# OPEN ETHER

*Being the Official Report at the Seventeenth International Congress of Medicine, London, August, 1913*

By

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# OPEN ETHER*

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By "Open Ether" is meant the administration of ether for surgical anæsthesia by means of any apparatus which permits to the respiratory gases an unrestricted interchange between the patient's lungs and the external air, at the same time that ether vapour is inhaled in sufficient amount to produce and maintain the anæsthesia. An open ether anæsthesia, then, is conducted by means of the simplest apparatus possible, the purpose of which must not extend beyond the holding of the liquid ether while it evaporates and the conserving of the vapour for the patient's use. Neither the ether vapour nor the exhaled air must be confined in such quantities or for so long a time that the confinement itself can exercise any appreciable influence on the anæsthesia.

Open ether is to be distinguished from the semi-open method, or the administration of ether by means of a cone or similar apparatus such as the Allis inhaler, and also from the closed method, the inhaler for which requires a reservoir for to-and-fro breathing, whether or not the apparatus be provided with valves to allow an escape of expired air. It is to be differentiated further from the so-called "Vapour" methods by which the ether vapour, either alone or in conjunction with another anæsthetic vapour, is supplied to the patient forcibly by means of some sort of pump.

*The official report at the Seventeenth International Congress Medicine, London. August, 1913.

Thus an anæsthesia by the method called open ether is produced by depositing liquid ether upon some absorbent substance through which air can pass easily, and which is so placed on the patient's face that from it he can readily inhale the ether vapour which has not been prepared previously, but as it evaporates spontaneously from the permeable substance. Also all exhalations from the lungs of the patient pass without hindrance through the substance which holds the liquid ether, into the external air.

There are various ways of exhibiting open ether, the differential points of which consist in various apparently small but nevertheless important particulars, as for instance:

(*a*) In the material used to hold the liquid ether while it evaporates, such as plain surgical gauze, stockinet, and the like.

(*b*) In the mode of adjusting this material to the face, that is, by simply laying it loosely on the face; or by means of some support such as can be had in the frame of an Esmarch, Schimmelbusch, Ochsner, Yankauer, Skinner, or a Ferguson mask.

(*c*) In the way the frame is made, whether rigid as an Esmarch or an Ochsner, or flexible as a Ferguson mask.

(*d*) In the size of the frame, that is, whether it is so large that it will cover the greater part of the face and fall below the chin as does the Schimmelbusch mask, or of such a size that it encircles only the nose and mouth as the Ferguson mask does.

(*e*) Another very special and important distinguishing feature is the method that is used to prevent the undesirable dispersion of the vapour, a phenomenon due to the specific gravity of ether vapour, and one which is inevitable if a mask with an unprotected surface is employed. This conservation of vapour is sought sometimes by encircling the mask with gauze even to the extent of its wrapping the face as with a turban, or by covering the frame with towels dry or wet, by rubber dam laid over the

frame, or by means of a suitable chamber above the convex diaphragm.

(*f*) Yet again there are different methods of applying the liquid ether, as, for instance, by pouring it on at intervals, sprinkling it over the absorbent covering from time to time, or by dropping it on intermittently or continuously.

Inasmuch as the dropping of the ether steadily on to the mask is by far the most convenient and most efficient method of delivering ether for the open method, this report will consider open ether chiefly from the point of view of the open-drop method, and therefore whatever advantages or disadvantages there may be in the other ways of delivering ether will be considered in the setting forth of the subject from this standpoint.

The question naturally arises—Is the open-drop method of ether anæsthesia trustworthy and otherwise satisfactory for all cases? The answer is positively Yes. It may be that for certain patients, to whom attention will be given farther on, a preliminary dose of morphine may be desirable, but no oftener and for no other reason than holds good for ether by either the semi-open or by the closed methods.

That open ether, especially by the drop method, is all that can be desired, can be determined by any anæsthetist who will try the method long enough to become familiar with its proper technique. A good ether is necessary for the best results, inasmuch as with the open-drop method, properly conducted, there is no accumulation of carbon dioxide or other gases to help out the anæsthesia. The work is done by ether alone, and there are some ethers from which good results cannot be obtained. Further, a practical illustration of the efficiency of the open-drop method is to be found in the fact that, according to conservative estimates, over 90 per cent. of the anæsthesias of the United States are by open ether.

Before taking up in detail an anæsthesia by open

ether it is necessary to consider certain essentials for obtaining the best results with it. I do not now have in mind conditions which must be presupposed for an anæsthesia by any inhalational method. In order to obtain a good anæsthesia by any method whatever, there must be a thorough physical preparation of the patient; a proper position of the patient on the table; tranquil surroundings; and preliminary medication if absolutely necessary. I refer here only to certain facts which are more or less peculiar to open ether or the open-drop method. These should be constantly kept in mind. I will mention six. They are:

*A.* NO AIR SHOULD BE ALLOWED TO PASS BETWEEN THE INHALER AND THE FACE, BUT ALL RESPIRATORY AIR SHOULD GO THROUGH THE GAUZE ON WHICH THE ETHER IS.

The simplest exhibition of the open-drop method is by the use of plain gauze only. When I laid aside the closed inhaler and the cone I placed several thicknesses of absorbent surgical gauze upon the face and dropped the ether on it, each side of the nose and between the nostrils and the upper lip. As such gauze rests on the face, it forms a sort of bridge from the nose to the cheek, and the space between these is a chamber which conserves the etherized air. A very good anæsthesia may be had in this way. At Professor John Deaver's clinic at the German Hospital in Philadelphia in the United States, all the patients for operation are anæsthetized and kept under ether by this method. If this form of the open-drop method is used, the face should be first smeared with some unguent to prevent any liquid ether that may come in contact with the skin producing an erythema. The gauze should be large enough to go from external of the malar bone of one cheek to external of the malar bone of the other cheek, and from the nasal bone to below the mental process, and great care should be taken that all around the edges it is flat on the face, so that there are no avenues from wrinkling through

which unetherized air can gain access to the nose and mouth between the gauze and the cheek. Of gauze with twenty threads to the inch about twelve layers loosely separated where they rest over the nose and mouth may be used. A piece of linen or rubber dam, somewhat larger than the gauze and with a hole three or four inches in diameter cut in it, laid on the gauze may aid in more effectually excluding peripheral air than any manipulation of the plain gauze can do.

If an Esmarch, Schimmelbusch, Yankauer, Ochsner, Skinner, or any similar frame over which the gauze is stretched be used, some special means of excluding air from entrance between the inhaler frame and the face must be employed, inasmuch as these frames are made of unbendable wire, and when they rest on the face they easily permit an abundance of unetherized air to enter beneath the mask. There are in actual use four particular ways of excluding such air. The first is by encircling the frame with an indefinite number of yards of surgical gauze bandage, even to the wrapping up of the head so that it looks as if it were beneath a turban, but leaving an opening over the centre of the inhaler. Secondly, by surrounding the frame with dry towels in a way similar to the using of gauze. Thirdly, by the use of the *wet* bandages or towels in the same way that dry ones are employed. Fourthly, by covering the mask with a piece of heavy cloth or of rubber dam large enough to hang down all around the mask, and in which, over the centre of the mask, a hole is cut an inch or more in diameter.

The first three adaptations are particularly bad, as they are inconvenient to manage and cover up very much, if not all, of the patient's face. I have known of patients dying and remaining dead on the table for an unknown length of time simply because the amount of gauze or towels that were around the inhaler and over the face prevented the eyes or countenance being seen by the anæsthetist.

Further, *wet* bandages and towels are worse than dry ones, for the additional reason that the moisture interferes with the efficacy of the ether.

The best way to exclude the air from entrance between the inhaler and the face, if one of the rigid masks is to be used, is by means of an oval cushion or pad of gauze or of absorbent cotton. This should be made of some thickness, half an inch or more being usually necessary, and of such a size that the inside of the ring does not in any way encroach on the mouth and with a periphery larger than that of the mask. First, this pad is laid in the proper position on the face, and then the mask is laid and pressed down on it. I have never seen this used except in England, but it is so efficient with a mask with a rigid face wire that it is to be highly commended. If the anæsthetist wishes the passage of respiratory air restricted to the centre of the mask, he can do it by placing a gauze collar of any desired width over the mask in the way so clearly described in the fourth edition of Sir Frederick Hewitt's book, *Anæsthetics and their Administration,* pp. 339 and 340, or by laying over the mask a piece of sheet rubber with a hole cut in it as described in the *Journal of the American Medical Association* for 1912, November 23, p. 1853. What I consider to be an altogether better way to exclude air from around the periphery of the inhaler is to use a mask which will have the part on the face fit the features exactly. As no rigid instrument can be constructed to do this I use the Ferguson mask, which was described in the *Journal of the American Medical Association,* 1905, December 30, pp. 2014, 2015.[1] This instrument is in general the shape and size of an ordinary Esmarch chloroform mask, but it has several peculiarities which make it a new instrument. The characteristic I mention here is the great flexibility of the wire that comes into contact with the face. It and certain adjacent parts of the

(1) See also *Guide to Anæsthetics*, 4th ed., by Thos. D. Luke, M.D., Edinburgh, pp. 31-5. *Anæsthetics* by Dudley M. Buxton, M.D., 5th ed. London. *Anæsthetics* by James T. Gwathmey, M.D., New York, 1914.

frame are made of annealed copper wire so that it can be easily bent, and therefore the mask moulded to make it conform exactly with the contour of the patient's face. If the instrument has been properly fitted to the face of the patient then no air can enter between the face wire and the face. All the air must pass through the gauze on which the liquid ether is, and all this is accomplished without the use of an extra piece of apparatus or without encroaching upon any part of the patient's face. When the mask is in use the eyes and whole countenance are in full view, a condition of affairs that I like and consider to be very useful.

Since I have called attention to the size of this mask, which is especially adapted to open ether, I may be permitted to add that for the size there were

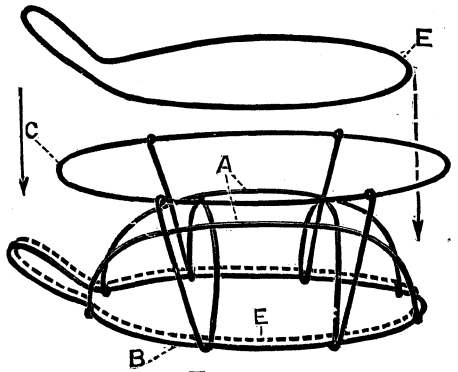


FIG. 1.

other determinants than those just mentioned. I wish in this connexion to emphasize two of them.

The first is that which determined its being made so as not in any way to cover the eyes. During experiments in the psychological laboratory, I noticed that if a student had any fear of the experiment, when I blindfolded him so that he could not see what instrument I was to use, he complained of a sense of impending suffocation. Reasoning from this I raised the question whether the sense of im-

pending suffocation, of which certain patients complain when they are about to be anæsthetized, might not be due to the fear they have of the anæsthesia plus the forcible closure of the eyes by a towel, gauze, rubber, oil silk, the inflated cushion of the inhaler, and the like. Now since I had the mask made so that it could not in any way interfere with the eyes, I have never had a patient complain of suffocation.

The second is that which determined its being made so that it would not go below the chin. It is necessary only to place the forefinger over the nasal bone and at the same time the thumb below the chin, and then try to open the mouth, in order to realize how little pressure is necessary to prevent the free opening of the jaws even while we are awake and the voluntary muscles in action. If, however, the person is anæsthetized and the muscles relaxed, such interference with the free movement of the lower jaw is had much more readily. I noticed that during an anæsthesia many students when using a Schimmelbusch or equally large mask would keep their patient cyanotic unless some special provision for keeping the lips and jaws apart had been made. I noticed further that this cyanosis would pass away when the inhaler frame was so adjusted that it could not encircle the mandible. As keeping a large frame from going below the jaw is a very difficult matter, I made my mask so that the lower border would rest between the lower lip and the mental process. Therefore with the Ferguson mask it is impossible to interfere in any way with the free working of the lower jaw. A person with the frame of the mask bound tightly on the face can talk, laugh, or sing just as freely as if it were not on the face at all. Therefore this mask precludes the possibility of interference with the free entrance of air through the mouth, and of the two entrances of respiratory air—namely, that through the buccal cavity and that through the nose—I consider, even for patients with a clear nasal cavity, the

airway through the mouth the more important for anæsthesia.

The second essential to a satisfactory anæsthesia by open ether is that:

*B.* THE PATIENT DURING THE INDUCTION AND THROUGHOUT THE ANÆSTHESIA SHALL BE ALLOWED TO HAVE ALL THE AIR NECESSARY FOR NORMAL RESPIRATION. That anæsthesia is not necessarily due to anoxæmia has been settled, I think, for all time, but there are still some anæsthetists who seem to be reluctant to give up the old idea, possibly because in the way that ether is so frequently administered a deprivation of air plays some rôle in the anæsthesia. To realize that a restriction of air is not essential for an anæsthesia it is necessary only to bear in mind the excellent ether anæsthesia that may be induced and maintained even while pure oxygen is administered simultaneously with ether, also that in rectal anæsthesia the sleep is induced and maintained while the patient is breathing with his lungs not only sufficient air for ordinary respiration, but even an abnormally large quantity. For in rectal anæsthesia, at the beginning of the induction, the patient is breathing and for a while continues to breathe normally, but as soon as the stimulating effect of the ether is had he breathes more deeply and more rapidly, thus increasing both the quantity of tidal air at one inspiration and also the number of inspirations per minute. Ether vapour itself is a true anæsthetic. All that is necessary for producing anæsthesia is to furnish a proper quantity of ether vapour to the cells of the body. Another proof of this fact is the method and results of intravenous ether anæsthesia. In any anæsthesia it does not matter how much air, oxygen, carbon dioxide, or chloroform vapour may be present, the ether does its work independently although in conjunction with them. This teaches us to allow the patient from the beginning to the end of the anæsthesia all the air he needs for normal respiration, yet in some way introduce with this air sufficient ether vapour.

Of an absorbent gauze having twenty threads to the inch, nine thicknesses are sufficient, and this is the number I use in my work. The rule is, *the smaller the mesh of the gauze the fewer the thicknesses that should be used, the larger the mesh the more thicknesses that may be used, but never enough to embarrass in any degree the respiration of the patient.*

It may, upon first thought, seem as if this statement were contrary to that in the rule to rigidly exclude all air from between the mask and the face. It is not so, however. The reason for preventing air from entering between the inhaler and the face is not because air is undesirable for the patient, but because if air enters beneath the framework of the mask it floods the mouth to the exclusion of the etherized air which should be in the chamber. This mixture in the chamber is formed by a thorough mingling of the atmospheric air as it passes through the gauze diaphragm and the ether vapour as the liquid ether evaporates from the same diaphragm.

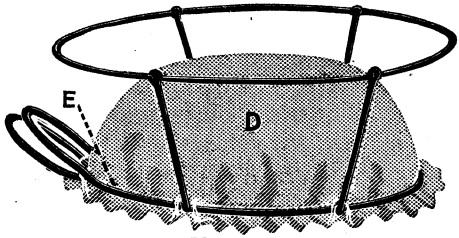


FIG. 2.

The phrases "proper quantity of ether vapour" and "sufficient ether vapour" raise the question of percentage. Personally, I have never yet satisfied myself from my own experiments of the percentage of ether vapour actually administered by the open-drop method or of the percentage necessary to produce anæsthesia by this method. My present opinion is that for ether the percentage is not nearly as definite as it is for chloroform, no matter in what way the chloroform may be administered. The

percentage of ether vapour actually used in open ether, both when no very careful attention is given to the quantity employed and also when the patient is kept close on the border line of consciousness, apparently varies very greatly, and this for several reasons, of which I will note here only the principal ones related to open ether according to my observation.

First and foremost is the general physical make-up and also the present physical condition of the patient. Males as a rule require more ether than females, although males of ordinary spare build do not require as much ether as some women of large build, especially if they have thick necks. I feel, from my experience, that the larger percentage here referred to is necessary more to put them fully asleep rather than to maintain the anæsthesia after it has been induced.

Second, alcoholics of either sex, provided no preliminary morphine has been given, require a stronger vapour both to induce and maintain anæsthesia than do non-alcoholics. Anæmic patients will go to sleep and remain anæsthetic with a more diluted ether vapour than will those with a normal amount of hæmoglobin.

Third, further, I have had patients, both men and women, who have fallen asleep with full surgical anæsthesia by means of such an incredibly small, not only amount of ether, but also of percentage of ether vapour, that hypnosis would have seemed a reasonable explanation of the narcosis did not a knowledge of the patient's idiosyncrasy and of the condition of the induction render such a possibility extremely unlikely. I need not extend the list of causes on the part of the patient, as all anæsthetists have had many such cases, and careful attention to the phenomena attending etherization of these will convince the observer that the variation relates not merely to the total quantity of ether required, but also and chiefly to the percentage of ether vapour actually inhaled.

Some causes of variation in the percentage of ether vapour observed apart from those due to the patient, are:

(*a*) The size of the chamber beneath the diaphragm. If the same sized drops of ether be put on at equal rates on two masks of unequal size, other things being equal, the percentage of vapour is the smaller in the larger chamber. That is, under like dropping and atmospheric conditions, I get a greater percentage of ether vapour with an Esmarch mask than I do using a Schimmelbusch or an Ochsner mask.

(*b*) Also I find the percentage of ether varies greatly with the quantity of ether deposited on the gauze diaphragm. It will increase up to a certain point with an increase in the amount of liquid ether dropped steadily during any definite space of time, but beyond that the percentage diminishes on account of a phenomenon, the setting forth of which I wish to reserve until I discuss further on the rate of dropping necessary for a good anæsthesia by open ether.*

(*c*) Further, all this about percentage, including the percentage itself, is modified by the temperature and the humidity of the surrounding air, the barometric pressure, the vigour of the patient's respiration, and the quantity of the tidal air. It seems to me that by open ether the variation of the percentage of ether vapour, not only actually administered but required for anæsthesia, is so large that it is an impossibility to reduce it to any practical limit for this method. In general, however, I believe that a mere saturation of the respiratory air with ether vapour is all that is necessary for an ordinary anæsthesia, and this can be had approximately—that is, sufficient for all clinical work—by allowing the ether to merely evaporate spontaneously under conditions that will preclude dispersion and at the same time not unduly confine either the air or the ether vapour. The specific gravity of ether vapour is 2.55, that is, it is over two and a half times as heavy

*See page 20.

as atmospheric air. For this reason much of the ether vapour that comes off from the ether on an ordinary mask falls to the floor by its own weight, and draughts of air produced by the movements of assistants in the operating room cause even more of this vapour to be dissipated. This occasions great disturbance in open-ether anæsthesia. Not only is the ether wasted, but also the anæsthesia is disturbed, because at one time the patient may get considerable vapour and at another time none at all; but, however large or small other advantages of such administration may be, a great difficulty exists in the inability to keep the patient's respiratory air just saturated with ether vapour, and therefore there is brought to the front the third requisite for a good open-ether anæsthesia, namely:

*C.* SOME PROVISION MUST EXIST FOR CONSERVING THE ETHER VAPOUR FOR THE PATIENT'S USE; that is, for preventing the ether escaping from the surface of the mask.

There are various means in actual use in the endeavour to accomplish this. One is to cover the mask with a towel as soon as the ether is dropped on the gauze, then to remove the towel and drop more ether on the diaphragm, and so continue the removal, dropping, and replacing until the end of the anæsthesia. This, however, does not serve the purpose well, while it allows carbon dioxide to accumulate beneath the diaphragm and produce cyanosis. Another means is the enmeshing of the ether vapour in the interstices of gauze. Ether is dropped on to the gauze diaphragm of the mask, then immediately a layer or two of gauze is laid over this and ether is dropped on to it, and this procedure is repeated until so much gauze has been laid upon the mask that the patient cannot breathe through it easily. Then all the superimposed gauze is removed and the process is repeated. All this is a laborious proceeding; it produces an irregular rebounding anæsthesia, and to me is otherwise unsatisfactory.

My own method is to form a shallow chamber (K) above the convex gauze diaphragm of the mask. In this chamber there is an opening (G) so large that much more air than the patient can use for normal respiration will easily pass through it. At the same time the chamber is not large enough to collect any appreciable amount of carbon dioxide. My experiments have convinced me that a lower concave chamber (M) of about two hundred cubic centimetres capacity with a superimposed chamber having a re-entrant convex bottom and of about four hundred cubic centimetres capacity, serves the purpose of open ether the best. Consequently the

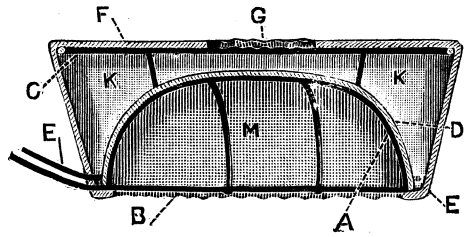


FIG. 3.

Ferguson mask for open ether is made to fulfil these requirements. Any essential modification from this size has not yielded in my hands as satisfactory clinical results as does a mask of these capacities.

With open ether and my mask I have never seen acapnia. A writer in an article in the *Medical Century* for October, 1912, calls attention to the fact that with the open-drop method, by means of the Ferguson mask, acapnia never occurs. He accounts for this by supposing that just enough carbon dioxide collects in the chambers to overcome over-oxygenation of the respiratory centres. It is true acapnia does frequently accompany anæsthesia by open ether when any of the ordinary masks are used, but I believe its absence with my mask is not

due to the presence of any carbon dioxide, but depends upon a simpler and more important condition.

For instance, if a Schimmelbusch mask is used for open ether, on account of the uncontrollable and incalculable amount of waste of ether vapour liquid ether is put on to the mask in quantities out of all proportion to what is necessary to maintain anæsthesia. In consequence of this a strong respiratory stimulation is produced which with the over-abundant supply of air following the spasmodic cessations of the supply of ether, and therefore of ether vapour, over-oxygenates the centres to the extent of acapnia.* With the Ferguson mask the ether is

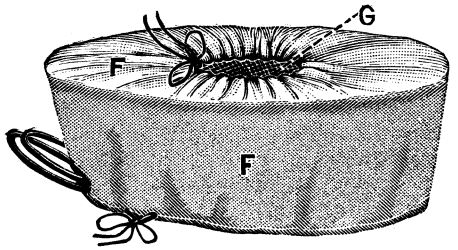


FIG. 4.

dropped on so regularly and in such small quantities, and the narcosis is maintained so easily at the level of surgical anæsthesia, that no marked stimulating effect is produced. Now as the respiratory air is not limited during either the induction or the maintenance of the anæsthesia, acapnia should not occur theoretically and does not occur clinically any more than it takes place in every-day life in the invalid who wears an anti-cold-air respirator or the workman who wears an anti-dust respirator.

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*Further experiments have led the author to believe, what at the time he read this report he announced as probable, viz., that the cessation of respiration called acapnia is not due to an over-oxygenation of the respiratory centers, but to central fatigue, in consequence of the highly labored breathing produced by hyperstimulation by excessive quantities of ether vapor.

*D.* A fourth requisite is A CONTINUOUS SERIES OF DROPS OF ETHER ON TO THE GAUZE DIAPHRAGM AT SUCH A RATE AS MEETS THE DEMANDS OF THE PATIENT FOR THE TIME BEING. The ether should be dropped on to the gauze steadily, not sprinkled or poured on at intervals. A spasmodic supply of ether produces an irregular anæsthesia, the depths of which may be represented by convex lines of varying amplitude with the corresponding concave lines representing the intervals of partial recoveries. Even if such an anæsthesia serves the purpose of the operation the recovery is not as satisfactory as if an anæsthesia of even depth had been had. Nausea and vomiting occur after the anæsthesia, when otherwise they would not be expected, and if for any reason nausea seemed inevitable, it is apparently more severe.

At first the dropping should be very slow—about one minim delivered in three or four drops (the number of drops depending upon their size) every five or six seconds. This slow dropping does not add to the anæsthesia proper. Its purpose is to anæsthetize the membranes of the posterior nares, the pharynx and the larynx, so that when the ether is dropped rapidly for the anæsthesia proper there will be no irritation from the ether vapour, there will be no coughing, no strangling, no other disagreeable sensations, and, what is of considerable importance for the reputation of the anæsthetist, no unpleasant remembrances of the induction after the patient is awake.

The length of time to continue this initiatory slow dropping will depend upon the patient and the sensitiveness of his throat. Any person with a very sensitive mucous membrane will require more careful and a longer slow dropping than one in a different condition. As a rule, in from forty-five seconds to one minute and a quarter from the beginning of this initiatory dropping the respiratory passages will be ready for the more rapid delivery of the ether.

In certain tonsil and adenoid cases it is of little

use to seek this preliminary local anæsthesia. The parts are hypersensitive to such a degree that not much impression can be made on them in a short time, and so with such patients it is best to proceed at once to the induction of the general anæsthesia.

As soon as the irritability of the membranes has been allayed the general surgical anæsthesia should be induced by a continuance of the dropping, but now much faster than during this preliminary dropping. No rule for this rapidity can be given. Experience alone can teach it. The ether should only be *dropped,* however, and if for any reason there seems to be a demand for more ether vapour than the rapid dropping which is under way furnishes, the end may be attained by distributing the drops over a larger surface of the gauze. For ordinary cases by such a procedure I find complete surgical anæsthesia to be present on the average in about four and a half to five minutes from the time of the beginning of the dropping for the anæsthesia proper, With females the time is from three to five minutes; with males from four to six minutes. Variations in the time depend, however, upon other factors besides sex.

Also for continuing the surgical anæsthesia after it has been induced, the ether should be only dropped. And again for the rate of this dropping no definite rule can be given except that the dropping should meet the demands of the patient at the time. This is the anæsthetist's only criterion.

Further, the physical condition of the patient, the depth and vigour of respiration, the temperature and humidity of the air of the room, the size of the drops, the character of the operative procedure at the time are all important factors in the problem of how fast to drop, and actually determine its rate. If a deeper anæsthesia is needed a dropping more rapid within certain limits will effect it, while if a lighter anæsthesia is all that is required a less frequent dropping will keep the patient as desired. It should be remembered, however, that a continuous

series of drops should be maintained. Relatively long cessations of dropping are to be avoided. It is better to drop once in five seconds twelve times a minute, than to drop once a second for twelve seconds and stop forty-eight.

The fifth requisite to which I now call your attention is related more or less closely to all methods of administering ether, but as it is of especial importance in connexion with open ether, it must be mentioned here.

*E.* THE ETHER SHOULD NOT BE DEPOSITED ON THE GAUZE FASTER THAN IT WILL EVAPORATE FROM IT. The rate will vary with the temperature of the room; the frequency and strength with which the patient exhales through the gauze; and the volatility of the ether.

The reason for this is that in whatever quantities the ether may be put on the gauze, some of it will evaporate, and the evaporation of this portion will lower the temperature of what remains as also of the gauze. After more ether is deposited this evaporation continues with a continuous lowering of temperature until the temperature becomes so low that not enough ether vapour can be given off to anæsthetize the patient or to keep him asleep, even if by a proper dropping he has once been in full surgical anæsthesia.

In saying that "the ether should not be dropped any faster than it will evaporate" is not meant no faster than it will evaporate in the laboratory from a dish, or under ordinary conditions from gauze and the like, but no faster than it will evaporate from the mask under the conditions in which it is in use. A very warm operating room will increase the rate of evaporation. The exhaling of the patient through the gauze will blow some vapour away. So also the pressure and humidity of the atmosphere and the strength of the respiratory act will make a difference in the evaporation. Thus it is evident that this rule can mean nothing else than that the ether should not be put on to the mask faster than it will

evaporate at the time and under the circumstances of the immediate administration. If the anæsthetist puts it on faster than this he will contravene his own purpose, because the patient will not remain asleep, for no other reason than that the liquid ether on the gauze cannot furnish him with vapour sufficient to keep the patient anæsthetized.

*F.* Finally, THE MASK MUST BE KEPT ON THE FACE AND NOT CONTINUALLY REMOVED. Seldom is there need to take the mask from the face. If the diaphragm is made of the right number of layers of gauze removal gives no more air. If the ether is dropped correctly the taking of the inhaler off the face is not necessary to cause the patient to get less vapour. If the patient has been laid on the table in a suitable posture the jaw and tongue will give little trouble. A removal of the mask means a stop in the dropping of ether, which in its turn means an uneven anæsthesia. Attention to a few details will make a removal of the mask as a rule unnecessary.

In conclusion, by way of illustration of what has been said and to make the subject clearer, let me describe in detail what is known as the Ferguson Method Of Open Ether Anæsthesia.

First, I do not wish ordinarly any preliminary opiate. Preliminary morphine slows the respiration, prevents pupillary and other reactions, and therefore interferes with two of the most important waymarks for the anæsthetist. Since it has been stated that a preliminary opiate is essential to open ether, let me here say I require such in only three classes of cases.

The first is that of patients with exophthalmic goitre. So many such patients have died while going from the ward to the operating room on account of fear and their highly nervous condition, that I wish the patient who is to have a thyroidectomy for exophthalmic goitre to have enough morphine long enough before the anæsthesia to permit him to be taken to the anæsthetizing room with a tranquil mind.

My second class is that of alcoholics who I think may give trouble on the table. The fighting of an alcoholic on the table during the induction of ether anæsthesia is not due to a special irritation of the patient by the ether. As alcohol and ether affect the cells of the body in somewhat the same way, the patient who is used to large quantities of alcohol theoretically ought to be affected less than the non-alcoholic patient with an equal amount of ether. The disturbance in the case of the fighting alcoholic is due to a dream. An alcoholic is very prone to dream as he falls asleep in ordinary every-day life. He has exalted exciting ideas when he drinks alcohol in moderate quantities; he has the fiendish dream of delirium tremens when he drinks to excess. He dreams as he goes under the influence of ether. Now this dreaming is always an exciting pugnacious ideation. On the contrary the dream from the use of opium is a quieting, pleasing state. It is the sense of well-being, of a life in Elysian fields, that fascinates the opium fiend. Now experimental psychology teaches that the physical condition productive of the exciting idea in alcoholism can be offset by the physical condition producing the tranquillity of morphinism. Therefore I wish that alcoholic whom I suspect will be a disturber of his anæsthesia to have enough morphine long enough beforehand to counteract any alcoholic hypercerebration and to reduce him to a normal subject for anæsthesia.

My third class consists of strong athletic young men of ages from fourteen to twenty-two or thereabouts. These I find are very likely, while inhaling only small quantities of ether vapour, to secrete a very minute amount of thick tenacious mucus. This is apt to span the lumina of the smaller tubes, bronchioles, and stomata of the alveoli, and form diaphragms that prevent any interchange of vapour between the respiratory air and the blood. Consequently not enough ether vapour enters the blood to produce anæsthesia, and perhaps not enough pure

air can enter to maintain normal oxygenation. Here we have that peculiar, and to some, a puzzling, picture of a strong healthy young man, perhaps for only an operation for hernia, after inhaling a little ether becoming cyanotic and remaining so although the inhaler has been removed, and not only plenty of fresh air but also perhaps oxygen supplied.

Now to prevent this secretion of mucus I wish such patients to have one-hundred-and-fiftieth grain of atropine hypodermatically, half an hour before the anæsthesia. But such patients have a very strong abdominal respiration. Normally the muscular action is powerful and the excursions of the abdominal parietes are great. Now under the stimulating action of the atropine the abdominal breathing becomes abnormally great, so that if the operation is one for appendicitis or for hernia, that is, involving the abdominal wall or the tissues in its vicinity, the movements of the abdomen are a serious disturbance to the surgeon. Therefore I wish such a patient to have with his atropine one-eighth or one-sixth grain of morphine, not for any demand of the anæsthesia, but to counteract the hyperstimulation of the atropine which was given for the purpose of the anæsthesia and thus I prevent the surgeon being disturbed in his work.

Having now treated my patient as regards a preliminary opiate according to these rules, he is put for anæsthesia upon the table on which the operation is to be performed. Transfer from a stretcher to the operating table just after the induction, although the patient may be fully under the ether, will almost always cause a partial recovery which may require quite as much time and trouble to do away with as the previous induction.

This operating table should be in the anæsthetizing room where there is nothing to disturb eye or ear. Then when the patient has been put in a proper position upon it, that is with his head slightly extended, with no straps over the body and no one touching him, I begin by asking the question, "Did

you ever take ether before?" Whether the answer be "yes" or "no," I say, "I have something to tell you. Patients who take ether as a rule don't like it. Some find the odour very disagreeable, and you probably will, but if you will breathe regularly and deeply, then what is disagreeable will pass away more quickly."

By this frankness I assure myself of the confidence of the patient during the induction; he understands the conditions necessary to render the induction the least disagreeable and he makes no effort to remove the mask after it is in position. I now place on his face the mask, which has been fitted previously. No unguent is used on the skin, nor are the eyes covered. The ether is then dropped on to the convex gauze diaphragm of the mask, very slowly at first and then more rapidly, as has been set forth above.

As the dropping is very important I will describe here my method, which will never fail in giving satisfactory results. I use the ether directly from the original can, which holds 4 ounces. I do not transfer it to another container because I believe that by so doing a good ether loses a working margin. I drop from this can by means of a wick, and for the exit of the ether from the tin I depend upon the capillary attraction of the wick and the pressure of the ether vapour in the can. The proper making of the wick is an essential feature of my method. I take a piece of gauze an inch or two wide, depending upon the size of the mesh of the gauze. A gauze with twenty threads to the inch will require a strip about two inches wide. If it has more threads it should be narrower. The length should be equal to three or four times the depth of the can from which the ether is to be used. This strip of gauze is folded across the narrow part or width so that the two ends come together. The two layers should not lie flat against each other but loosely. Then one end of this folded strip is held tight in one hand, while the other end is pinched between the fingers and

thumb of the opposite hand and all is twisted into a firm wick. A wick made thus will give the maximum amount of capillary attraction. This wick is now put into the can, to the very botton, and about one-half inch left projecting beyond the mouth of the can. Now an ordinary cork, whole—that is, with no slit or slits in it—is put into the neck of the can


FIG. 5.

so as to confine the wick between it and the neck, and then pressed down very tightly. If put in tightly enough it cannot be drawn out easily, cannot be shaken out, when the can is tipped no ether will run out, and if the container falls on the floor, no ether can be spilled. Nevertheless if this can, with the wick in it, is held upright and then tipped a little, drops of ether will come from the end of the wick, very slowly at first but more rapidly as the can is tipped more and more, but if the cork and wick are arranged as they should be the ether will

not run out in a stream. This is known as the Ferguson Method of Dropping, and is the simplest and at the same time the most efficient dropping of ether for anæsthesia that I know of. The materials for its construction are always on hand, it is easily and quickly made, and as long as there is any ether in the tin it will always work.

By such an apparatus I drop the ether on to the mask, at the same time giving further careful attention to the psychical condition of my patient.

I do this by anticipating a prejudice against the odour of ether that a few patients have, and further by keeping below the threshold of consciousness two ideas which previous to an anæsthesia practically all patients have formed, and which, if not carefully controlled by the anæsthetist, are likely to come to the front and disturb the induction.

Some patients who know the odour of ether and who consider it disagreeable, anticipate the induction as a repulsive experience. Others, for one reason or another, have a mere prejudice against it, while still others who have formed no idea of the odour of ether seek to remove the inhaler at the first whiff of ether vapour. In the majority of cases the frank statement concerning the odour and full directions how to breathe, as has been described, will arouse an effort of will that will cause the initiatory stage to be passed easily; but for some fastidious people and children something more is desirable, although perhaps not necessary. In such cases I put upon the gauze of the mask, on the concave portion of the diaphragm, and in such a position on the gauze that it will not come in contact with the skin, about two minims of the terpeneless oil of orange. The odour of this oil is more than twenty times as strong as the odour of ether; therefore, if at first the ether is dropped very slowly, as it should be, its odour is masked sufficiently not to disturb the patient, or perhaps the agreeableness of the odour will surprise him to the extent of permitting a quiet induction.

The rôle played in the anæsthesia by oil of orange is merely an æsthetic one. There are three things that render the inhalation of ether vapour disagreeable. The first is the mere contact of the non-oxygenating gas with the membranes. Quite likely this is a complex of sensations. I call it *the tactual element.* Then there is the direct irritation of the nerve-endings by the ether vapour. This I call *the physico-chemical element.* The third is a mere personal dislike to the odour of ether vapour. The fact that a very large number, indeed the majority of patients, find the odour of ether disagreeable does not remove the condition from the realm of æsthetics. This, then, I call *the œsthetic element.*

At the beginning of the induction I get rid of the tactual and of the physico-chemical elements by the slow dropping as described above under "The fourth requisite." I deal with the æsthetic element by means of the oil of orange, and it is important to bear in mind that it is only with this element that the oil of orange has to do. It masks to a certain extent the odour of the ether, and does not augment or diminish the anæsthetic value of the ether vapour or modify otherwise the narcosis.*

The figures given are true only in regard to the oil of orange, and do not hold for the so-called American essences, which are not nearly as strong. I have used it now for over ten years and consider it a valuable adjunct to open ether.

The two ideas which I find it necessary to keep below the threshold of consciousness are the indefinite notion on the part of patients that something may go wrong, and the idea that they may be cut before they are unconscious. These must be dealt with separately and in different ways.

To meet the first I always talk to my patient during the induction. I never ask a question, because after the initial dropping of the ether co-ordination of the senses is very soon lost, and if

*Except that it seems to increase the percentage of post-anæsthetic nausea and vomiting.

the patient replies to any question the speech centre retains its activity, and the reiterated answers of the patient, at first coherent, soon become incoherent, and finally pass into a mere jabber. All this while the patient does not breathe well, therefore the induction is prolonged and otherwise disturbed. On the other hand, I make positive statements to the patient about just what he wishes to know, namely, that "everything is all right." This idea I repeat over and over again in as varied a phraseology as I can command, but always keeping certain facts in mind, namely, that the patient becomes drowsy, therefore a clear, clean-cut enunciation is necessary; that the power of association is lost, consequently a long word cannot be guessed at from one or two of its syllables, therefore monosyllables should be used; again, that the field of consciousness narrows very rapidly. Soon after the initial dropping only six short words or syllables are understood, as "Breathe deeply; you are doing fine." Then only five, as "Every thing is all right." Then only four, as "You are all right." Then three, as "All is right;" "You are fine." And just before consciousness goes out only two and one, as "All right," "Fine."

Talking to my patient steadily in this way I keep a perfect control over his mind and render the induction shorter and easier than it would be otherwise.

The second disturbing idea, namely that the operation will begin before the anæsthesia is complete, I prevent being brought from subconsciousness by not allowing the patient to be touched in any way during the induction, with one exception. The rationale of this is as follows. The patient, very soon after the ether has begun to be dropped, is out of all reasoning relation with his surroundings. We say co-ordination is lost. Now if the patient is touched in even a friendly way, either by a relative or nurse, or if his position upon the table is changed, or he is otherwise disturbed, he arouses

somewhat and the subconscious idea that he is to be cut before he is asleep leaps over the threshold into consciousness and he tries to let you know he is still conscious. This he does according to his present idea by making some small motion such as a movement of the feet or the hands. This, however, is only as *he* interprets his action, for in reality he is thrashing all over the table. To prevent this disturbance, which is often considered as a necessary secondary stage, I use no straps to hold the patient on the table and do not allow any one to touch him.

The exception to this has to do with the scrubbing up of the patient. I am willing the scrubbing up should go on during the induction provided that it has been begun and is well under way before any ether is given. Tell the patient plainly that the nurse will scrub him up, and that while she does it the ether will be given, and act accordingly and no trouble will be had, but if the induction has even but just begun, then the patient must not be touched in any way until surgical anæsthesia is had.*

As a rule patients will pass into the state of surgical anæsthesia without moving upon the table. A slight movement of legs or arms in the case of some patients requires no attention. If, however, as in the case of certain alcoholics, restraint is necessary, it should be employed. Such can be done most effectively by grasping firmly the opposite side of the table with one hand at a point which will permit your arm to span the front of both the thighs of the patient, four inches above the upper border of the patellæ. Put the arm in this position, then stoop so as to bring firm pressure on the thighs, and the patient, although very strong, will be effectually restrained.

*For a full description of the psychical condition of the patient during anæsthesia and how to manage it, see "Some Psychic Factors of Surgical Anæsthesia," by Robert Henry Ferguson, A.M., M.D., Sc.D., in *Illinois Medical Journal*, August, 1914.

Having now the patient unconscious, I continue the anæsthesia as directed above by dropping the ether faster or slower, according to the need of the patient, until the mask is removed for good.

If the patient has been placed on the table properly the tongue or the jaw usually gives no trouble. In the few cases in which the tongue did prove troublesome, I used to hold it forward by means of a flat wick made of a three-inch gauze bandage. A year ago, 1912, however, I became acquainted with the airway devised by Sir Frederick Hewitt, and since then have used it with such success that I now

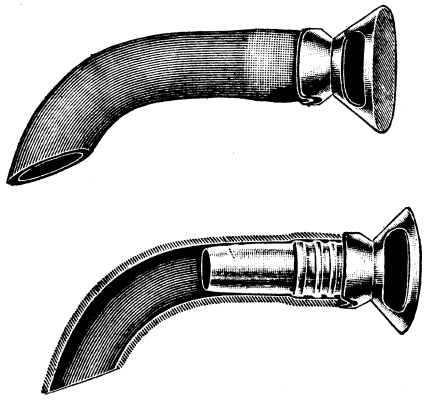

FIG. 6.

consider it an essential part of the anæsthetist's armamentarium. For use in the United States, however, I have made a slight modification, the reason for which is this: In America many anæsthesias are conducted by inexperienced nurses or careless internes. If now, for open ether, the airway, as made in England, is used, there is danger of liquid ether being poured through the gauze down the airway, as the opening is like a funnel and opens directly below the middle part of the gauze diaphragm on which this ether is dropped. While I

have never had this accident happen, I have felt the possibility of it, and have taken especial care that it should not occur. It is not at all likely with the semi-open method or with the closed method, and indeed not with open ether, in the hands of a skilled anæsthetist if a good dropper is used. It is, however, a real danger with open ether if an inexperienced or a careless person administers the ether, or if a dropper which will sometimes allow a stream to run is used and only a very thin gauze diaphragm is on the mask. Therefore to preclude this danger I have had the present opening to the airway closed and apertures for the ingress and egress of the respiratory air made around the sides of the metal end, which makes the entrance of liquid ether from a careless depositing of it upon the mask almost impossible.

I may say in closing that with an open-ether anæsthesia conducted in the way I have outlined surgical anæsthesia is induced in a very short time, is easily maintained with a minimum quantity of ether, while nausea and vomiting seldom follow if a good ether has been used.* My own percentage is about eight of nausea, not all of whom vomit; further, the recovery is very rapid.

*It is worthy of note that post operative nausea and vomiting may be due to the operative procedure alone. Such frequently follow operation, on or about the gall bladder—decapsulation of the kidney, operations for strangulated hernia, rough handling of the peritoneum, long or severe traction on the tubes and ovaries—or on the spermatic cord.