A DESIGN FAULT IN THE BOYLE APPARATUS

Sir,—We would like to draw attention to a most serious and fundamental fault in the design of the "old faithful" of anaesthetic apparatus, the Boyle machine.

Eger and associates (1963) suggested that if a leak should occur within the Rotameter block then, because of the upstream position of the oxygen Rotameter, there would be a selective loss of oxygen, with resulting hypoxia. They were, however, unable to give an example of such an incident.

This unfortunate event occurred recently at this hospital. During a routine tonsillectomy list, a child, induced uneventfully on one machine in the anaesthetic room, rapidly became hypoxic on transference to a second machine in the operating theatre. Normal oxygenation was restored on depressing the oxygen bypass which in this machine was located adjacent to the reservoir bag on the downstream side of the vaporizing bottles. On returning to the oxygen/nitrous oxide mixture, cyanosis reoccurred, such that, after further resuscitation, the case was abandoned. When the events were repeated in the next case, the list was cancelled.

Superficial examination of the machine did not disclose a fault, and analysis of the cylinder contents revealed no abnormality. Detailed examination, however, showed a hair crack in the cyclopropane Rotameter, without displacement of the broken parts (fig. 1). This may have resulted from overtightening of the retaining screw during routine maintenance with resulting stress on the glass, which ultimately cracked.

On allowing 2 l./min of oxygen to flow together with increasing volumes of nitrous oxide, there was a rising loss of gas through the cracked cyclopropane

<table>
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<tr>
<th>Oxygen Rotameter setting (l./min)</th>
<th>Nitrous oxide Rotameter setting (l./min)</th>
<th>Oxygen percentage Cracked tube</th>
<th>Oxygen percentage Sound tube</th>
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FIG. 1

(a) Apparently intact cyclopropane Rotameter.
(b) Same Rotameter showing the break.

Rotameter. Analysis of the resulting gaseous mixture, as shown in table I, shows that oxygen is progressively lost, until at the usual mixture of 2 l./min of oxygen and 5 l./min nitrous oxide there was no oxygen in the mixture, although the reservoir bag filled apparently normally.

This series of unfortunate events shows that the oxygen Rotameter, because of its position on the upstream side of the bank of Rotameters, will indicate a flow of oxygen which in the event of a leak, will not reach the patient. In other words the present arrangement does not "fail safe".

This can be corrected simply by reversing the position of the oxygen and nitrous oxide Rotameters. However, as the leak described must be a very rare event, for we cannot find any previous reference to actual cases, such a reversal of the oxygen Rotameter from its time-established position may well result in more unfortunate accidents than it prevents. Alternatively the oxygen Rotameter could be isolated from the remaining meters within the Rotameter bank. A more practical approach, however, may be to realize the possibility of a selective loss of oxygen in any unexplained hypoxia.

In the older type of Boyle machine we would suggest a routine simple test for leaks in the apparatus by occluding the exit port with the gases flowing. The Rotameter bobbins should be forced down towards their seatings when the apparatus is free from leaks. This test is not recommended in the new stainless steel machines with their higher supply pressure, for fear of damaging gaskets, etc. However, we are assured by the Technical Department of the British Oxygen Company that the 9-inch Rotameters are even less likely to break as they are held in place by an alternative method.

We wish to express our thanks to the British Oxygen Company, and in particular to Dr. A. Bracken of their Gases Application Development Department, for advice and help in measuring the oxygen concentration.

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REFERENCE