1667, Lower, 1654, and Mayow, 1668, and completed by Black, 1775, Priestly, 1772, Lavoisier, 1775, Laplace, 1780-1785, and Lagrange, 1791; the invention of three thermometers of Fahrenheit, 1714, Reaunier, 1730 and Celsius, 1742, and the steam engine by Watt, 1765, of the viable gas jet, 1779, and the Argand burner, 1784, gave a new impetus to heating and ventilating

From such inventions as Benjamin Franklin's inverted smoke flue in 1763 and Count Runford's investigation of hearth fires in 1796, the modern stove was evolved. Hot air heating became common in the Neues Palais at Potsdam, 1740-1786, the City Theatre and the Lunatics Tower of Vienna, 1765-1790, and the clinic at

Mainz in 1792. The use of both hot water and steam heating in greenhouses was the first step toward modern heating.

Central hot air heating of buildings by stoves of boiler brass invested with a shell of masonry and placed in the cellar was in vogue up to 1824 and still is in many single room buildings with a few minor changes. During 1801-1808, Sir Humphrey Davy, produced a variable carbon electric arc light. The union jet or fishtail gas burner was invented by Nielson of Glasgow in 1820. Carnot's treatise on the motor power of heat, 1824, with subsequent investigations by Mayo, Joule, Helmholtz and others created the modern science of thermodynamics. Bischoff introduced a successful gas heater in 1839, and in 1847, James Young, distilled petroleum, which was in use as an illuminant, etc., in 1853. Central heating came into vogue in Germany about 1870, and was operated by low pressure steam (0.3 atmosphere) by Bechem and Post in 1878.

The Welsbach burner was perfected during 1885-1893. In 1886 and 1896, the American and German Societies of Heating and Ventilating Engineers were respectively founded. Electrical heating, which by the way is the probable source of heat for the future, was introduced as early as 1892, by Crompton and Co., London. Electric lighting was in full swing in the United States by 1914 and was improved by Edison, Nernst, Finsen, Bolten, Tungsten, Ultraviolet and radium lamps.

Central heating by steam was first applied on a large scale by Holtz at Lockport, New York in 1880. Central heating by natural gas had been in common use in the western states and was in use

in New York as early as 1821.

Windows.- The Encyclopedia Britannica (16) and MacCurdy's Human Origins (31) provided the history of windows presented here.

Windows are obviously a very ancient invention, probably almost coincident with the development of fixed and enclosed houses, particularly in those parts of the world where courtyards were of little importance. Where courtyards were of importance several rooms around this central area opened directly into the yard and no windows were necessary.

Representations of windows occur alike in early wall paintings in Egypt, reliefs from Assyria, and terra-cotta plaques from Crete. The Egyptian examples show openings in house walls covered with mattings, like the doors, as in the V Dynasty tomb of Ti. Well known examples of Egyptian windows also exist in the hypostyle hall of the great temple at Karnak, built by Seti I and Ramesis II, and in the so-called pavilion at Medinet Obu, nearby. Many such windows were found in the palace reliefs of the ninth and eighth centuries, B.C.

That the above windows were merely for ornamental purposes and to let in light is proven by the fact that when the Greek civilization developed somewhat later a return to the house built around a court was made with consequent disappearance of windows. Windows were either in style or they were not with no regard for ventilation. The temples of this period were also without windows which is further evidence that windows were merely a matter of style.

In Roman imperial times the glazed window first definitely

appears, and fragments of glass in a bronze frame have been found in Pompeii, as well as many other fragments of glass in the remains of Roman villas in England. Moreover, it is obvious that the great windows in the Roman bath halls must have been enclosed in some way in order to retain the heat. In addition to glass the Romans are known to have used thin sheets of translucent marble, panes of mica, shells and horn. In and before the fifteenth century the windows were of the swinging casement type, but in the seventeenth and eighteenth century these were superseded by the type of window known as the "double hung" which is the same as the common modern window.

A great difference in window design between the orient and the west is due to the almost total lack of window glass in oriental windows.

It is interesting to note that in England in 1696, during the reign of William III, windows were taxed.

Air.- Charles Singer (49) informs us that Boyle in 1654, showed by means of his air-pump, that air was a material substance and could be weighed, that Mayow in 1668, proved that a part only of the air was necessary for life and that this part was removed equally by respiration and combustion. He also informs us that Stahl at this time came out with his phlogiston theory and set back the hands of the clock.

Some years later, 1760, Sir James MacKenzie (35) in his "History of Health," quotes Dr. Arbuthnot, who in 1738, wrote probably the first account of the importance of air to health as follows; "Every human creature, whose manner of life demands,

and whose constitution can bear it, ought to inure himself to the outward air in different sorts of weather. In the choice of habitations for mankind, the wholesomeness of the air is a principal consideration and is as much a particular in the purchase of a site as the soil. The local qualities of the air depend upon the exhalations of the soil, and of it's neighborhood which may be brought there by the winds. The air of cities is unkind to infants and children, for every animal, being by nature adapted to the use of fresh and free air, the tolerance of air replete with sulphurous steams of feul, and the perspirable matter of animals is the matter of habit, which young creatures have not yet acquired."

"The first care in building cities is to have them airy and well ventilated because infectious distempers must necessarily be propagated amongst mankind living too close together."

MacKenzie goes on to state that the air is extremely tainted by having burial places within the precincts of great cities; that private houses ought to be perflated once every day, by opening doors and windows to blow off animal steams. Houses, for the sake of warmth, fenced from wind and where the carpenters work is so nice as to exclude all outward air, are not healthy; for people who pass most of their time in houses whose air is tainted with steams of animals are frequently infected with nervous distempers.

In the summary of the same book Dr. MacKenzie states that the most healthy site for a house is on a gravelly high ground in a rather dry area. The rooms should be pretty large but not cold

and the house should be so arranged as to be easily perflated by the east and north winds. He states further that that air is best which is pure, dry and temperate, untainted with noxious damps, or putrid exhalations from any cause whatever; but the surest mark of a good air is the longevity of it's inhabitants.

No advance was made until the work of Joseph Black (49), which appeared soon after the middle of the eighteenth century. At this time he proved that carbon dioxide, which he formed from lime, was a normal constituent of the atmosphere. Henry Cavendish (1731-1810), further investigated the properties of CO₂. The next great advance in the chemistry of air was made by Joseph Priestly (1733-1804), whom Sir John Pringle, states prepared oxygen, in 1774, by heating certain oxides, though, still hampered by the phlogiston theory, he failed to recognize the nature or uses of the oxygen he had produced. It remained for Antoine Laurent Lavoisier (1743-1794), to give us the modern viewpoint in our knowledge of the air. He discovered the true composition of fresh and respired air, and showed how both CO₂ and H₂O are normal products of the act of breathing.

Humidity and Temperature.- Following the discovery of carbon dioxide by Joseph Black in the middle of the eighteenth century the more or less general belief developed that discomfort in closed rooms resulted from the increase in the carbon dioxide content of the air.

Max Pettenkopfer (39) working under the above illusion made many studies along that line and is probably the earliest authority on the subject. He attempted to determine what the amount of CO₂

put out by each person was and what percentage of the air, in a closed room, could be so contaminated without causing discomfort to the inmates. He found that when the respiratory CO₂ reached 0.04 per cent, the air was rather close, the organic matter was becoming perceptible to the sense of smell and injurious to health. Later, 1862, Pettenkopfer showed the CO₂ content of the air was not important in itself but was a good indication of the amount of organic matter thrown into the air by animal surfaces. He concluded that this organic matter was the cause of the ill-feeling produced by a closed occupied room. This idea is not original with Pettenkopfer, in fact, according to Winslow (56), the theory that miasmatic vapors of the atmosphere were the chief cause of epidemic diseases dates back to the days when Hippocrates lighted fires in the streets of Athens to purify the air and put a stop to the plague.

At about the time Pettenkopfer was doing his work with CO₂, Brown Sequard and D'Arsonval, as Winslow (56) tells us, came forward with their theory that the harmful effects were due to a toxic organic volatile substance the result of respiratory processes which they called Authropotoxin. This hypothesis held until quite recently and in fact was supported, at least to some extent as late as 1923, by the work of Sewall and Gutstien (50), who succeeded in sensitizing guinea pigs to rebreathed air and who concluded that the discomfort produced by a closed room was an anaphylactic reaction.

Although Hermans as far back as 1883, had reached the conclusion that the harmful effects of bad air were due, not to it's

chemical but to its physical properties and though Flugger (46) in 1905 had shown that the phenomenon was cutaneous and not respiratory we still have accounts as late as 1918, which state that the effect is not due to physical conditions of the air. Such a statement was made in 1918 by S. J. Baker (3). Baker made an extensive investigation based upon 5,533 school children in 73 classrooms in 12 schools operated under three different types of ventilation, conducted during a five month period in late fall, winter and early spring. It was his desire to determine the relationship of upper respiratory infection to the different types of ventilation. He concluded from this study that humidity had nothing to do with the health of the children and that natural ventilation was more beneficial than artificial ventilation.

Carlos I. Reed (46) points out the historical work of Savarret who in 1851, showed that when O₂ was supplied and CO₂ taken away to keep up the normal constituents of the air in a chamber in which animals were confined, the animals died anyway. He also presents the work of Lebanc, who showed that the O₂ of an occupied room seldom fell below 20 per cent, and the work of Regnault and Reiset who showed that it was necessary to reduce the O₂ content of the air to 10 per cent to cause labored respiration.

The great majority of physiologists today accept the view that the harmful effects of bad ventilation (apart from the presence of industrial poisons and industrial dusts) are no more the result of hypothetical organic poisons than of changes in concentration of oxygen and carbon dioxide. They are due to the other two effects of human occupancy, increase in temperature and moisture,

combined with lack of air movement-conditions which, in combination produce a serious interference with the heat regulating mechanism of the body. (12) The experimental data supporting this view will be presented in the body of this paper.

Ventilators.- That movement of the air was known to be important to health hundreds of years ago is shown by a review of the writings of Sir James MacKenzie in 1760 (35), Dr. Arbuthnot in 1738 and many other early scientists.

Stephen Hales (22), in his book "A Description of Ventilators" published in London in 1743, gives us the first description of ventilators. His work was primarily for the betterment of air conditions on board the "men-o-war" ships. Rev. Hales expresses the purpose for this work very clearly in the following paragraph taken from the original thesis: "There is no doubt but it will fully answer your Lordships tender care and concern for the welfare of navigators, as it will contribute much to their health, by supplying them, in exchange for a very noxious, with plenty of fresh air, that genuine cordial of life. For that wonderful fluid the air, which, by infinite combination with natural bodies, produces surprising effects, as it is on the one hand when pure, the chief nourisher and preserver of life of animals and vegetables; so, when foul and putrid, it is the principle of their destruction" Prior to the invention of ventilators by Hales, the decks of ships were purified by sprinkling them with vinegar, by hanging up cloths dipped in vinegar, and in case an infectious "distemper" should be in any ship the infection was cured with the fumes of burning brimstone.

Hale's ventilators consisted of two large bellows placed side by side with pipes leading from them to the various deck rooms to be ventilated. At the exit of each bellows a valve was so arranged that on compression the air in one was allowed to enter the system of pipes, now, as the other one is being compressed the first is sucking air out of the room through a second set of pipes and visa-versa. This machine was run by manpower and Rev. Hales had the shifts of men worked out so that practically no more men were needed on the ship to keep the apparatus in operation than were formerly employed on a ship of the same capacity and manpower.

A few years later Rev. Hales applied the windmill to work the bellows and he then ventilated by this means, and quite successfully, many of the important buildings of London.

The ventilation systems of today are merely modifications of Hale's with, of course, the use of electrical fans etc., in place of the bellows.

MEDICAL ASPECTS OF AIR CONDITIONING

The Optimum Physical Air Conditions.- Ellsworth Huntington (25) has shown by a study of hospital records at the Boston City Hospital and Massachusetts General Hospital, that all kinds of ailments show a surprisingly close correlation with temperature, humidity and variability. That different types of disease, however, respond differently. He found that for surgical operations the best conditions, as indicated by the records of these hospitals, is high humidity, 80 per cent or more, directly after operations, and moderate humidity, about 60 per cent at a temperature of 64 degrees F, a few days after the operation. He states that these conditions can be easily produced artificially by blowing warm air through an air washer and that the mortality in operative procedures would be reduced about 20 per cent by so doing.

In another study by Huntington, it is stated that constant, but not excessive variability of the air conditions appears to be beneficial in almost all diseases, as well as for persons in good health.

Konrad Miller (32), states that for indoor humidities of 40 to 60 per cent (relative), the death rate was lower and that a humidity of 80 per cent, as suggested by Huntington, would be oppressive indoors, and is not advisable. He also differs in his views on changes or variability of the temperature stating that a more even temperature is best.

To Hohn R. Allen (1) the most important items in air conditioning are temperature, humidity and circulation and he adds two

more to the list namely dust and bacteria. He affirms that no outside air is needed except for reducing the temperature and for circulation and that good ventilation equipment is needed for this.

According to Beard, Palmer, Mazyck (37) and others, the important thing in proper ventilation is to insure a definite amount of cubic space per inmate of a room and see that a certain amount of fresh air is supplied each hour. They state that each person should have from 1,000 to 2,000 cubic feet of space. In hospital wards this space is supplied by having the beds at least four feet apart in rooms which have a ten foot ceiling.

Dr. E. R. Hayhurst (24) believes that air space is not as important as temperature, humidity and movement. He states that the temperature for those who are normal should be from 68 to 72 degrees F. For those having a fever the temperature should be 60 degrees F, with a wet bulb reading of 10 degrees F below this, with a relative humidity of 50 to 60 per cent. The movement of the air should be about two feet per second, but should be about twice this if the patient has a fever. This desired movement, he states, is best provided for by the use of a small oscillating fan or a baffled window ventilator. He also states that the distance between beds in a ward is very important in preventing droplet infection. He advises that if there are no screens between the beds they should be 12 to 18 feet apart. If screens are present 8 feet apart is sufficient. Good lighting according to this author is even more important than space and a patient would be just as well off in a cubby hole

as in a large pavillion providing it was well lighted and well ventilated.

E. Vernon Hill states that cubic space is a minor detail, that clean air is the important thing though he offers no methods for doing this cleaning.

Dr. C. E. A. Winslow (56), agrees with Hayhurst, that the essential thing is maintaining a temperature not above 68 degrees F, with good air motion.

The principle objects to be accomplished in conditioning the air, according to McConnel are: (a) removal of solid or liquid matter in the form of dust or spray and elimination of soluble gasses and vapors including those of disagreeable odor; (b) addition of moisture where necessary to give the desired humidity. He points out the study of "The American Society of Heating and Ventilating Engineers, U. S. Bureau of Mines", and "The U..S. Public Health Service" who, by a long series of studies on human beings, found the optimum temperature, as regards physical well being, to be between 63 to 71 degrees F for healthy persons. He states that the air may be heated or cooled by passing it through heated or cooled water as it is desired. If the water temperature is low the air is dehumidified and visa-versa and the air may be heated after it is dehumidified, etc.

Ivan L. Barach (4), states that human comfort depends entirely upon the rate of heat production within the body and the rate at which that heat is removed, that the body loses heat to the atmosphere by radiation, convection, as well as by evaporation of moisture from the surface of the body. He found from a study

of the experimental work of "The American Society of Heating and Ventilating Engineers," that still saturated air at 91.5 degrees F resulted in a definite rise in temperature of the body with moderate increase in pulse, profuse sweating, weakness and dizziness. At 95 degrees F the temperature of the body rose to 101.5 degrees F, the pulse was 50 beats above normal with a fall in both systolic and diastolic blood pressure, and weakness and exhaustion were pronounced. At 100 degrees F in saturated air, the effects were still more pronounced, with a fall of diastolic pressure but a rise in systolic. The pulse was elevated to 134 to 184 beats per minute, with added restlessness, irritability, conjunctivitis, headache, vertigo and confusion with exhaustion. His very logical conclusion was that since the air was saturated with moisture the perspiration could not escape from the surface of the body and hence cooling of the body by evaporation could not take place.

Winslow in testing the efficiency of typists found that the amount of work done by them was 6.3 per cent greater at 20 degrees C than at 24 degrees C. In manual laborers he found that 15 per cent more work was done at 68 degrees F than at 75 degrees F and 37 per cent more than at 80 degrees F. He also found that more work was done outdoors in a breeze at 75 to 79 degrees than indoors at 72 degrees with no breeze. This last finding bears out the point stressed by most of the above men, that air motion is of great importance, this we have seen was recognized hundreds of years ago.

C. A. Mills (33), who made a geographical study of appendicitis

found that acute appendicitis has a tendency to occur most frequently where storm temperature changes are the widest, and to be most deadly during the summer heat waves. The fatality rate for the disease is highest in the Gulf States, 13 per cent, and diminishes steadily toward the north being 5.2 per cent in Canada. Resistance to infection, he continues, seems lower in hot weather and operative risks are greater. He points out the danger of postoperative pneumonia which may result from cooling with fans and that the cooling must be done more indirectly for instance by refrigeration plants. There are, however, certain conditions that are benefited by summer heat such as toxic goiter, diabetes, and arteriosclerosis. Evidence is also accumulating which tends to show that sudden drops in barometric pressure causes attacks of appendicitis, homicides and suicides, so this phenomenon must also be given some attention in air conditioning.

A. S. Bacon (5), would even go so far as to do away with the open window in hospitals since the conditions of the air by the window ventilation is too variable and allows dirt, pollen, bacteria and noise to enter the room unmolested. He would seal up the windows with triple glass panes allowing only light to enter through them and do all his ventilating artificially. He states that the air may be automatically heated, cooled, filtered and humidified by the use of specially built machines for this purpose.

Returning again to the question of the observed effects of poor ventilation we are informed by Fluggee (46), that the ill-effects are due to increase in temperature and humidity. Hill (12) con-

firmed these results. The New York Ventilating Commission (46), found that vasotone was increased at 20 degrees C, 50 per cent relative humidity and decreased at 30 degrees C and 80 per cent relative humidity.

Lowering of the vasotone, the commission states, interferes with the ready adaptation of the vascular mechanism to changes of position or reflex stimulation.. This would unquestionably be a factor in the early onset of fatigue, in that muscles and other organs might not be readily supplied with blood.

This New York Commission, according to Reid (46), also found that from 85 to 90 per cent of all heat loss takes place through the skin. By raising the temperature from 7 degrees C to 30 degrees C the heat loss by radiation was reduced 58 per cent, but partial balance was maintained by an increase of 300 per cent in the heat lost by evaporation. However, the total metabolism measured in calories is cut down 35 per cent and the percentage variation is greater at higher temperatures. If at the same time that the temperature is increased the relative humidity is also increased the amount of evaporation is lessened and hence the efficiency as shown above. This results in vasodilatation and the muscles and brain become anemic with consequent vertigo, weariness and lassitude.

E. R. Hayhurst (24), who carried out a series of air conditioning experiments in homes concludes that the proper conditions for air are 68 degrees F with a relative humidity of from 40 to 60 per cent. Burning of natural gas, he states, is best because it in some way, probably by the oxidation of hydrogen in the gas

produces a relative humidity of 40 to 60 per cent in places where the outdoor humidity is even lower than 40 per cent. Another of his observations is that when the temperature out-of-doors is above 32 degrees F the relative humidity in homes is usually between 40 to 60 per cent which is adequate but when the outdoor temperature falls below 32 degrees F the additional heating necessary causes a drop in the humidity and artificial means of supplying moisture are needed. This author has devised an atomizing device which attaches to the water supply and leads into air ducts where an electric fan promotes circulation. This is an automatic arrangement and is alleged by the inventor to be very efficient.

W. D. Pierce (40), studying air conditioning along the same lines as Huntington (25), suggests that temperature and moisture conditions be controlled in the Hospital to meet the needs of the specific diseases at hand. Whereas Huntington outlined only the conditions of temperature and humidity suitable for operations, Pierce, attempts to outline the proper air conditions for all different types of diseases. For example, he suggests dehumidifying the air in rainy weather for rheumatic and asthmatic patients, pure fresh air for lung diseases, moderately moist air for fevers and with chill and fever control of the air in the opposite direction, i.e., if the patient is having a chill increase the temperature and visa-versa.

W. D. Pierce (40) terms the human comfort zone the "practicotatum" and defines it as being bounded by a relative humidity of from 32 to 55 per cent and a temperature of from 55 to 70 de-

degrees F with an average of 43.5 per cent relative humidity and 63 degrees F. He also brings in the atmospheric pressure factor and states that it should be under 30 to 31 inches for ideal conditions.

W. J. McConnell (36), unsatisfied with many of the reports regarding the physiological effects of the different air conditions has emphasized the fact that as many bodily functions as possible must be determined in any study of proper air conditions because frequently, in experimentation, it is the unexpected thing that happens. He recommends that besides blood pressure, pulse rate, temperature and basal metabolic rate, the physiological phenomena that are usually determined, the lactic acid, blood sugar, blood counts, hemoglobin, H ion concentration of the blood, agglutinating and hemolyzing power of the blood, resistance of the red cells to laking by hypotonic salt solutions, chloride concentration and the bicarbonate in the plasma should also be determined.

We turn now to a more recent article by C. E. A. Winslow, to whom we have referred several times previously, since he seems to have done most of the work along this line and to have written more on the subject than anyone else. He states that moderate or high temperatures combined with high humidities, tend to interfere with the normal function of heat loss which gives rise to discomfort. A burden is thrown on the heat regulatory mechanism with a resulting increase in body temperature, an increase in the rapidity of the heart, an increase in the rate of breathing and a fall in the general tone of the circulatory system. He explains the lack of heat loss by stating that high humidity

militates against heat loss through evaporation of water from the skin and a high humidity will, therefore, reinforce the harmful action of a high temperature. He observed that a room without any fresh air supply containing the odoriferous constituents arising from respiration and from the bodies of the occupants had no demonstrable effects whatever on comfort, body temperature, heart rate, blood pressure, respiration and certain other carefully observed physiological functions. Mental efficiency was not affected either, patients doing as well in stagnant air as in fresh air though the appetite was decreased. Because of the loss of appetite he recommends that there be a change of air often enough to get rid of the odoriferous effects.

As a result of a careful study of school health records in the New York schools, Winslow, found that there were more absences from school due to upper respiratory infections in schools using the plenum fan ventilation system than in schools using the window system. This, he concludes, is due to the fact that with the fan system the air has to be heated slightly higher to keep up the circulation, this in turn reduces the relative humidity and causes irritation of mucous membranes due to the drying out effect on them. He points out another advantage in window ventilation to the effect that in rooms thus ventilated the walls are cooler which allows for cooling of the body by radiation.

Another study of the kind just described was made by George T. Palmer.(37) In his study the rooms having plenum fan ventilation and gravity exhaust were voted "cold" by a group of blindfolded nurses. He did not attempt to explain this in his thesis

but I believe it must have been due to a low relative humidity since no attempt was made to control this factor.

Temperature, air movement and humidity are again the three important factors according to Fisher (18), who states that the temperature should be between 68 degrees and 70 degrees F but should not be held steadily at this level because changes tend to tone up the circulatory system. Cool, moving air stimulates the nerve endings in the skin and promotes activity in the individual which is necessary to keep the circulation active. He states that colds are not due to draughts but to the lack of them in polluted air where germs multiply except that they (draughts) have a cooling effect with consequent contraction of the blood vessels giving the germs which must be present a chance to multiply. Dust, he continues, is harmful and should be removed by means of air washers and filters. On this account he favors artificial ventilation which will also keep out bacteria, obnoxious odors and noise.

Fisher's contention that cold air is conducive to infections of the upper respiratory tract is borne out by the work of Miller and Noble. (31) These experimenters using a salt suspension of Bacillus Bovicepticus, which is pathogenic to rabbits about the same as pneumococcus is to man, exposed the nasal mucosa and throats of rabbits to temperatures of 20 to 56 degrees F for one to three hours after they were sprayed with these bacilli. These rabbits were also drenched with water. A second series were exposed to warmer atmospheres and a control series was run.

Of those exposed to cold and wet, 40 per cent reacted and only

24 per cent of the controls or those exposed to cold but not to wet reacted. Their conclusions were that any marked changes in temperature predispose rabbits to this infection, the severity of which varies with the amount of change and that a change from a low to a high temperature has an even more marked effect than that from a high to a low temperature.

S. R. Douglas and Leonard Hill (12) using mice instead of rabbits and doing the same type of experiments as Miller and Noble, found that cold caused a condensation of germs and mice were much more readily infected when placed in cold chambers than when in warm ones. They also found that relative humidity had no effect on the number of colonies that would grow on petri dishes exposed to the same temperature with different humidities. They were able further, to prove that dusty air on hitting infected surfaces carries away microbes from those surfaces and in this way helps to spread infection. Massive spray infection, they conclude, is much greater in a room with the windows closed than in one with the windows open. A moist room caused less infection than a dry room.

Hilding (24A), found on experimenting with dogs and rabbits that, in general, the ciliated epithelium either of the sinuses or of the nasal chambers could be readily changed to the stratified type by merely increasing the exposure to air. There were also inflammatory changes closely resembling the changes found in specimens taken for biopsy in cases of common cold. If this change is due to change in temperature, (which the author fails to state), then these findings bear out the work of Miller, Noble

Douglas and Hill.

Baetjer (6), knowing that air movement was important attempted to determine at what rate air could be circulated through a room without it being felt on the cheeks of it's occupants. He defined the greatest current of air which could be so circulated as the threshold air current.

The value of the threshold velocity, he states, varies with the temperature but is independent of the humidity of the current of air. The threshold value varies from 0.15 to 0.65 meters per second with current air temperatures varying from 12 to 30 degrees C. When the current air temperature equals normal room air temperature, the threshold velocity varies from 0.2 to 0.3 meters per second.

Another interesting finding which may prove of great importance in air conditioning is that of Dr. Kinlock (27). Using an electroscope he showed that exhaled air when passed through this instrument had lost it's ions, also air passed through a rubber tube was deprived of it's ions. It is evident therefore, that should the ionic content of the air have any benignant effect on human well being, it's treatment in any modern system of artificial ventilation serves but to deprive it completely of such energy content.

Besides attempts to purify the air by means of filtration, dehumidification, etc., various substances have been introduced into the air with the idea of purification. Of those mentioned, ozone is the most popular. In the Public Health Reports (43), there appears a review of several of the experimental works on

ozone in ventilation. The concensus of opinion was that concentrations suitable for ventilation result in some bacterocidal power though this is not marked. Ozone was harmful when in great enough concentration to be smelled. A concentration of 0.1 mgm. per cubic foot of air has an invigorating effect and purifying effect. It has no effect on dry bacteria or dust particles. It does have a germicidal effect on moist bacteria. Experiments showed that bacteria failed to grow in air which contained 0.6 to 1 per cent ozone by volume. The most marked effect noticed in these experiments was absence of odors.

Edward C. Rosenou (47), by a series of tests showed that a healthful, relative humidity of from 40 to 50 per cent in double windowed houses and about 25 to 36 per cent in single windowed houses can be readily maintained without attention throughout the heating season. This is obtained by bringing the requisite large area of moist surface, in the form of parallel, vertical sheets or fins, into the currents of air produced by heated radiators or other heating units, thus evaporating water continuously proportional to the amount of heat radiated, and inversely proportional to the amount of moisture already in the air. The fins are kept cool by running water so that excess moisture is not thrown into the air by overheating them. By simply increasing or decreasing the number of fins, the humidity can be increased or decreased at will.

Returning again to air conditioning in hospitals and it's effect on different diseases, we note a list by C. A. Mills (33), which defines a few of the many conditions in which air condition-

ing is very helpful. These are as follows:

1. For infants, especially the premature and delicate.
2. For children with summer diarrhea and other debilitating conditions.
3. For patients suffering from heat stroke or exhaustion, heart failure, etc. (A cool room)
4. For surgical patients, especially to obviate the deliterious effects of summer heat.
5. For bronchitis, hay fever and asthma, etc. (A dust and pollen free air)
6. Humid warmth for such over stimulative diseases as hyperthyroidism, severe cases of diabetes and pernicious anemia; also for excitable nervous states.

Mills (30) and Willard agree that the above conditions can be adequately cared for by the use of artificial ventilation.

Willard states that the relationships between temperature, humidity and air movement can always be altered and thus obtain comfort for any type of patient. Thus if the temperature is above 70 degrees F and is too warm for the patient the relative humidity should be decreased below 30 per cent or the air motion increased above 150 feet per minute and visa-versa. About the best apparatus thus far described for necessary dehumidification is that described by Drinker and Thompson. They have devised an apparatus which consists of a spray of water at 32 degrees F, through which, the air must pass before entering the rooms, the temperature of the room being held constant.

The Prophylaxis and Treatment of Hay Fever, Asthma, and

Pneumokoniosis by Means of Air Conditioning.-- Cohen (9) using rooms made pollen and dust free by means of mechanical filters has been able to eradicate the symptoms of simple hay fever in twelve to twenty-four hours and those with asthma in two to five days.

Leopold (29), in discussing the types of patients for whom it is feasible to produce dust free rooms, mentions the following:

1. Cases of dust asthma with nocturnal attacks, which are unrelieved despite most painstaking investigation and attention to house and bedroom environment.
2. Cases reacting to house dust when attempts at specific desensitization with the particular dust have brought no relief.
3. And patients having hay fever or pollen asthma in whom specific desensitization cannot be used, or has been tried with complete failure.

Van Leewen (53), thinks that all asthmatics are sensitive to air-borne substances, many of them unknown in origin and composition. He has constructed so-called miasm free rooms, ventilated by suction fans, which take the air from a height of fifty feet or more above the house tops and filter it through cotton, the air being chilled before it is filtered to cause small particles to clump together. He reports that asthmatics may be divided into two groups: (a) a group which remains asthma free when breathing miasm free air ten to twelve hours daily, and (b) the other, a group which requires several days of continuous breathing of such air to become symptom free. Once free, individuals in this group

may also be outside for a variable number of hours daily without recurrence of symptoms.

Rappaport, Nelson and Welker (45), were not quite as successful as Van Leewen and some of the others in their work with miasm free rooms. Only 83.2 per cent of their cases of uncomplicated hay fever became symptom free. In 7.5 per cent no relief at all occurred and in 13.9 per cent night attacks occurred. They found that the heavier the dose of pollen to which one was subjected, the longer the time required for relief of symptoms. It took much longer at the height of the pollen season.

For these men cases of pollen asthma responded very slowly and in most cases only partial relief was obtained. Recurrence of symptoms were prompt on exposure to pollen.

Vaughn and Cooley (54) using the standard frigidaire air conditioner, were able to relieve the symptoms of one patient with hay fever. During the three days the patient spent in the conditioned room the pollen count was zero. At the end of 24 hours in the room the patient was about 25 per cent improved, at the end of the second day he was 50 per cent improved and at the end of the third day he was about 75 per cent improved. After he had been out he suffered a return of symptoms in about 48 hours. He was then placed on cosiasonal ragweed desensitization with approximately 75 per cent relief. Therefore, the conditioned room was just as effective in relieving the symptoms as the desensitization treatment though, of course, not so lasting.

Kahn and Grothaus (26), have found that patients, who are reacting to a substance but whose skin tests are negative to it,

often show a positive skin test to that substance after placing them for awhile in antigen free rooms. This aids very much in diagnosis and, since the length of time it takes for symptoms to disappear depends upon the severity, the treatment may be judged accordingly.

Gay (19), using the general motors frigidaire unit, was able to produce a pollen free room in which the temperature was 10 degrees F below out-door temperature and the humidity was 40 per cent.

Ten patients at a time, suffering from hay fever were brought into the room. A striking change was noted in the patients in from 10 to 15 minutes. Within one hour the symptoms had entirely subsided and after two hours there was no evidence of hay fever. The patients, at the end of two hours, were returned to their own rooms and within 15 minutes were as miserable as they were before they went into the air conditioned rooms.

Patients with pollen asthma did not respond so well but within an hour their conditions were strikingly improved and they were able to sleep after they had been in the conditioned rooms for 36 hours with very little coughing.

They also found that chilled air with pollen in it caused as severe symptoms as warm air with pollen and therefore conclude that the removal of the pollen is the essential factor. Patients with bacterial asthma were not relieved. These findings agree with those of Rappaport, Nelson and Welker.

Another possibility for the cause of discomfort was presented by Sewall and Gulststien, who were able to sensitize guinea pigs

to rebreathed air, the idea being that perhaps the occupants of closed rooms might be so affected. This is perhaps possible but improbable at least in very many cases because, as far as is known, the experiment has not been repeated on humans.

It has long been known that besides the anaphylactic reactions perpetrated by dust laden air people such as mine workers, stone cutters, etc., develop silicosis if they are not protected from inhaling the dust in some manner. Rowe (48), in fact found, that of 208 rock drillers, 57 per cent had the disease after 10 years of exposure. He also showed that mortality due to respiratory diseases is definitely increased in workers exposed to dusts. Obviously, most of the industries have taken steps in this direction by installing air filters and washers where possible with a decided improvement in the health of the workers.

The Council of Physical Therapy of the American Medical Association (10), realizing the importance of air conditioning in hay fever, pollen asthma and silicosis has accepted, 1933, several types of air conditioners as being valuable in the treatment of these diseases.

One may be guided as to the time and localities for the most efficacious use of air conditioning in these diseases by reviewing the many interesting atmospheric studies made by Durham (15), Duke (14), Parlato (38), Green (21) and others. Wodehouse (57), on the basis of his study of the distribution of the pollens of the air in different regions and during the different seasons, has constructed a very useful chart to which physicians may refer and thus determine at what time to protect their patients by

conditioning the air or by desensitization treatment.

Barach (4), using an air conditioned room, which was filtered of 99 per cent of the dust and bacteria, found no improvement in three cases of active tuberculosis after having spent eleven weeks in the room.

The Use of Air Conditioning in the Care of Premature Infants.--

K. D. Blackfar and C. P. Yaglow (7), in a study of three years duration of the effects of atmospheric conditions on growth and development of premature children have arrived at some very definite conclusions which define very emphatically the need for air conditioning in this branch of child welfare.

They found that the humidity best suited to stabilizing the body temperature of premature infants was about 65 per cent, with a temperature of 75 to 100 degrees F, depending to some extent on the general constitutional state of the infant and the body weight. A humidity of 30 per cent induced instability of body temperature and other untoward effects often leading to serious consequences. They found too that the body temperature could be much more easily controlled in rooms in which the temperature, humidity and ventilation rate are adequately controlled. The body temperature and fluctuations are related to body weight. The low weight child has a lower temperature and it's fluctuation is greater as the weight increases the body temperature increases and fluctuations become less. The period of time over which the normal initial loss of weight continued averaged four and six tenths days in the unconditioned nursery, four and two-tenths days in the conditioned nursery under low humidity and three days

under high humidity. This weight was regained in an average of twenty-six and five tenths days in the unconditioned nursery; in the conditioned nurseries, in an average of nineteen and five-tenths days under low humidity and fifteen and fifteen and five tenths days under high humidity. This time varied inversely in proportion to the weight at birth.

The maximum gain in weight in patients weighing less than 5 pounds occurred under high humidity in the conditioned nurseries. Patients weighing four and one half pounds or more at birth gained weight more rapidly at low humidities whereas those weighing less than four and one half pounds at birth gained more rapidly at high humidities. The growth in length followed these same rules.

Gastrointestinal upsets were at a minimum when the humidity was low. The mortality rate was in all instances lower in the conditioned nurseries than in the unconditioned ones. The most significant lowering of the gross mortality was observed in infants of the lowest weight groups. The general mortality for all weights and ages was 7 per cent in the conditioned nurseries as compared to 28.9 per cent in the unconditioned nurseries.

Acute and chronic infections accounted for 70.3 per cent of the total number of deaths in the unconditioned nursery and for 31.9 per cent of the deaths in the conditioned nurseries. These findings very clearly illustrate two new factors in the care of premature infants namely, the importance of control of the humidity and temperature in premature nurseries and the most important single criterion for judging these environmental requirements is the body weight. This index has been found to

be more reliable than the estimated fetal age, chronological age or body length.

Talbott (52) has noticed that there is usually a lack of subcutaneous fat which, favors the escape of heat from the more vital tissues of the body, the normally low production of heat by the organism itself, and the failure to increase this production by shivering and crying and other forms of exercise when the environmental temperature falls below that optimal for the child.

The Public Health Committee of the New York Academy of Medicine found that the mortality of infant wards was directly proportional to the degree of overcrowding. They recommend a temperature of 62 to 68 degrees F, a relative humidity of 40 to 50 per cent, air movement of three feet per second and a CO₂ content of not more than six parts in 1000. Each child should have 100 square feet of floor space, beds 12 feet apart and have 1000 to 1500 cubic feet of air.

SUMMARY

The history of air conditioning has been presented in which the importance of fire, heating devices, air, ventilating, windows and temperature and humidity to the advancement of society and prevention of disease have been enumerated.

The theories as to the cause of discomfort in stuffy, poorly ventilated rooms have been described.

The physical effects of different air conditions on the human and animal organisms in health and disease have been pointed out with discussion of the optimum physical air conditions.

Finally, the special uses of air conditioning in the treatment of hay fever, pollen asthma and pneumokoniosis have been described and the necessity for definite air conditions in the care of premature infants have been presented.

A few of the many methods of air conditioning have been described in some detail.

CONCLUSIONS

1. The cause of discomfort in a stuffy, poorly ventilated, crowded room is increase in relative humidity.
2. The optimum air conditions are:
 - A. Temperature of 68 to 72 degrees F.
 - B. Humidity of 40 to 60 per cent. (Relative)
 - C. Air movement of 3 feet per second.
3. Combinations of artificial and window ventilating systems are best for schools.
4. Artificial ventilation is very necessary for hospitals.
5. Allergic free rooms relieve the symptoms of hay fever and pollen asthma but are not a cure for these conditions.
6. Dust free rooms reduce the mortality of pneumokoniosis.
7. Dust, pollen and bacteria free rooms are of no value in the treatment of tuberculosis.
8. Artificially air conditioned rooms or wards are very necessary for the care of premature infants.

BIBLIOGRAPHY

1. Allen, John R.: Hospital Ventilation and Heating. Mod. Hosp. 15:22, July, 1920.
2. Anderson, H.: Histologic Changes in the Nasal Mucosa Following Experimental Variations in Ventilation and Exposure. Proc. Staff Meet Mayo Clinic 6:772-774, Dec., 1931.
3. Baker, S. J.: Classroom Ventilation and Respiratory Disease Among School Children. Am. J. Pub. Health. 8:19, Jan., 1918.
4. Barack, Alvan A.: a Keeping Patient Comfortable by Means of the Health Room. Mod. Hosp. 33:89-91, Dec., '29.
(b) The Use of Filtered Air Chambers in Pulmonary Tuberculosis. Am. Rev. Tuberc. 27:508-514, May '33.
5. Bacon, A. S.: Doing Away With the Open Window in Hospitals. Mod. Hosp. 39:37-38, Aug. '32.
6. Baetjer, A. M.: Air Conditioning, Longevity and Health. Nation's Health 5:653, Sept. '22.
7. Blackfar, K. O. and Yaglow, C. P.: The Premature Infant. Am. J. Dis. of Children 46:1175-1236, Nov. '33.
8. Blackfar, K. C.: The Care of the Premature Infant. J.A.M.A. 102:1228-1229, April, '34.
9. Cohen, Milton B.: The Prophylaxis and Treatment of Hay Fever and Asthma in Rooms Made Pollen and Dust Free by Means of Mechanical Filters. J. Lab. & Clin. Med. 13:59, 1927.

10. Council of Physical Therapy of A.M.A. Milwaukee Air Filter Acceptable. J.A.M.A. 100:885-886, March 25, 1933.
11. Davies, Charles: Air Filtration in Hay Fever Relief. M. Dec. 139:543-544, May, '34.
12. Douglas, S. R. and Hill, Leonard: Spray Infection. J. of Indust. Hyg. 3:206, Nov. '21.
13. Drinker, Phillips and Thompson, R. M.:
 - (a) Experiments on Air Conditioning. J. Indust. Hyg. 4:63-69 June '22.
 - (b) The Kata Thermometer, it's Valve and Defects. 6:20-27, May '34.
14. Duke and Durham: Pollen Determinations. J.A.M.A. 90:1529-1532, May 1932.
15. Durham, O. C.:
 - (a) The Ragweed Season of 1932. J. Allergy 4:105-113, Feb. '33
 - (b) A Pollen Survey of Miami Florida. Southern Med. J. 24:947-948, Nov 1931.
 - (c) An Atmospheric Study. J.A.M.A. 100:1846-50, June '33.
 - (d) The Contribution of Air Analysis to the Study of Allergy. J. Lab. and Clin. Med. 13:967-969, July '28.
 - (e) Ragweed Pollen Incidence. J. Allergy 1:12-21, Nov. '29.
 - (f) Comparison of Ragweed Pollen. J. Allergy. 2:258-71, May 31
16. Encyclopedia Britanica. 14th edition. 9:262-263.

17. Fansler, P. E.: Progress in the Science of Ventilation. Clin. Med. & Surgery 34:48-53, Jan. '27.
18. Fisher, A.: Newer Views on Ventilation. Canada Med. Ass. J. 7:229, March '17.
19. Gay, Leslie N.: The Treatment of Hay Fever and Pollen Asthma by Air Conditioned Atmosphere. J.A.M.A. 100:1382-1385, May 6, 1933.
20. Garrison, F. H.: The History of Heating, Ventilation and Lighting. Bull. N. Y. Acad. of Med. 3:57-67, Febr. '27.
21. Green, H. L.: Accurate Methods of Determining the Number and Size Frequency of Dust Particles. J. Indust. Hyg. 16:29-39, 1934.
22. Hales, Stephen: A Description of Ventilation. London, 1743.
23. Haney, Wm. Jiles: Economy and Comfort in Heating the House Using Coal and Coke as Fuel. Univ. of Nebr. Publication, Dec. 1932 100 pp 3-8.
24. Hayhurst, E. R.: Experiments in Air Conditioning the Home. Nation's Health. 3:577, Oct. '21.
25. Huntington, Ellworth:
 - (a) Air Control and Reduction of Death Rate After Operations. Mod. Hosp. 14:10, Jan. '20.
 - (b) Purpose and Methods of Air Control in Hospitals. Mod. Hosp. 14:271, April 20, 14:348, May 20.
26. Kahn, I. S. and Grothaus, E. M.: The Antigen Free Room in

- the Detection and Control of Cutaneous Allergy in Pollen
Bronchial Asthma. J. Allergy 5:45-52.
27. Kinlock, J. P.: The Constituents of Fresh and Vitiated
Air and Their Significance in Problems of Ventilation.
Bact. Med. J. 2:356, Aug. '22.
28. Larson, Lawrence M.: History of England and the British
Commonwealth. N. Y. Henry Holt & Co. May 1924. pp 512.
29. Leopold, S. S. and Leopold, C. S.
J.A.M.A. 84:731, 1925.
30. Miller, J. A.: Some Physiological Effects of Various
Atmospheric Conditions. A. M. J. Med. Sc. 153:412, Mar. '17.
31. Miller, J. A. and Noble, W. C.: The Effects of Exposure to
Cold Upon Experimental Infection of the Respiratory Tract.
J. of Exp. Med. 24: Sept. '16.
32. Miller, Konrad: Hospital Ventilation. Mod. Hosp. 15:272, Oct.
33. Mills, C. A.: Air Conditioning in Hospitals. Bull. Am.
Hosp. Ass. 6:67-68, Jan. '32. Hospitals can do Something
About the Weather. Mod. Hosp. 42:69-70, April, '34.
34. MacCurdy, George Grant: Human Origins. 2:pp136, 137, 138.
D. Appleton and Co. New York, 1924, London.
35. MacKenzie, James: The History of Health. Printed for Wm.
Gordon, Bookseller. 1760, pp 317-318.

36. McConnell, W. J.: (a) The Effects of High Temperatures and Humidities. Nations' Health 4:616-617, Oct. '22.
(b) Air Conditioning and it's Hospital Application. Mod. Hosp. 27:45-48, Aug. '26.
37. Palmer, Geofge, T.: Ventilation, Weather and the Common Cold. J. Lab. & Clin. Med. 6:602, Aug. '21.
38. Parloto, S. J.: Studies of the Relative Intensity of Distribution of the Ragweed Pollen During a Period of Three Years. N. Y. Med. J. 28:1095-1096, Sept. 1928.
39. Pettenkofer: Uber Der Luftwechsel In Whongebanden. J. G. Cotta Shen Buchhandlung 1858, pp 18.
40. Pierce, W. D.: Air Conditioning in Hospital Sanitation. Nations Health 4:444, July '22.
41. Pringle, Sir John: A Discourse on the Different Kinds of Air. London. Printed for the Royal Society. 1774, pp3-4.
42. Public Health Committee of N. Y. Acad. Of Med. Ventilation and Cubic Space for Infants in Institutions. N. Y. Med. J. 106:884, Nov. '17.
43. Public Health Reports, U.S. 35:989, April '20.
44. Putnam, J. P.: The Open Fire Place in All Ages. Boston 1881. 2nd Ed. 1886.
45. Rappaport, B. Z., Nelson, T., and Welker, Wm.: (a) Effect

- of Air Filtration in Hay Fever and Pollen Asthma. J.A.M.A. 98:1861, 1932.
46. Reed, Carlos I.: Why is Poor Ventilation Harmful? J. Pub. Health. 9:192, Jan. '19.
47. Rosenau, Edward C.: A Simple Method for Humidifying and Partially Sterilizing the Air of Heated Buildings. Am. J. Hyg. 16:466-581, Sept. '32.
48. Rowe, A. H.: Medical Aspects of Conditioned Air. M. J. & Rec. 138:345-349, Nov 15, '33.
49. Singer, Charles: A Short History of Medicine. Oxford Uni. Press, New York, 1928 pp 151-156.
50. Sewall, Henry and Gutstein, H.: On the Experimental Sensitization of Guinea Pigs to Rebreathed Air. Am. J. Hyg. 3: 300-314, May '23.
51. Suttan, Frank.: Is Mechanical Ventilation in Hospitals a Success? J. Mod. Hosp. 6:317-318, May '16.
52. Talbot, E. B.: Metabolism Findings in Twenty-One Premature Infants. Am. J. Dis. Child. 26:29, July, '23.
53. Van Leemven, S. W.: Therapeutics and Pharmacology. Proc. Royal Society of Med. of London 1725, 1927.
54. Vaughen, W. T. and Cooley, L. E.: Air Conditioning as a Means of Removing Pollen and Other Particulate Matter and of

- Removing Polinosis. J. Allergy 5:37-44, Nov., '33.
55. Willard, A. C.: What We Know About Ventilation. J. Indiana M. A. 19:159, April '26.
56. Whislow, E. A.: (a) The Relation of Indoor Atmosphere to Human Health and Comfort. Trans. Of College of Phys. 49: 94-116, May '27.
- (b) Window Ventilation Preferred for Schools. Nations Health 4:757, Dec. '22.
- (c) The Effect of Atmospheric Conditions Upon Fatigue and Efficiency. Am. J. Pub. Health 7:827, Oct. '17.
57. Wodehouse, R. P.
- 24A. Hilding, Anderson: Process. Staff Meet. Mayo Clinic. 6:772-774, Dec. '31.