

AN IMPROVED CIRCULATOR FOR CLOSED CIRCLE ANAESTHESIA

DAN G REVELL, M D ¹

A PREVIOUS PAPER described a circulator for the elimination of dead space in closed and semi-closed absorption systems (1) A simpler, more convenient method of propelling the anaesthetic gases around the circle absorber has been developed This method also employs the divided chimney-piece to lead the gases down into and away from the under-mask space The pump employed to impel the gases is of simple design and is conveniently inserted or included into the circle system at the point where the inhaling connecting tube leaves the absorber head This circulator is better than the oscillating type in that it moves *all* the gases continuously in the circle, and a moisture condenser-trap with additional taps into the bag and the circle is unnecessary Thus it may be attached to the gas machine in a matter of seconds.

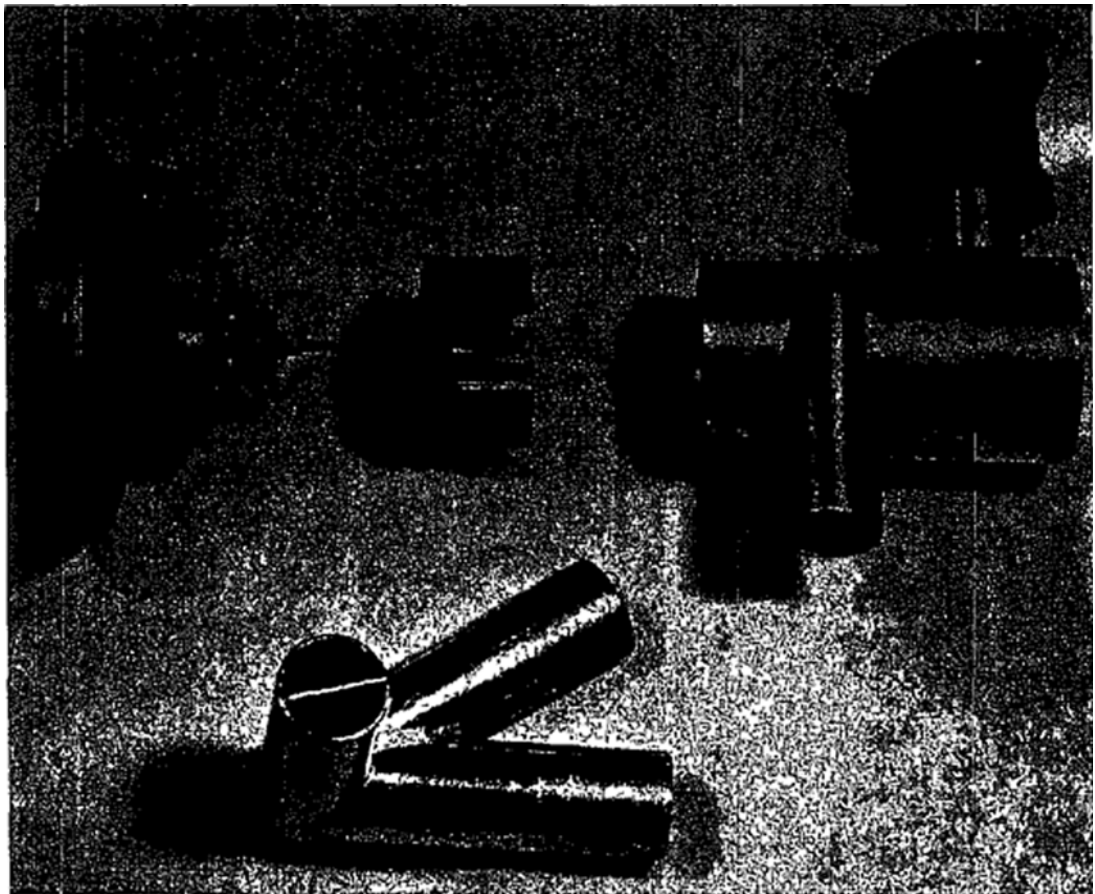


FIGURE 1 Disassembled total circulator for the elimination of under-mask dead space *Upper left* is the suction-powered turbine motor (Trico), *centre*, plastic impeller, which threads onto shaft of motor inside the cylindrical housing, *right* The ends of the housing are closed except where the shaft of the motor is mounted *Below* is the divided chimney-piece without which the under-mask gases would not be circulated

¹St. Joseph's Hospital, Victoria, B C.

This circulator may be described as a turbo-impeller (Fig 1) It consists of two rotating parts on a common shaft One rotating part is the turbine-type motor powered by suction, or in reality by atmospheric air pressure This little motor comes as the main part of the Trico automobile fan which is designed for mounting near the windshield to prevent condensation on the inside of the glass The other rotating part is a polythene plastic squirrel-wheel type of air-mover found in a push-button electric plant-duster made by the E C Brown Co at Canandaigua, NY This neat spindle-shaped air-mover happens to be threaded the proper size to fit onto the shaft of the Trico motor

The housing of the circulator is made of brass tubing of 1½ in inside diameter The motor is mounted on one end of a 3 in cylinder of this tubing, so that the shaft is inside and in line with the axis of the cylinder The squirrel-wheel fits into the cylinder and is mounted by threading onto the shaft of the motor This can now be made to spin inside the brass cylinder, and with the proper placing of tubular ports becomes an effective pump The other end of the brass cylinder is closed with a removable plug Maintenance is very simple as the small shaft is lubricated with graphite oil and is air-cooled when in operation

When used in a Heidbrink circle, the original metal-rubber valve disks are replaced by very light plastic disks These are so light that at quite moderate operation speed this new circulator causes them to stand open during all phases of the respiratory cycle It would not harm the effectiveness of the circulator if either valve were to seat momentarily at the peak respiratory flow caused by the patient during either inhalation, or exhalation, or both, as long as they are open during the pause before inhalation It is during this latter interval that the just exhaled gases are swept away towards the absorber by fresh gases from the bag

When mounted ready for use, the intake port is connected to the inhalation outlet of the absorber head by a rubber nipple and the connecting tube leads from the outlet of the circulator to the divided chimney-piece on the mask (Fig 2) In operation, after a gas-tight fit of the mask on the face has been made, the suction line to the motor is opened by a screw clip and the rate adjusted so that the valves of the gas machine are made to float open This of course means that the gases are circulating, and the valves will be seen to move slightly with the inspirations and exhalations of the patient The action of this pump raises the under-mask pressure by about 2 mm of water above the pressure in the whole system This in no way interferes with the respiratory movements of even the smallest patient but does relieve the patient from having to lift the inhalation valve or overcome the inertia of the gases with each inhalation

In order that the gases will not be passed through the soda lime too rapidly, the circulator should be run at the slowest rate at which the valve disks can be kept floating, though it does not matter if they become seated momentarily at the height of respiratory gas movements Without circulation the gases dwell in the soda-lime chamber either during inhalation or during exhalation depending on which side of the circle the absorber is located With circulation this pause is absent, but absorption is quite adequate as the gases pass through the soda lime many more times per minute than otherwise No clinical signs of carbon dioxide accumulation have been observed during the use of circulated closed technique in hundreds of paediatric and adult patients

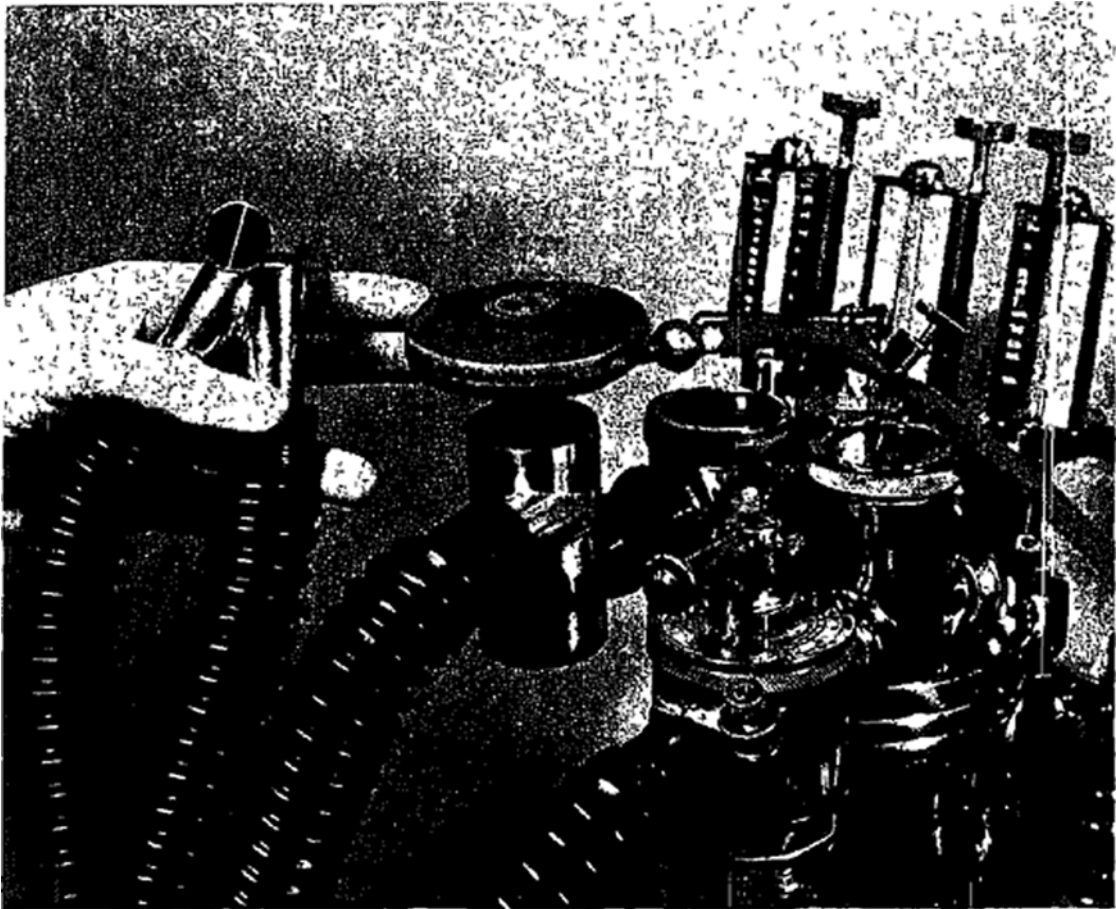


FIGURE 2 Vacuum turbine-powered circulator in place on a Heidbrink absorber head. This circulator moves all the gases in the system at such a rate that they pass through the soda lime many times in a minute, ensuring repeated opportunities for carbon dioxide absorption. Lightweight valve disks have been placed in the absorber head. The circulator is set to operate at a rate which just keeps these valves open. The rate of operation is dependent upon the degree of suction available and the adjustment of the screw clamp shown on the suction line leading to the motor. The divided chimney-piece patterns the under-mask gas flow to provide continuous change.

One effect of circulation in a closed system must be kept in mind. The usual Heidbrink wick-type ether vaporizer operates by having fractional amounts of the exhaled gases pass through the ether chamber. Thus ether vapour is picked up only when the respired gases pass around the circle as a result of the patient's respiratory effort or as a consequence of manual assistance by the anaesthetist, and etherization is therefore dependent on the minute volume. However, with the circulator propelling the gases continuously around, much more ether vapour can be added to the system per unit time. This is actually found to be an advantage since deep ether anaesthesia may be accomplished quite quickly with the circulator in operation. One soon learns to set the vaporizer control at a small opening to avoid too rapid increase in concentration.

Carefully controlled clinical studies have been made in which endotracheal carbon dioxide concentrations have been continuously recorded during anaes-

thesia Arterial blood specimens taken prior to and during use of the circulator have shown satisfactory levels of blood plasma pH and CO₂

A prototype of this circulator has been in clinical use for five years with very satisfactory results in all sizes of paediatric patients As cyclopropane is such a versatile and satisfactory agent for anaesthesia in babies and children, the use of a circulator allows the use of this agent with any adult circle absorption machine with light valves Circulation may be used in closed or semi-closed techniques, and it obviates the need for high flow rates or semi-open techniques as a means of minimizing dead space

The illustrations show the circulator, both disarticulated and assembled in place on the gas machine The divided chimney-piece—an essential part of the apparatus—is to be noted

SUMMARY

A vacuum-powered turbo-impeller is described for use in closed or semi-closed anaesthetic techniques Use of this apparatus with a divided chimney-piece eliminates the under-mask dead space and permits the safe use of cyclopropane and ether in a closed system for paediatric anaesthesia

ACKNOWLEDGMENT

The author wishes to acknowledge the help and stimulating guidance of Dr Lucien E Morris, Professor of Anesthesiology, University of Washington School of Medicine

RÉSUMÉ

Nous avons décrit un circulateur amélioré à turbine pour éliminer l'espace mort sous le masque Ce circulateur, plus simple, plus silencieux, fonctionne par succion, se fixe facilement et rapidement à n'importe quelle machine à gaz, requérant seulement que les valves soient un matériel très léger Au moyen d'un connecteur divisé appliqué sur le masque, la circulation des gaz engendre sous le masque un courant d'air qui emporte l'air exhalé et le remplace par le l'air frais venant de la machine Ce circulateur, plusieurs fois à la minute, fait faire le tour du circuit à l'atmosphère qu'il contient, y compris à travers l'absorbeur De plus, il facilite considérablement l'évaporation de l'éther ou de tout autre agent liquide lorsque cet agent est ajouté aux mélanges cyclopropane, protoxyde et oxygène

REFERENCE

- 1 REVELL, D G A Circulator to Eliminate Mechanical Dead Space in Circle Absorption Systems *Canad Anaesth Soc J* 6 98-103 (April, 1959)