

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 the mixture would pass through the explosion range and extraordinary precaution is necessary for the safety of the patient and operating personnel.

Copious ventilation, from 6 to 12 air changes per hour, which is necessary to preclude accumulation of explosive mixtures also reduces the concentration of anesthetics to below the physiologic threshold so that the surgeon and his personnel will not be affected.

The most important cause of accidents is probably static sparks which may result from accumulation of frictional charges on the rubber surfaces of the anesthesia apparatus, on woolen blankets, and on the bodies of the operators as they walk on insulated floors, when the humidity is low. Grounding the various parts of the anesthesia apparatus is not entirely

TABLE 1. EXPLOSIVE PROPERTIES OF ANESTHETICS^a

ANESTHETIC	FORMULA	DENSITY AIR = 1	LIMITS OF INFLAMMABILITY			
			IN AIR		IN OXYGEN	
			Lower	Upper	Lower	Upper
Ethylene.....	C_2H_4	0.97	2.75	28.6	2.90	79.9
Propylene.....	C_3H_6	1.45	2.00	11.1	2.10	52.8
Cyclopropane.....	C_3H_6	1.45	2.40	10.3	2.45	63.1
Nitrous Oxide.....	N_2O	1.52	-----	-----	Not Inflammable	
Ethyl Chloride.....	C_2H_5Cl	2.23	4.00	14.8	-----	-----
Ether-divinyl.....	$(C_2H_5)_2O$	2.42	1.70	27.0	1.85	85.5
Ether-diethyl.....	$(C_2H_5)_2O$	2.56	1.85	36.5	2.10	82.0
Chloroform.....	$CHCl_3$	4.12	-----	-----	Not Inflammable	

^aExplosion and Fire Hazards of Combustible Anesthetics, Report of Investigations, U. S. Bureau of Mines, R.I. 3443, April, 1939.

effective, so long as rubber remains in use in the conventional equipment. Some form of protective grounding within the apparatus may be a partial solution.

A comprehensive study of the explosion problem and of the general causes and prevention of operating room hazards, is being conducted by the University of Pittsburgh, the A.S.H.V.E. Research Laboratory, and the U. S. Bureau of Mines. In the absence of more understanding, no single safeguard can be given, but desirable precautions may be classed as follows: (1) to limit the region of the explosive gas mixtures; (2) to make all electric contacts explosion-proof; (3) to avoid building up static charges; (4) to ground those surfaces where charges may be built up; and (5) to discourage accumulation of static electrical charges by humidity control.

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 dilatation 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. In spite of this a recent paper² reports little more than 0.8 F variation in the rectal temperature during the course of the operation. 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. A comparison of surgeons' statements who operate in both air conditioned and non air conditioned rooms strongly indicates lesser fatigue; and the greater recuperative power of the patient is confirmed by the previously referred to study³.

Although the comfortable air conditions for the operatives are not identical with those for the patient a compromise is as a rule not difficult; with a relative humidity of 55 to 60 per cent, temperatures from 72 to 80 F are used. The work just cited, reported that 68 to 70 deg effective temperature not only furnished comfort for the operating room workers but apparently prevented exhaustion of the patient as evidenced by rapid convalescence in the recovery ward. Additional heat may be furnished to the patient locally or by suitable covering according to body temperature in individual cases.

The increasing incidence of allergies or of their recognition is becoming a factor in the operating room. Operations may be postponed on allergic patients during asthmatic manifestations through fear of complications. The removal of the allergens, therefore, is in some cases an important function of the air conditioning system.

Central-system air conditioning plants and unit air conditioners prove satisfactory in operating rooms when producing between 8 and 15 air changes per hour of filtered and properly conditioned air without recirculation during the course of anesthesia. A separate exhaust fan system is as a rule necessary to confine and remove the gases and odors. Double windows are desirable and often necessary to prevent condensation and frosting on the glass in cold weather and to minimize drafts. The high air flow of 8 to 15 air changes in operating rooms is desirable for three reasons: (1) to reduce the concentration of the anesthetic to well below the physiologic threshold in the vicinity of the operating personnel, (2) to remove the great amounts of heat and sometimes moisture, from sterilizing equipment if inside the operating room, from the powerful surgical lights, from solar heat, and from the bodies of the operatives, and (3) to provide extra capacity for quickly preparing the room for emergency operations. Much can be gained by careful insulation of sterilizing equipment and by thorough exhaust ventilation of sterilizing rooms adjoining the operating rooms.

A very common complication presumably traceable to operations is pneumonia. The difference in conditions between the operating room and the final hospital destination of the patient, including corridors and elevators, is conducive to post-operative pneumonia. A suggested remedy is a recovery ward where conditions closely approximate those of the operating room and in which the patients remain from one to four

²A.S.H.V.E. RESEARCH PAPER—Air Conditioning Requirements of an Operating Room and Recovery Ward, by F. C. Houghton and W. Leigh Cook, Jr. (A.S.H.V.E. JOURNAL SECTION, Heating, Piping and Air Conditioning, June, 1939, p. 381).

³Loc. Cit. Note 2.