THE PLACE OF LEATHER-SOLED SHOES IN THE PREVENTION OF ANESTHETIC EXPLOSIONS

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THE practice of depending on the conductivity of leather-soled shoes has been questioned lately. Recently I made the statement (1) "The leather soles of the anesthetist in contact with a conductive floor form a circuit which allows static electricity to be dissipated as rapidly as it is formed" which has drawn forth adverse comment. Thomas, in the March 1951 *News Letter* of the American Society of Anesthesiologists, reported a similar objection by one of the readers of his regular and popular column, "Do You Know? Fires and Explosions." Thomas had stated in the December 1950 *News Letter* that "Conductive soled shoes should be worn by hospital personnel. If these are unobtainable, leather-soled shoes are less objectionable than ordinary rubber or composition shoes." Apparently his critic objected to the implication of even allowing leather-soled shoes as a possible substitute for conductive soled shoes. In Thomas' reply to his critic he admitted that there was no intention to convey the idea that leather-soled shoes are equivalent to good "conductive shoes." "In general, leather-soled shoes are of higher resistance than that recommended in present codes for the rapid removal of static electricity. . . . Leather, however, has the property of absorbing moisture from the feet or from wet floors during use. . . . Sometimes leather shoes which at first show undesirably high resistance, later are found to be in the acceptable range. This property is utilized in some hospitals by standing for a few minutes on a wet floor or wet floor mat. Of course, such procedures are makeshift; there is no substitute for the combination of proper conductive shoes and floor. There are many hospital employees who may have access to anesthetizing locations who may be financially unable to purchase conductive soled-shoes. Such personnel would do well to wear leather shoes rather than the usual rubber or composition. Their activities are such that they would not be likely to acquire dangerous static charge. Moreover, it may be some time before there is a plentiful supply of low-priced conductive shoes on the market."

Since "conductive shoes" have been commercially available the

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literature has promoted a feeling that leather soles are not quite satisfactory. It is true that "conductive shoes" have a lower resistance than leather-soled shoes, but this is not the fact that should be stressed. The important point is that ordinary leather-soled shoes, as used and worn in everyday practice, are sufficiently conductive to serve the purpose. Leather-soled shoes should not be discarded or barred for the sake of theoretically better conductive shoes which, in practice, will not be worn by all personnel entering an operating or delivery room.

The point of view expressed here is not in accord with the "Recommended Safe Practices for Hospital Operating Rooms" wherein it is stated, "All shoes . . . should be so fabricated that the resistance between a metal electrode placed inside the shoe and making contact with the inner sole, equivalent in pressure and area to normal contact with the foot, and a metal plate making contact with the bottom of the shoe, equivalent in pressure and area to normal contact with the floor, shall not be more than 250,000 ohms" (2).

Even if one wore shoes so low in resistance as the designated 0.25 megohm "how does one know that the conductivity . . . has not been lost because wax and dirt have accumulated on the soles to provide an insulating coating?" (2). Logically, therefore, if one were to be truly concerned with observing the low resistance of 0.25 megohm, he should strictly enforce the injunction stated in the "Recommended Safe Practices" that "footwear . . . should be tested on the wearer prior to each use in a hazardous location . . . by a direct reading ohmmeter, or similar approved instrument. . . ." Apparently only one department of anesthesiology, that of the Hartford (Connecticut) Hospital, has adopted this practice (2). The extent to which this rule has been approved and followed by other anesthesiologists should be determined by official investigation under the auspices of the American Society of Anesthesiologists and published for the professional and legal guidance of all anesthesiologists. Further consideration of this problem by electrical engineers apparently is needed.

In the interim this dissenting opinion should be published for the support as well as the protection against alleged malpractice required by the majority of anesthesiologists who continue to wear leather-soled shoes. Eventually it may be found that the "Recommended Safe Practices" should again be modified just as it was in 1949 with regard to explosion proof overhead lamps and specific ventilation requirements; these are no longer mandatory whereas in 1944 they were demanded by the recommendations of The National Fire Protection Association (3).

The majority of anesthesiologists have long regarded the practice of wearing leather-soled shoes as a safe one. In 1940 statements were widely circulated such as "Shoes which include the ordinary leather soles are usually safe. Rubber heels are not objectionable if soles are of leather" (4). "The conductivity of ordinary leather-soled shoes has been thoroughly investigated at the Massachusetts Institute of

Technology. The soles of such shoes have been found to be a reasonably satisfactory substitute for conductive rubber soles" (5). Most anesthetists continue to wear leather-soled shoes. I do not know any anesthesiologist or institution that insists on and strictly enforces the use of "conductive shoes." I doubt that there is a hospital other than Hartford Hospital (2) where all personnel and visitors entering the operating and delivery rooms are always shod with special conductive shoes or straps.

I have two objections to the exclusion of leather-soled shoes from the operating room. The first is a clinical one, namely, that I have never found the use of leather-soled shoes, even in part, responsible for the chain of circumstances leading to an anesthetic fire or explosion. This experience comprises the 63 static-caused explosions which I studied for the American Society of Anesthesiologists before 1941 (6) and, since then, 6 cases which I investigated at the request of litigants. Nor have I ever found, in a careful survey of the literature, that leather-soled shoes were responsible for the failure of dissipation of static electricity from a person involved in an anesthetic combustion caused by static electricity. Finally, my close associates and I have never had a static-caused anesthetic accident and we have always worn ordinary leather-soled shoes while administering over 100,000 general anesthesias during the past fifteen years; the majority of these anesthesias included combustible concentrations of cyclopropane or ether or both.

My second objection to the exclusion of leather-soled shoes is a theoretical one and involves the following electrical data and principles. Leather soles, in the presence of low humidity and on a nonconductive floor, have shown an average resistance of 52 megohms and a minimum of 0.1 megohm (7). Even with a resistance of 1000 megohms leather-soled shoes would not be a significant hazard in practice because any person so shod and charged with static electricity would be fully discharged to a grounded floor as promptly as the charge could accumulate. "The rate at which a charged condenser (a charged person) may be discharged plays an important role in electrostatic fire hazards, particularly where the ignition originates in the spark energy from the body electrification of individuals" (8). The time required in seconds for a charged body "C" to discharge to 36 per cent of its maximal charge through a resistance "R" is equal to their product, that is, $T = C \times R$ seconds. The time required for practically full discharge is about three times the above value of the electric time constant. The importance of the time constant is best illustrated by an example. Assume the resistance to ground through both shoes to be 1000 megohms (a value far greater than any found by actual measurement), and assume the person's capacitance to ground to be 100 micromicrofarads (an average known figure). Then the time constant, being the product of the two quantities, is 0.1 second. About three times this time interval, or about 0.3 second, would be required for this person to dis-

charge his body completely. In walking rapidly at the rate of 4 miles per hour a person takes two steps per second. Thus even with rapid walking any body entering a grounded zone would fully discharge during each step. In other words, the person could accumulate no appreciable charge while rapidly walking over a grounded floor. If the resistance of his shoes to ground were 100 megohms (about twice the actual quantity found by Thomas under adverse circumstances) the time constant would be 0.01 second and the time to discharge his body completely would be 0.03 second. Under these conditions a body would be fully discharged at the instant his foot contacted the grounded floor. It is for this reason that Robin Beach, Professor of Electrical Engineering and Head of Department, Polytechnic Institute of Brooklyn, has stated, "It is not generally necessary that shoes possess really low resistances from body to ground" (9).

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FIFTH ANNUAL MEETING: ILLINOIS SOCIETY OF ANESTHESIOLOGISTS

The Illinois Society of Anesthesiologists will hold its Fifth Annual Meeting at the Sherman Hotel in Chicago on May 12 and 13, 1952. An ambitious program has been arranged—both clinics and scientific papers—that will be of interest to all Anesthesiologists in the region. The program for the meeting follows:

Monday, May 12

CLINICAL DEMONSTRATIONS

St. Luke's Hospital, 1439 S. Michigan
Presbyterian Hospital, 1753 W. Congress
Illinois R. & E. Hospital, 1819 W. Polk
Michael Reese Hospital, 29th and Ellis
Wesley Memorial Hospital, 250 E. Superior

Registration Hotel Sherman

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