THE ADAPTATION OF CONTINUOUS NITROUS OXIDE TO THE "TO AND FRO" CARBON DIOXIDE ABSORPTION TECHNIC

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SINCE the introduction of carbon dioxide absorption to anesthetic atmospheres by Waters in 1923 (1), the science of anesthesiology has been replete with achievements heretofore unprecedented. Recently in carefully conducted and controlled experiments, Adriani and Rovenstine (2) have conclusively shown that the continuous absorption of carbon dioxide by means of the to and fro canister is more efficient than that obtained with the circle type of absorbers. All anesthetic appliances incorporating the latter type of absorbers permit the continuous flow of nitrous oxide while ether anesthesia is being established. In clinical anesthesia this is a distinct advantage, for it must be admitted that the induction of narcosis by means of nitrous oxide allows for smoother introduction of the ether vapor—the complemental agent. It must likewise be admitted that the maintenance of narcosis with nitrous oxide throughout the induction phase and while ether anesthesia is being established, militates in a great measure against the so-called "stormy induction." The crux of the problem evolves about the ability to maintain satisfactory narcosis with nitrous oxide and oxygen until the patient is anesthetized beyond the stage of delirium by means of ether. To accomplish this with the carbon dioxide absorption technic, the continuous flow of nitrous oxide independent of ether, is obligatory. Employing our present to and fro absorption method, the continuous delivery of nitrous oxide with oxygen independent of ether, is not feasible. Once induction of anesthesia is established by means of nitrous oxide and oxygen, the nitrous oxide must be shut off before a tolerant concentration of ether vapor can be administered to the patient. This latter maneuver is essential due to the fact that our present anesthetic appliances employing to and fro absorption permit the passage of all gases through the ether vaporizer. Thus, when vaporizing ether with oxygen, the attempted addition of the slightest amount of nitrous oxide must perforce pass through the liquid ether, thereby increasing the concentration of ether vapor so greatly that the patient cannot tolerate it. As a result of the coughing, laryngeal spasm or apnea initiated, it becomes necessary to discontinue the nitrous oxide, dilute the irrespirable mixture with oxygen or nitrous oxide or a combination of both, and begin

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the induction of anesthesia again. From this point on, the anesthetization of the patient to the surgical stage of anesthesia becomes a progression of additions to and dilutions of the anesthetic mixture until such time as the patient succumbs. An induction so deranged may completely alter adversely the maintenance of anesthesia to the extent that the patient and the anesthetist are at variance throughout the entire surgical procedure. To this may be added the embarrassment to the surgeon and the unfavorable influence that such a stormy anesthetic may have upon the patient's postoperative convalescence. To obviate this, it seemed very desirable to have an anesthetic apparatus which would permit a continuous flow of nitrous oxide while ether anesthesia was being established; at the same time utilizing the more efficient to and fro carbon dioxide absorption technic.

In addition to this significant feature, this type of apparatus suggested possibilities for incorporating other established physical and mechanical principles heretofore unattempted. Last, but not least in importance, it permitted the elimination of trapping any of the explosive mixture of nitrous oxide-oxygen-ether within the apparatus itself. In order to preserve refinements of design, a standard metric anesthetic machine was utilized for experimental purposes. This apparatus diverts all the anesthetic gases including oxygen through the ether vaporizer. In its present construction, the continuous flow of nitrous oxide and oxygen, independent of ether vaporization, and employing the to and fro absorption technic, is not practicable. To attain this objective, it was necessary to devise some means whereby the anesthetic gases and at least "coarse" oxygen might be administered without passing through the ether vaporizer. For vaporization of the liquid ether and to insure the uninterrupted flow of oxygen for the metabolic requirements of the patient, the "fine" oxygen control was adequate.

The radical departure in design of the anesthetic apparatus, presently to be described, incorporates the aforementioned features. It in no way alters the approved methods taught of administering any one of the anesthetic agents at our disposal. In reality, the adaptation of continuous nitrous oxide to the to and fro method of carbon dioxide absorption has several very decided advantages.

Description of the Machine

The outstanding alteration in design is in the water reservoir or water jacket. The original single large water reservoir has been broken up into two separate chambers. The larger compartment has five calibrated ports which permits the delivery of five different gases, namely, "coarse" oxygen, carbon dioxide, nitrous oxide, helium and cyclopropane. If ethylene is desired, a port for its delivery may be included within this compartment. The smaller compartment has only one calibrated port for the delivery of "fine" oxygen exclusively. *No* *other gas can be shunted through this smaller chamber.* This latter compartment is directly connected to the ether vaporizer, so that any and all of the fine oxygen delivered may be passed through the liquid ether by turning the ether key into proper position. All of the other gases are piped individually to their respective ports at the top of the larger water compartment, and, after registering on their flowmeters, are allowed to mix within the common mixing chamber above the water level and subsequently bi-pass the ether vaporizer to the common gas outlet. Thus with the present arrangement, the liquid ether may be intermittently or continuously vaporized by means of the fine oxygen

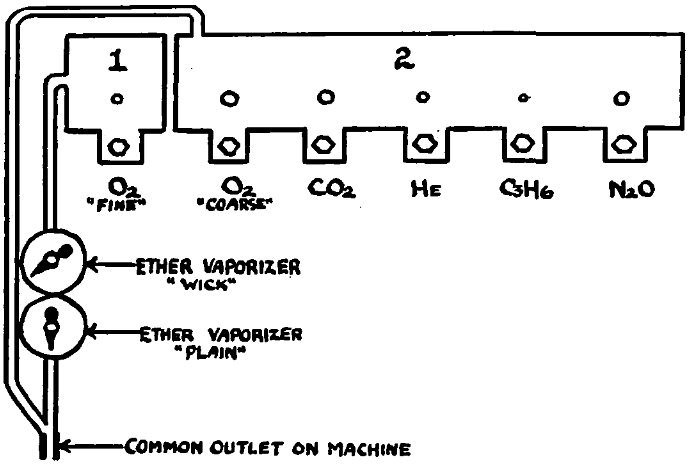

FIG. 1. Diagrammatic sketch showing both water reservoirs. No. 1, Smaller compartment for "fine" oxygen only. No. 2, Larger compartment for all other gases bi-passing the ether vaporizers to the common outlet.

control while any of the other anesthetic gases are being delivered, without these latter passing through the liquid ether. To accomplish the desired objective, division of the water reservoir was essential. At first it would appear that the construction of two water compartments might increase the size of the present apparatus to awkward proportions, but even to the most trained observer, the photograph of the completed machine below will attest to the fact that there is no recognizable alteration in its former design. One more important detail in construction needs clarification—the safety valve. On the top of the standard water reservoir there are two attachments. One, when unscrewed, allows for refilling of the reservoir. The other is the safety valve which protects the glass flowmeters against breakage when exposed to sudden, excessive gas pressures. On the larger compartment of the machine herein described, these same two valves have been retained. The size of the smaller compartment does not permit the use of a separate filling port and safety valve. These have therefore been incorporated into one. If unscrewed from the metal casement, filling of the reservoir may be accomplished. The ball-bearing safety valve incorporated within it, is regulated by a heavy, non-rustable steel spring which will release the sealing ball-bearing when pressure in excess of 8 pounds of oxygen per square inch is delivered.

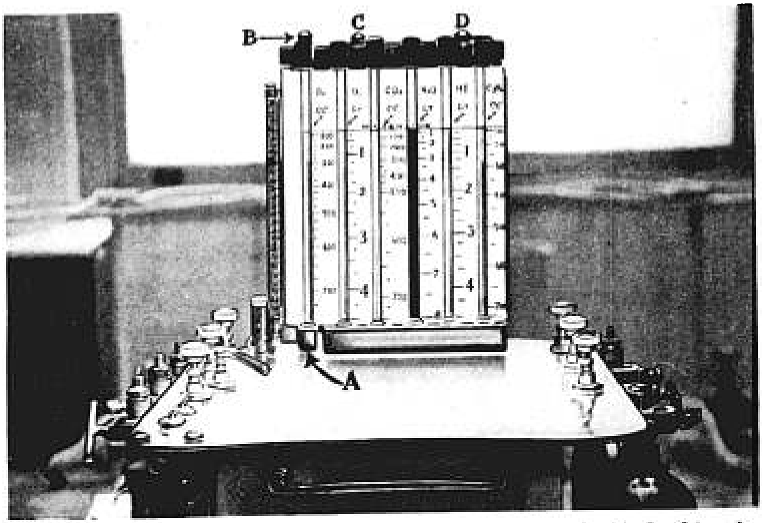

FIG. 2. *A*, Smaller water reservoir for "fine" oxygen only. *B*, Combined safety valve and filling port. *C*, Safety valve of larger water reservoir. *D*, Filling port of larger water reservoir.

CONCLUSIONS

In no way has the re-routing of the gases interfered with the basic principles upon which the to and fro absorption of carbon dioxide from anesthetic atmospheres are based. Every heretofore recognized advantage claimed for this method of administration of anesthesia has been retained, while the adaptation of continuous nitrous oxide during induction and the establishment of ether narcosis has effectively enhanced the efficiency of this technic of anesthesia in clinical practice.

Summary

1. An apparatus which permits the continuous flow of nitrous oxide, independent of ether vaporization, to the to and fro absorption technic, has been described.*

2. Ease, smoothness, rapidity of induction and establishment of ether narcosis is now feasible and practical by employing this technic.

150 E. 50th St.

REFERENCES

1. Waters, Ralph M.: Carbon Dioxide Absorption from Anesthetic Atmospheres, Anesth. & Analg. 3: 20–23, 1923.
2. Adriani, John, and Rovenstine, E. A.: Experimental Studies on Carbon Dioxide Absorbers for Anesthesia, Anesthesiology 2: 1–19 (Jan.) 1941.

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COMBINED MEETING OF THE SECTION ON ANESTHESIA OF THE CONNECTICUT STATE MEDICAL SOCIETY AND THE AMERICAN SOCIETY OF ANESTHETISTS

Breakfast Room, Stratfield Hotel, Bridgeport, Conn.

May 21, 1941—3:00 P.M.

1. Mechanisms of Respiratory Failure Under Barbiturate Anesthesia (Evipal, Pentothal)—30 minutes.
   By Henry K. Beecher, M.D., Massachusetts General Hospital, Boston, Mass.

2. Respiration in Anesthesia—30 minutes.
   By Wesley Bourne, M.D., Royal Victoria Hospital, Montreal, Canada.

3. Fluid Therapy in the Preoperative and Postoperative Patient—A Simple Laboratory Method for its Control—25 minutes.
   By J. Harold Fine, M.D., Beverly Hospital, Beverly, Mass.