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 reduces to some extent the danger from the open drop method but is of little value in the closed system type of anesthetic machine now in common use. However, this abundant circulation reduces the concentration of anesthetic gases 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	$(C_2H_3)_2O$	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	

[a]Explosion and Fire Hazards of Combustible Anesthetics (*U. S. Bureau of Mines*, Report of Investigations No. 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*. The first result of this investigation has been 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 replacement and since its flame quenching qualities are known it 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 also increases the safety factor of anesthetic administration. A more general idea of the mixtures containing cyclopropane, oxygen and helium necessary to produce satisfactory anesthesia is given in Table 2. Clinically and with slight variation, the non-inflammable mixtures of Table 2

have produced satisfactory results and samples of gas taken during operation show no tendencies to explosion.

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 paper[2] reports little more than 0.8 F variation in the rectal temperature during the course of the operation. The severe physiological

TABLE 2. NON-INFLAMMABLE MIXTURES FOR ANESTHETIC USE[a]

Mixture No.	Composition, Per Cent by Volume		
	Cyclopropane	Oxygen	Helium
1	15	20	65
2	20	20	60
3	25	25	50
4	30	30	40

[a]Explosive Properties of Cyclopropane: Prevention of Explosions by Dilution with Inert Gases (*U. S. Bureau of Mines*, Report of Investigations No. 3511, May, 1940).

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 study[3].

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.

[2]A.S.H.V.E. RESEARCH REPORT No. 1111—Air Conditioning Requirements of an Operating Room and Recovery Ward, by F. C. Houghten and W. Leigh Cook, Jr. (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 161).

[3]Loc. Cit. Note 2.