CURRENT COMMENT AND CASE REPORTS

CURRENT COMMENT is a section in ANESTHESIOLOGY in which will appear invited and unsolicited professional and scientific correspondence, abbreviated reports of interesting cases, material of interest to anesthesiologists reprinted from varied sources, brief descriptions of apparatus and appliances, technical suggestions, and short citations of experiences with drugs and methods in anesthesiology. Contributions are urgently solicited. Editorial discretion is reserved in selecting and preparing those published. The author's name or initials will appear with all items included.

APPARATUS FOR TESTING ELECTRICAL CONDUCTIVITY OF SHOES USED IN HAZARDOUS LOCATIONS

The acceptance of ether as an anesthetic agent over one hundred years ago introduced additional physical hazards of fire and explosion in operating rooms. As other anesthetic agents were discovered and applied clinically, the incidence of these hazards increased since most of these drugs were inflammable. Similarly, agents found suitable for the cleansing and preparation of skin surfaces for operation were inflammable. The widespread use of oxygen mixed with anesthetic gases or vapors in a closed system intensifies the problem since accidental combustion may occur as a violent explosion, damaging to property and personnel. Since combustible materials are used in every operating room and cannot, at present, be entirely eliminated, it is necessary to direct attention to the prevention of ignition. Sources of ignition can be reduced in number by relatively simple measures such as elimination of unsafe electrical systems, open flames, hot bodies and high frequency equipment but the hazard of static electricity necessitates more extensive safeguards for its continuous dispersal.

The principle of grounding all personnel and equipment in hazardous locations in hospital operating and delivery rooms was tentatively adopted by the National Fire Protection Association in 1941 and accepted officially in conjunction with other recommended safe practices in 1944 (1, 2). Grounding is accomplished primarily by the use of conductive flooring, the wearing of shoes with conductive soles by all personnel in hazardous locations, and by the use of conductive material to intercouple electrically all furniture and apparatus with the floor.

In the most recent revision of the Recommended Safe Practices for Hospital Operating Rooms, Section 13–5 (3) shoes which are suitable for operating room personnel are described as follows:

"Because of the possibility of percussion sparks, shoes having ferrous nails which may make contact with the floor should not be permitted in storage locations for combustible anesthetic agents or in anesthetizing locations.

"The recommended method for electrically connecting all persons entering anesthetizing locations to conductive floors is through the wearing of shoes conforming to the following specifications:

"All shoes having soles and heels of conductive rubber, conductive leather, or equivalent material, 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 be not more than 250,000 ohms.

"Footwear or other personnel conductive devices to be introduced into hazardous locations should be tested on the wearer prior to each use in a hazardous location. Such test may be made by a direct reading ohmmeter, or similar approved instrument, indicating the resistance between two insulated electrodes so located that the wearer may stand in a normal manner with one foot on each electrode. The electrodes may be of some nonoxidizing metal such as stainless steel. Shoes in use for which the indicated resistance between electrodes is one megohm or less are considered safe."

Even when the recommended type of shoe is being worn and the conductive soles are in good condition there is still no positive means of telling by observation whether static electricity will be carried off to ground through the shoes. An accurate method for measuring the conductivity is essential and since no simple device has been available at low cost for making such a test it was necessary to design apparatus which could be readily constructed in the average hospital from standard equipment.

The recommendations of the National Fire Protection Association were used as a guide in designing a simple, inexpensive but dependable shoe conductivity tester (fig. 1) which has been built by the Engineering Department at Hartford Hospital and has been used satisfactorily in operating and delivery rooms.

Specifications state that each shoe should have a resistance not exceeding 250,000 ohms, and that the combined resistance of two shoes and the wearer's body shall not exceed 1,000,000 ohms. The control of current must be such that a person will not receive a shock when standing on the foot

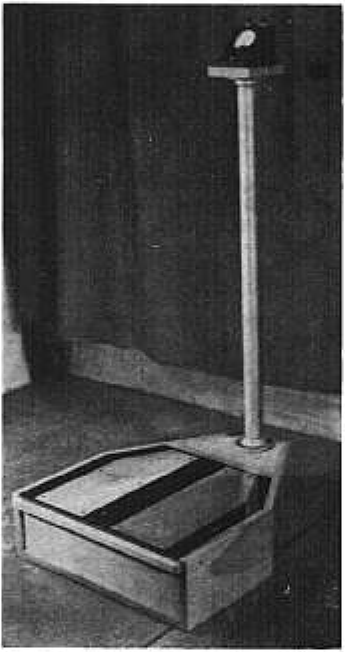

FIG. 1. Shoe conductivity tester.

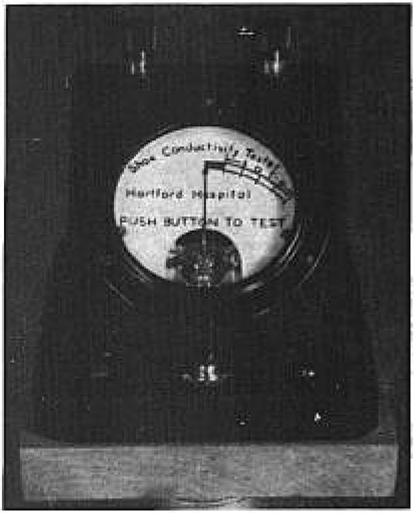

FIG. 2. Galvanometer with altered scale.

plates of the testing apparatus with bare wet feet. Since the minimal perceptible current is less than one milliampere (1/1000 of an ampere) the short circuit current should be held to one milliampere or less. A standard galvanometer,* obtained at a cost of approximately $15, incorporates a movement sufficiently sensitive for use in the shoe tester. The full scale current of this meter is 0.5 milliampere which is well within the safety limit mentioned.

The galvanometer, as received, was equipped with three test buttons (fig. 2). Two of these buttons were disconnected, leaving only the center button in operation. The meter scale was carefully removed and a new scale prepared which was cemented to the back of the original scale and re-inserted in the instrument. The left half of the new meter scale is blank and the right half is marked off into "safe" and "unsafe" ranges. The "unsafe" range marked in red extends from the center point of the scale representing high resistances to a point corresponding to 1,000,000 ohms resistance. Beyond this to the right is the "safe" range comprising the balance of the scale indicating resistances of less than one megohm. To determine the point on the scale corresponding to the maximal allowable resistance for shoes and body, a resistance of 1,000,000 ohms was inserted across the two foot plates and with the full resistance of the variable 100,000 ohm resistor in circuit, the position of the needle was noted on the scale; this was accepted as the dividing line between the safe and unsafe ranges of the scale.

The power source consists of three 45 volt radio "B" batteries connected in series to provide 135 volts. A 100,000 ohm variable resistor and two 100,000 ohm fixed resistors, available at radio supply stores, completed the equipment which was purchased and installed. A one million ohm fixed resistor was also purchased for testing purposes. All other necessary material was available in the hospital shops.

In a previous publication (4) the wiring diagram differed from the description

* Central Scientific Company, Cambridge, Mass., Catalogue No. 82115.

already given. The original diagram did not include the fixed resistor between each foot plate and source of power. In order to provide additional protection to personnel using this equipment, the present wiring diagram is recommended.

The galvanometer is mounted on a wooden pedestal supported by a 1½ inch metal pipe stand through which the connecting wires pass. The base of the unit consists of a substantially built wooden box (maple or birch preferred) in which are housed the "B" batteries and the resistors (fig. 3). The cover of the box may be removed by sliding it backward for access to the batteries, resistors and wiring. On the top of the cover a sheet of bakelite, ¼ inch thick, is attached on which are fastened the two stainless steel foot plates (fig. 1). The foot plates are wired into the electrical circuit (fig. 4) by extending a bolt from each plate through the bakelite and wood box top (carefully avoiding contact with the wood). The wiring is attached to the bolts on the underside (fig. 3). It is essential that all other bolts and nuts fastening the stainless steel foot plates to the bakelite be kept from contact with the wood top by the countersunk holes. It is necessary periodically to test the equipment for accuracy as the batteries become discharged. This is done by placing a 1,000,000 ohm resistance across the foot plates and adjusting the variable resistance until the meter needle rests again at the dividing line between safe and unsafe ranges of the scale.

The shoe tester as described and illustrated, costing approximately $50, is easily transported, weighs about 75 pounds, is 4 feet in height and covers 2 square feet of floor space. It should be placed at a location on the operating and delivery floors convenient to all personnel. To operate the tester an individual stands with one foot on each foot plate and presses the single button immediately below the scale on the galvanometer (fig. 5). If the galvanometer needle deflects across the scale into the "safe" range the shoes have a resistance of one megohm or less and are sufficiently conductive to connect electrically the individual to conductive flooring. If the needle does not move out of the red position of the scale the footwear has a resistance greater than one megohm and is not conductive enough to interconnect the wearer to the conductive flooring safely. If the latter occurs the soles of the shoes should be cleaned. This may be accomplished by scrubbing them vigorously back and forth on an ordinary fiber doormat contained in a shallow metal pan located next to the testing apparatus.

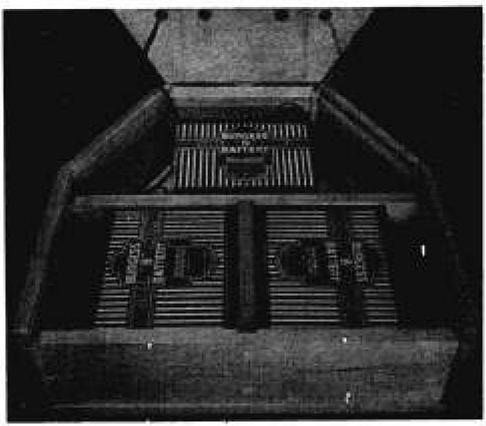

FIG. 3. Base of shoe conductivity tester.

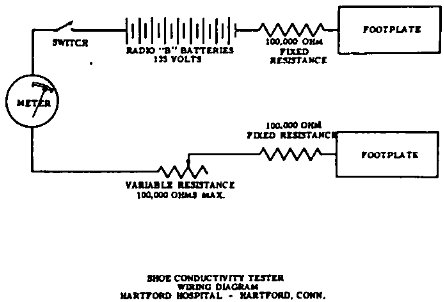

FIG. 4. Diagram for wiring shoe conductivity tester.

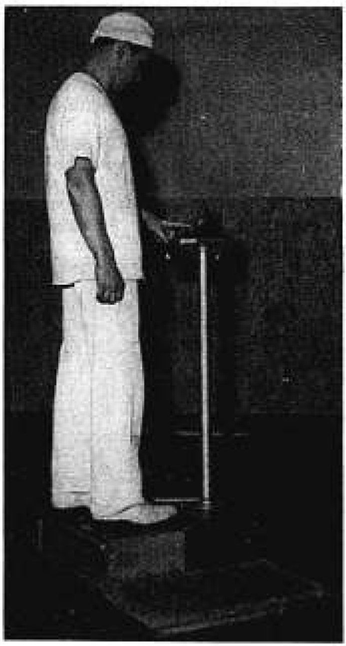

FIG. 5. Operation of shoe tester.

The mat should be kept moistened with water. After cleaning the shoes of foreign material such as wax, dust or powder, a second test should be made.

In the event that the needle shows no deflection when the testing button is pressed, the apparatus may be checked roughly but quickly by contacting the two steel foot plates with the fingers of one hand and depressing the test button. If the tester is in working order the needle will deflect into the safe position of the scale; if there is no deflection the apparatus should be considered to be out of order.

SUMMARY

A simple and inexpensive apparatus has been described for testing the electrical conductivity of shoes used by personnel in hazardous locations within hospitals. The testing apparatus has proved satisfactory for daily usage during the past three years at Hartford Hospital. It is considered a valuable adjunct in meeting the Code established by the National Fire Protection Association.

REFERENCES

1. Bulletin, National Fire Protection Association; Combustible Anesthetics in Hospital Operating Rooms. Boston, 1941.
2. Ibid., revised 1944.
3. Bulletin No. 56, National Fire Protection Association, Recommended Safe Practices for Hospital Operating Rooms, Boston, May 18, 1950.
4. Hickcox, C. B., and Lovell, B. B.: A New "Build-It-Yourself" Conductive Shoe Tester, Hospitals **24**: 57–59 (Nov.) 1950.

CURTISS B. HICKCOX, M.D., *Associate*,
RALPH M. TOVELL, M.D., *Chief*,
Department of Anesthesiology,
AND BURTON B. LOVELL, B.S.,
Chief Engineer,
Hartford Hospital, Hartford, Conn.

VOCAL CORD PALSY AS A COMPLICATION OF ROUTINE ARTERIOGRAM OF INTERNAL CAROTID ARTERY: TWO CASE REPORTS

Two cases are reported to call attention to the possible complication of palsy of the vocal cords in conjunction with the technic of arteriography of the internal carotid artery. This complication may occur whether the procedure is performed by percutaneous technic or by surgical exposure of the artery. In the first case report palsy of the vocal cord was suspected twelve hours after arteriography and confirmed in twenty-four hours. In the second case the procedure was done ten days later. The complication was recognized at the time the procedure was completed.

REPORT OF CASES

Case 1.—On December 31, 1949, a 48-year-old white woman was admitted to the hospital, with a history of emotional and mental disturbances, gradually developing before admission. Further history was unobtainable since the patient was disoriented and moderately agitated.

Physical examination revealed that the patient was obese. The essential physical findings were as follows: blood pressure 120 mm. systolic and 70 mm. diastolic, pulse 80, respirations 20 and temperature 98.4 F. There was a midline rectus scar in the lower part of the abdomen. Findings on neurologic examination were compatible with an expanding intracranial lesion in the left cerebrum.

Routine admission examinations of the blood and urine were within normal limits. The Kahn test gave negative results. An electro-encephalogram showed a focus of delta waves in the left prefrontal area (nothing posteriorly). Roentgenograms of the skull revealed marked erosion of the sella and posterior clinoids.

On January 5, 1950, bilateral arteriograms were done. The patient was given nembutal, 0.1 gm., at 12:00 noon and demerol, 50 mg., with scopolamine, 0.3 mg., at 12:30 p.m. In surgery the patient's larynx was cocainized and anesthesia begun at 1:54 p.m. using intravenous pentothal-curare mixture (1.0 gm. with 100 units [15 mg.] in 40 cc.). The vocal cords moved well and seemed normal in every re-