A New Device for Synchronized Intermittent Mandatory Ventilation

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Weaning a patient from long-term mechanical ventilation is hazardous and extremely time-con-
suming. To facilitate weaning, intermittent mandatory ventilation (IMV) has been advocated by Downs and associates. Several respiratory circuits for IMV have been developed. With these devices, however, IMV does not always precisely coincide with the patient's inspiratory phase. As a result, the patient may fight the respirator, frequently causing bucking, bronchospasm, or dysrhythmic respiration. The more the ventilatory ability of the patient recovers, the greater the occurrence of this problem.

It has been shown that intermittent demand ventilation (IDV) or intermittent assisted ventilation (IAV) is a helpful technique to maximize patient cooperation.

Fig. 1. S-IMV controller during weaning of a patient from mechanical ventilation. The controller is attached to a Bird MK 8 respirator.
Intermittent demand ventilation, as described by Shapiro, delivers mechanical breaths at a rate dependent on the patient's spontaneous respiratory rate. A patient who decreases his own respiratory rate, therefore, will have a slower mechanical rate. This may cause hypoventilation when the spontaneous rate is dangerously lowered by respiratory center depression or by other causes.

In an effort to overcome the disadvantages of IMV and IDV, we devised a respirator controller which, attached to the respirator, delivers IDV at a rate independent of the patient's own respiratory rate. Artificial ventilation with this system has advantages of both IMV and IDV, and might be reasonably called "synchronized IMV" (S-IMV).

The controller, which we call the S-IMV controller,
can be easily added to a conventional pressure-sensitive respirator, e.g., the Bird MK 8, Bennett MA-1, etc. The device consists of an electrical circuit, a detector of spontaneous respiration, and a solenoid valve (fig. 1). A circuit-block diagram of the S-IMV controller is shown in figure 2.

**Mode of Action**

A pulse generator consisting of a basic stable multivibrator (3.75-sec interval) and a six-bit binary counter produces six different pulses through the frequency division. A desired pulse rate (S-IMV rate; 4–16/min) is freely selected using the selector switch. Each of these pulse rate settings resets the flip-flop open, which is shown by a green light.

Each of the patient’s inspiratory efforts opens the inspiratory valve, which covers the photocell from the light source, producing electrical current. This current can trigger the monostable oscillator for 0.3 sec only by resetting the flip-flop, which has been preset by a pulse from the generator. The triggered monostable oscillator opens the solenoid valve, which is connected in series from the negative-pressure triggering circuit of the respirator to the suction unit. Through these mechanisms, each inspiration can activate the respirator into the pattern of assisted ventilation.

As of April 1977, the controller has been used for respiratory care of nine patients for one to four days. Some of the clinical data obtained from these patients are shown in figure 3. The respiratory pattern with S-IMV recorded by pneumotachography (Nihon Koden, Japan) is smooth and rhythmic, compared with that obtained during conventional IMV. By impedance pneumography (Nihon Koden, Japan), S-IMV showed regular spontaneous respirations with well-synchronized mechanical breaths. IMV, on the contrary, is not as well synchronized.

Obviously, subjective information from patients is of value in determining the efficacy of the respiratory care. Without information concerning this device, the nine patients were subjected to IMV and S-IMV in sequence and asked which they preferred. All nine patients claimed that they could breathe more comfortably with S-IMV. Much more clinical experience is needed to determine whether the device can shorten the period of weaning.

The electrical parts used in this device are inexpensive (approximately one hundred dollars), and it is simple for electrical technicians to construct.

In summary, the synchronized IMV controller is apparently more acceptable to the patient than IMV, may be safer than IDV, and is useful for weaning the patient from mechanical ventilatory support.

**References**