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### A Venturi Circulator for Anesthetic Systems

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The Dual-Venturi Circulator † is designed to move the warm, moist, anesthetic atmosphere at high flow around the circuit of a semi-closed carbon dioxide absorption system. The input of anesthetic gases and oxygen is injected into the system at low flow through two identical, parallel, Venturi jets. This convenient mode of operation thus eliminates any need for an auxiliary source of power. The mechanism is simple in construction, quiet in operation, and unusually free from trouble because there are no moving parts.

Besides these advantages, inherent in Venturi design, the use of such a circulator provides all the benefits of a high-flow circulating system. Gases and vapors are mixed rapidly

within the circuit, eliminating abruptness or undue delay in changes of concentrations in the inspired atmosphere. Resistance to breathing through tubes, valves and soda lime is compensated. Under-mask deadspace is ventilated thoroughly if a partitioned Y piece is used to connect the breathing tubes with the face mask. ‡ Control of temperature and humidity is available. The breathing space becomes, in effect, a miniature air-conditioned chamber. These advantages are progressively more important with the smaller sizes of children and infants.<sup>1</sup>

For pediatric anesthesia, the diversity of apparatus and methods in past use has resulted from a general dissatisfaction with the various answers to the problems of deadspace, resistance, and control of temperature and humidity. A current trend toward the use of adult circle absorbers in preference to the miniaturized versions or the various non-rebreathing systems has been accelerated by the development of halothane as a very expensive but also very desirable anesthetic agent. The problems still inherent in the ap-

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† The Dual Venturi Circulator is available commercially from Ralph Neff Associates, 1441 Flicker Way, Sunnyvale, California 94086.

‡ The partitioned Y or divided chimney Y piece is listed in the catalogs of Dupaco, Arcadia, California 91006, and Ohio Chemical Co., Madison, Wisconsin 53700.

FIG. 1. Diagram of Dual-Venturi Circulator. Supply nipple is connected to gas supply tubing from anesthetic machine. Bypass nipple is connected to usual inlet to canister or other point in circuit. Inflow is attached to canister by mounting clamp *M* and secured by tightening the wing nut shown. Inspiratory breathing tube is connected to outflow. The control valve *C* is shown in the "on" position with the circulator operating and the bypass cut off. Also indicated are the Venturi jets *V* and the pressure relief valve *R*.

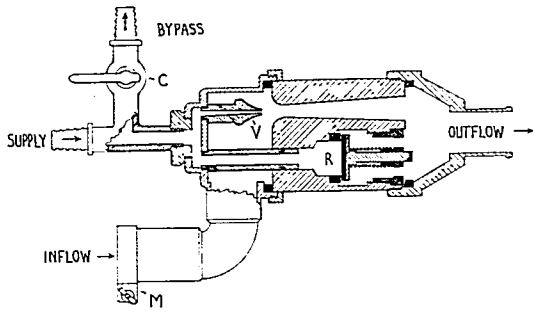
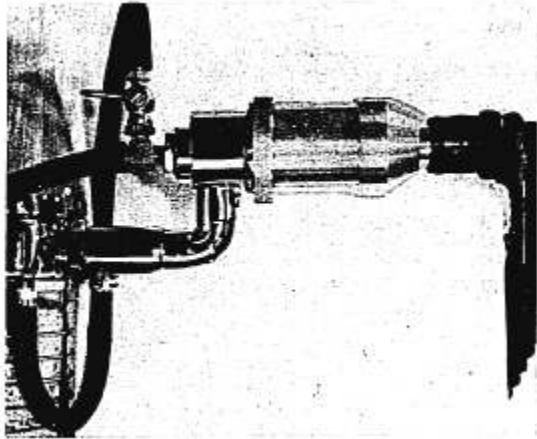


FIG. 2. Photograph of Dual-Venturi Circulator in use. The unit is mounted by clamp on the canister in the inspiratory limb of the circle. Bypass is connected to normal inlet to canister.



plication of the adult circle system to the child or infant, or even to the very ill and debilitated adult, are practically eliminated by the use of a Venturi circulator.

The method of use demands a gas-tight fit of mask to face. This first prerequisite is not so difficult to accomplish because the size of the mask is no longer a critical factor. Even on a small infant, one may use a large mask if it will conform better to the face and prevent leaks. A second basic requirement, if

one would realize the advantages of minimal rebreathing, is the use of a partitioned chimney in the Y piece connecting mask to breathing tubes.

For induction of anesthesia it is advisable to begin in a conventional manner with the control valve turned to the "off" position so that the circulator is not functioning. After the mask is in proper contact with the face, the input flow of gases may be reduced to a total of three or four liters per minute and the

circulator is turned "on." Both inspiratory and expiratory valves of the circle will float in an open position. Measurement with a Wright respirometer placed in the circuit will indicate a total flow of 18 to 20 liters per minute through the breathing tubes and the mask. While these valves remain open, they do not serve as directional controls; but they do indicate that the circulator is operating. If it is turned off, the valves of the circle resume their normal function. Another indication that the circulator is operating is the sound of the turbulence to be heard in the breathing tubes when they are held very close to the ear.

When anesthesia has been established it may be maintained with a flow of three or four liters per minute of gas input after the manner of any semiclosed carbon dioxide absorption method. Respiration may be assisted or controlled by hand or machine in the usual fashion, although the anesthetist will observe how quickly assisted breathing becomes controlled.

Experience with the use of the Venturi circulator will demonstrate its varied applications. For example, near the end of a prolonged administration of nitrous oxide with oxygen, proper re-aeration of the alveoli may be accomplished simply and effectively by removing the breathing bag. Oxygen continues to power the circulator and augments the concentration in the room air that is being drawn into the system during the transition period. In another situation, during induction of anesthesia with an agent such as nitrous oxide, cyclopropane, halothane, or methoxyflurane, with the circulator turned on, the removal of the breathing bag at the very beginning provides a cooling, breezy flow of gas over the face of the child as the mask is being applied. This eliminates much of the sense of closeness or claustrophobia and dilutes the initial odor of the anesthetic agent. As soon as a proper fit of the mask is achieved, the breathing bag is attached and induction will proceed smoothly.

A back pressure of 80 mm. Hg occurs in the flowmeters and in the gas delivery line as a flow of three liters per minute is injected through the orifices of the twin Venturi jets.

This pressure can be measured by a sphygmomanometer attached to a sidearm connection in the gas delivery tube. The pressure reading can be used to monitor the operation of the circulator, the flow through the anesthetic circuit being a linear function of the pressure applied to the Venturi jets. It is to be emphasized that the pressure within the anesthetic circuit is not elevated significantly by the circulator, as used with standard size canister and breathing tubes. Our measurements during anesthesia indicated an increase in pressure of only 0.3 to 1.0 cm. H<sub>2</sub>O over values in the mask or other components of the system when the circulator was added to the motive power of the patient's own respiration. Such a small increment is comparable to the values of 1.0 to 1.7 cm. H<sub>2</sub>O pressure induced by the spring-loaded escape port in the standard circuit.

The back pressure in the flowmeter delivery tube system is not a linear function of the gas flow input to the Venturi jets, but the exact relationship is unimportant. If the back pressure rises much above 80 mm. Hg at a given flow of three liters per minute, this indicates that one or both of the jets are partially blocked and should be cleaned with a fine steel wire. On the other hand, if the back pressure is much less than the proper value at the three-liter flow, a safety relief valve in the circulator or in the anesthetic machine is partially open and should be checked. It may also indicate a leak in the flowmeter system, which should be corrected immediately whether the circulator is to be used or not.

The effects of these increased pressures on the flowmeter functions are not significant. In the normal operating range of 80 mm. Hg, or approximately 1.6 p.s.i., the flowmeter readings were reduced by ten per cent. In the absence of a differential leak, there is no appreciable change of relative concentrations in the gaseous components of the anesthetic input to the circuit. The concentration of halothane generated by vaporizers was decreased by about ten per cent also, this effect being more noticeable at the higher ranges of vaporizer setting, and more apparent with the Fluotec than with the Vernitrol. Analysis of

the anesthetic atmosphere within the circuit showed concentrations of halothane which closely paralleled the predicted values. There is an important advantage to the back pressure in the flowmeter-vaporizer system. Intermittent positive pressure for controlled ventilation is not reflected with the same degree of fluctuation of pressure within the vaporizer, and halothane output is stabilized.

In clinical application, the Venturi Circulator has been used in its final design for nearly all cases in the general anesthesia practice of two of the authors during the past year, with complete satisfaction. The patient groups included all ages from newborns to 90 years. No cases were excluded because of type of operation, anesthetic agent, or operative risk.

#### SUMMARY

We have described a Dual-Venturi Circulator for anesthesia, the reasons for its value, and the methods for its use. Circulation of the respired atmosphere appears to be most advantageous when applied to infants, children, and the debilitated. The method also provides definite benefit to any patient. The factor of economy in reduced wastage of anesthetic agents is significant. The apparatus is simple in design, reliable in operation, and readily serviced by the anesthesiologist.

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## A Method for Concurrent Artificial Ventilation and Cardiac Massage by the Same Individual

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When cardiac resuscitation must be initiated by a single individual, the current technique of interrupting massage to inflate the lungs can be both physically strenuous and relatively inefficient. This report describes a simple device (fig. 1) which reduces these difficulties by providing free use of the hands during artificial ventilation, thus allowing for improved coordination of resuscitative efforts with less physical strain and potential exhaustion for the rescuer.

The device is basically a mouth-to-mask ventilator using standard components: a mouthpiece from an underwater breathing apparatus (which is kept between the physician's teeth), a plastic elbow adapter, an accordion breathing tube, a nonbreathing valve and a metal elbow adapter for either an endotracheal tube or a face mask (with headstrap). Optionally, a demand valve for the administration of oxygen can be used.

For more efficient operation of this type of ventilator, and in order adequately to protect

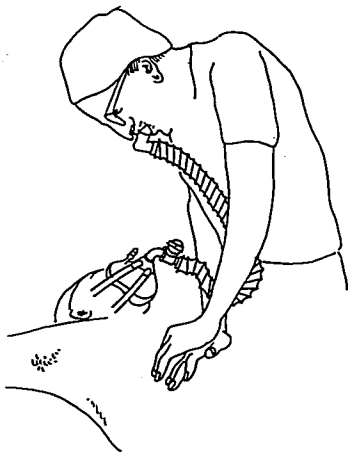


FIG. 1. Cardiac resuscitation with mushroom-type pressure equalizing valve in modified mouth-to-mask ventilator.

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