plement to accepted methods of respiratory disease control has been reported.[28] The amount of radiation over the last two years of the period was believed to be about five times that recommended commercially. No significant effect on the incidence of disease could be detected in about 400 inmates during the six-year period. This conclusion may not be applicable to present ultraviolet equipment installed in accordance with manufacturers' recommendations. The data imply that air layers were not sufficiently mixed. However, more efficient mixing would have been obtained at the expense of increased circulation of dust and lint. Sources of ultraviolet radiation should be so situated as to protect the eyes of the occupants of the room from direct or reflected rays. A combination of ultraviolet radiation and dust control measures is believed to be more effective than either one of the two used alone, but the proof for this has yet to come.

In all this the problems of the hospital are of two kinds, either of which can probably be more effectively solved in specific cases by isolation of the affected patients than by any effort at sterilization. Any hospital which can afford it should provide isolation wards to satisfy both. The first of these concerns the type of patient who is particularly prone to infection from the general hospital. Quarters for such patients should be so constructed and equipped that they are under positive pressure from the air conditioning system, which should be non-recirculating with reference to other areas, thus preventing or at least minimizing an *inward* drift of building air. The second is to protect other patients and hospital personnel from the bacterial effluvium of a patient having a readily communicable disease. Here the arrangement should be such as to maintain *negative* pressure so as to minimize the *outward* drift of room air into the hospital building.

OPERATING ROOMS

The widest application of air conditioning in hospitals is in operating rooms. Complete air conditioning of operating wards is important because winter humidification helps reduce the danger incident to the use of anesthetic gases. Summer cooling, with some dehumidification, tends to eliminate excessive fatigue and to protect the patient and operating personnel, and filtering aids the removal of allergens from the operating room air.

Reducing Explosion Hazard

Explosion hazards in operating rooms increase with the introduction of anesthetic gases and apparatus. Ether administered by the old drop method gives rise to an explosive mixture, but in practice this method is still regarded as comparatively safe. When ether is mixed with pure oxygen, or nitrous oxide in certain concentrations, the explosion hazard may be as great as with ethylene-oxygen, or cyclopropane-oxygen mixtures.

Of the anesthetic gases nitrous oxide alone does not explode but supports combustion. Ether, vinyl ether, ethylene, and cyclopropane are as potentially dangerous as gasoline or illuminating gas in the home.[21] Chloroform does not explode violently in contact with flame, but decomposes to liberate phosgene. All of the anesthetic gases and vapors, except ethylene, are heavier than air. Although the incidence of injury or death from explosion is negligible compared with other hazards in the operating room, the dramatic features surrounding an explosion justify continued investigation to eliminate the hazard.

During the course of ethylene anesthesia, the mixture, usually 80 percent ethylene and 20 percent oxygen, is so rich that the danger of explosion is slight in the immediate vicinity of the face mask, but leakage of ethylene into the air may result in lower concentrations, and thus introduce a serious hazard. The most dangerous period is at the end of the operation when the patient's lungs and the anesthesia apparatus are customarily *washed out* with oxygen with or without the addition of carbon dioxide. Even when this procedure is omitted, it is difficult in practice to avoid dilution of the anesthetic gas with air during the normal course of breathing following the administration. In either case, since the mixture would pass through the explosion range, extraordinary precaution is necessary for the safety of the patient and operating personnel.

In a study[22] of 230 anesthetic explosions and fires, 70 percent of the explosions and 60 percent of the deaths were caused by igniting agents other than static sparks. The National Fire Protection Association[23] made certain recommendations for safe practice based on available information in NFPA No. 56, *Code of the use of Flammable Anesthetics.* This code outlines ways and means for eliminating or correcting hazardous conditions which experience and investigation have shown to contribute to the hazards in question. They are divided into four parts: Part I, General, deals with the nature of the hazards; Part II, Construction and Equipment, deals with physical standards for features incorporated into the construction and equipment of the surgical suite; Part III, Administration and Maintenance, contains requirements for administration and maintenance; and Appendixes A and B contain explanatory statements to assist in understanding this code. The requirements and recommendations are interdependent, and each will be ineffective unless coordinated with the other. To approach complete success in the prevention of anesthetic explosions, all persons (the surgical staff, the nursing staff, the maintenance staff and administrative personnel) must be educated and periodically reminded of the explosive nature of combustible anesthetic agents.

Experience has shown that neither high humidity nor intercoupling devices have eliminated the danger from static electric discharge. The removal of gas concentrations from the operating table area, by means of specially devised exhaust ventilation, should be thoroughly tested. Portable duct systems as installed aboard ship should be acceptable. Serious explosions can occur in a closed system, but proper precautions will reduce this hazard to a minimum.

A comprehensive study of the explosion problem and of the general causes and prevention of operating room hazards, by the University of Pittsburgh, the ASHRAE Research Laboratory, and the U. S. Bureau of Mines has led to a fruitful attempt to eliminate the explosive range of cyclopropane, one of the best but most difficult gases to handle. The use of helium as a diluent in the total gaseous mixture controls the oxygen concentration by displacement and, because of its flame quenching properties, is the ideal gas for this purpose. In addition, a gaseous mixture containing helium is more difficult to ignite by electric discharges, and this quality increases the safety factor of anesthetic administration.

Operating Room Conditions

Little is known about optimum air conditions for maintaining normal body temperatures during anesthesia and the immediate post-operative period. An anesthetized patient displays dilation of blood vessels in the skin resulting in profuse sweating and (it has been believed) inability to regulate body temperature. From this it was concluded that all anesthetized patients suffered considerable heat loss, although there may be little more than 0.8 F deg variation in the rectal temperature during the course of the operation.[24]

The severe physiological effects, such as excessive sweating and rapid pulse, of high operating room temperatures on attendants and patients during the hot months signify the need for proper cooling. Statements of surgeons who operate in both air-conditioned and non-air-conditioned rooms strongly indicate that the recuperative power of the patient is greater when operated upon in air-conditioned rooms.[24]

Although the comfortable air conditions for the operators are not identical with those for the patient, it is usually not difficult to compromise within a range of 50 to 60 percent relative humidity and 70 to 75 F temperature. It is generally reported that a dry-bulb temperature of 72 F with 55 percent relative humidity is satisfactory and not only furnishes comfort for the operating room workers, but apparently prevents exhaustion of patients as evidenced by rapid convalescence in the recovery ward. Additional heat may be furnished to patients locally or by suitable covering, according to body temperature in individual cases.

In the control of airborne infection in the operating room, the prevention of dispersal of infectious materials into the air, control of dust, and proper ventilation supersede attempts to remove or kill pathogenic organisms. The bacterial content of conditioned operating rooms is generally lower than that of non-conditioned rooms.

Bacterial counts aboard an air-conditioned submarine were found to be exceptionally low and not cumulative with time, although all of the air was recirculated for more than 12 hours[25] without replenishment. The removal of bacteria by the process of air cooling and condensation of moisture out of air, merits further study.[26]

The degree of air contamination can be reduced by proper ventilation if velocity of air over the floor does not exceed 50 fpm. Research is in progress on the use of filtered air flowing through a system of mechanical cleaners which protect the patient against infection from attendants, and from bacteria-containing air in the corridor or ward.[17]

Operations are frequently postponed on allergic patients during asthmatic manifestations through fear of complications. The removal of airborne allergens, therefore, is in some cases an important function of the air-conditioning system in preparing patients for operation.

The best practice in air conditioning hospital operating rooms is the use of all outdoor air with arrangements for preheat, reheat, and the control of humidity, coupled with a mechanical exhaust system that removes the air from both the high and low levels of the operating room. However, there is some evidence of lack of any cumulative effect on bacteria count due to recirculation of air through an air conditioning unit in operating rooms. This consideration and the fact that relief cooling frequently provides improved, if not ideal conditions, has led to the use of central systems employing 50 percent recirculated air. Also, perhaps as a recognition of practice, the NFPA No. 56 outlines the conditions under which room air conditioners may be used in operating rooms. These conditions are so written in the pamphlet that the recommendation of separate mechanical ventilation of such rooms is clearly inferred.

The use of room air conditioners for relief cooling of mechanically ventilated rooms is now considered permissible when used with the necessary precautions. These precautions generally involve costly modification of standard room air conditioners. The use of larger systems employing 50 percent recirculated air is a recognized practice. Such a system must have the necessary precautions (regarding the electrical and air moving equipment) against the hazard of gross spillage of the anesthetics. Systems using 100 percent outdoor air and adequate air removal means are regarded as following the best practice. The choice between the systems is usually made on the basis of first costs. As compared with the other daily usage costs of an operating room, the differences between the operating costs of the various air conditioning systems is not a significant item.

Good thermal construction of the operating rooms is a recommended practice. Much can be gained by thermal insulation of sterilizing equipment, and by exhaust ventilation of sterilizing rooms adjoining the operating rooms. The amount of glass surface should be kept to a minimum, particularly in walls exposed to the sun. Double windows are desirable and often necessary to prevent condensation on the glass in cold weather. The equipment capacity and control methods must be properly selected for the type of system employed and for the loads encountered. The resulting air flow rates are usually in the range of 10 to 15 changes per hour.

Where all outdoor air or a large percentage of outdoor air is used, the supply should slightly exceed the amount of air exhausted from the room. It is considered preferable to supply through sidewall outlets and to exhaust through other sidewall outlets with 75 percent exhaust taken from near the floor and the balance taken from near the ceilings. The various supply and exhaust outlets should be located and sized to provide uniform air distribution with no draft. The air motion in the operating area should be less than 50 fpm. Where there is a sterilizing room in connection with the operating room, it is permissible to exhaust the operating room through the sterilizer room, utilizing undercut or low louvers in the door between the two rooms, with the air velocity through or under the door not in excess of 380 fpm.

An air-conditioned recovery ward in connection with the air-conditioned operating room, is of great value in stabilizing peripheral circulation and in reducing excessive loss of fluids on hot humid days.

NURSERIES FOR PREMATURE INFANTS

One of the most important requirements in the care of premature infants is the stabilization of body temperature. This is necessary because the infant's heat regulatory system is not fully developed, with the resultant tendency for environmental temperature to influence body temperature. The younger the premature infant, the greater is the tendency. As the infant's metabolism is low, heat production is not adequate to maintain a normal body temperature in a cool environment. The resistance to infection is low, and the mortality rate is high. In general, the younger the age of the premature infant, the higher the mortality rate.

Nurseries constructed for metabolic research should be air-conditioned so that conditions are reproducible. Results of such studies may be invalid if environmental conditions are not identical, since fluid and electrolyte loss may vary greatly with change in environmental conditions.

Air-Conditioning Requirements

The optimum air conditions for growth and development of premature infants were determined by extensive research[28] at the Children's Hospital, Boston, Mass., using four valid criteria, namely: stability of body temperature, gain in weight, incidence of digestive syndromes, and mortality. Individual temperature requirements varied widely (from 72 to 100 F) according to the constitutional state of the infants and body weights. The optimum relative humidity was about 65 percent, and the air movement less than 20 fpm.

A single nursery conditioned to 77 F and 65 percent relative humidity was found to fulfill satisfactorily the require-