

the complications of laparoscopy reported have been associated with inexperience of the operator and/or the physical status of the patient. On the other hand, gastric perforation in our case could be attributed only to the inexperience of the anesthesiologist. Had the stomach not been inflated secondary to the inaccurate placement of an endotracheal tube, the complication probably would not have occurred.

A similar episode of gastric perforation has recently been reported by Whitford and Gunstone.<sup>4</sup> In their case the insufflated carbon dioxide remained in the patient's stomach and the situation was not diagnosed until the laparoscope was in place and the operator observed gastric rugae. Laparotomy was necessary to repair a perforated anterior gastric wall. In contrast, laparotomy was not necessary in our case because the diagnosis of gastric perforation was made prior to the insertion of the 10-mm laparoscope and the 14-gauge Verres needle, fortunately, had passed through an avascular area of the stomach.

Such a complication of laparoscopy need never occur if the proper precautions are ob-

served. Whitford and Gunstone urged that whenever the stomach of a patient has been inflated by the placement of an endotracheal tube in the esophagus, a large-bore nasogastric tube should be passed before the laparoscopic procedure is started. We have found that a no. 14 French suction catheter threaded down the esophagus is sufficient to empty the stomach of gas. We recommend that whenever there has been any difficulty with the management of the airway of a patient for laparoscopy, the stomach always should be emptied by a technique more effective than manual decompression.

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## Pin-indexing Failures

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Safety devices applied to equipment convey an impression of infallibility. The pin-index safety system applied to anesthesia machines is an example of such a device. Failures in the pin-indexing safety system prompted our review of its development and the technical reasons for failure. These factors are the basis of this communication.

The pin-index safety system was developed to eliminate the hazard of accidental interchange of gas tanks. The problem received considerable attention prior to World War II. The idea for the present system was presented to the Ohio Chemical Company by Dr. Philip

Woodbridge in 1939.<sup>1</sup> The need for such a system was recognized by the manufacturer and by various societies, including the Compressed Gas Manufacturers Association, American Society of Anesthesiologists, and the American Hospital Association. Agreement by these associations, as well as the military, resulted in the adoption in 1949 of the present standard known officially as "The Pin-Index Safety System for Flush-Type Cylinder Valves."<sup>2</sup> It has been presented to Technical Committee No. 5S of the International Organization for Standardization as a proposed international standard.

The system consists of six possible pin positions on the yoke and six possible hole locations on the valve. Each gas is identified by two pin positions, allowing ten possible com-

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TABLE 1. Pin Positions Assigned to Eight Gases and Gas Mixtures

Cylinder Contents	Pin-hole Numbers (See fig. 1)
Oxygen	2 and 5
O <sub>2</sub> and CO <sub>2</sub> (CO <sub>2</sub> not more than 7 per cent)	2 and 6
O <sub>2</sub> and He (when He is less than 80 per cent)	2 and 4
Ethylene	1 and 3
Nitrous oxide	3 and 5
Cyclopropane	3 and 6
He or He-O <sub>2</sub> mixtures (when O <sub>2</sub> content is less than 20 per cent)	4 and 6
CO <sub>2</sub> or CO <sub>2</sub> -O <sub>2</sub> mixtures (when CO <sub>2</sub> content is more than 7 per cent)	1 and 6

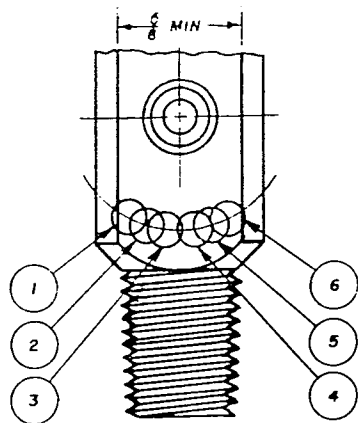


FIG. 1. Pin positions on the cylinder valve.

binations or the use of ten different gases. Cases or mixtures of gases totalling eight have been assigned combinations (table 1). Pin diameters are identical, and positions are numbered 1 through 6. Pin 1 is located 30 degrees from the horizontal; the other pins are located at 12 degree intervals. Although other safety

standards could have been adopted, this one was chosen because it could be easily installed on existing equipment without returning it to the manufacturer. The dimensions and tolerance of this system are listed in the National Bureau of Standards Handbook H-28.<sup>3</sup>

A new anesthesia machine was delivered to this institution by the manufacturer. Rubber goods and gas cylinders were attached by a nurse. Before being used with patients, it was tested by a member of our staff. Inspection revealed that a nitrous oxide cylinder was securely fitted in the cyclopropane yoke. To determine whether nitrous oxide would be delivered through the flowmeter, the tank was turned on. This caused the tank pressure gauge to stick permanently at the top of the dial. Nitrous oxide was delivered through the cyclopropane flowmeter with no detectable leak at the yoke. In an effort to detect other failures in the system, we removed one oxygen cylinder and replaced it with a nitrous oxide cylinder. We were able to deliver nitrous oxide via the oxygen flowmeter without detectable leakage at the yoke, indicating that a gas-tight joint was secured despite the presence of the wrong pin index (or position).

On another occasion, a staff member examined a machine after it had been cleaned and empty tanks had been replaced by an operating room technician. This machine had been in use at this institution for approximately eight years. A green tank was found on each oxygen yoke; however, the shades of green were considerably different. Closer inspection revealed that one cylinder was labeled oxygen, and the other nitrogen. The nitrogen cylinder was firmly attached, and allowed nitrogen to be delivered through the oxygen flowmeter without detectable leak at the yoke.

Several factors were responsible for the failure previously described. Nitrous oxide is indexed in positions 3 and 5; cyclopropane is indexed in positions 3 and 6. With pin 3 common to both, pins 5 and 6 theoretically prevent interchangeability. When the yoke is manufactured, a blind hole is drilled and a pin inserted in it. Specifications list pin protrusion as  $\frac{1}{32}$  inch (+0 to  $-\frac{1}{32}$  inch tolerance). The depth of the hole and the total pin length are

not specified. The number 6 pin was inserted in a blind hole that was too deep on the cyclopropane yoke. When the nitrous oxide cylinder was attached, tightening the handle forced the pin deeper into the hole, and allowed the tank to seat.

Examination of N<sub>2</sub>O and oxygen cylinders revealed that they were provided by more than one supplier. It also revealed that any of four types of washers (fig. 2) may be used to effect a seal between the cylinder and the yoke. Two of these were designed to fit on the cylinder, and two were designed to fit the nipple of the yoke. Of those designed to fit the yoke, one is nylon, 0.065 ( $\pm 0.003$ ) inch thick; the other is of a fiber composition, 0.09S ( $\pm 0.005$ ) inch thick. Of those attached to the cylinder, one consists of a metal washer with a rubber insert which fits over a nipple screwed into the valve body; this is 0.078 ( $\pm 0.02$ ) inch thick. The fourth consists of a nylon nipple with a flange measuring 0.077 ( $\pm 0.003$ ) inch. The nipple comes inserted in the valve body of the tank. The Compressed Gas Association Standards specify that the washer should be  $\frac{1}{16} \pm \frac{1}{64}$  inch thick (0.046–0.078 inch). By leaving a fiber washer on the nipple, we were able to seat a nitrous oxide tank with a flange-type nylon washer on the oxygen yoke, and thereby deliver nitrous oxide through the oxygen flowmeter.

In the second case presented, a nitrogen cylinder which is not pin-indexed was inserted on an oxygen yoke which had two fiber washers inadvertently placed over the nipple. The indexing pins were then too short to prevent the cylinder from making a gas-tight seal.

The Compressed Gas Association Standard for basic yoke dimensions lists the flanged nipple as having a nose length of 0.140–0.120 inch, but the shoulder length of the flange is not specified except "to fit yoke." Variations in this flange length, coupled with variations in washer thickness, alter the effective lengths of the indexing pins.

#### CONCLUSION

The pin-index safety system provides only partial protection against placing a cylinder on

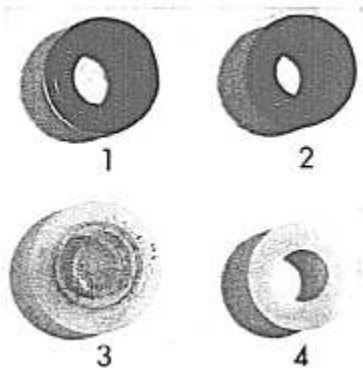


FIG. 2. Types of washers: 1) metal washer with rubber insert; 2) fiber washer; 3) nylon nipple with flange; 4) nylon washer.

the wrong yoke. One must carefully match the color code and label of the cylinder to the color code and marking on the yoke. The changing of cylinders should not be considered a menial task and assigned to a poorly-trained orderly or technician; it should be the responsibility of the anesthetist using the machine.

*Recommendations:* 1) Increase pin length. Fit drilled holes and pin length to prevent accidental jamming of the pin into the hole. 2) Washers should be standardized; only one type to be used by all manufacturers. 3) The nipple diameter for the oxygen tank should be different from all others to prevent accidental seating of any other gas tank. 4) Colors used for coding medical gases must not be used on non-medical gas tanks.

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