Select methods in the administration of nitrous oxide and ether / By Frederic Hewitt.

NITROUS OXIDE AND ETHER

HEWITT

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IN THE ADMINISTRATION OF

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IN THE ADMINISTRATION OF

NITROUS OXIDE AND ETHER:

A Handbook for Practitioners and Students.

BY

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LONDON: BAILLIÈRE, TINDALL, & COX,
KING WILLIAM STREET, STRAND.

PREFACE.

NITROUS OXIDE and ether have very justly acquired an extensive reputation as general anæsthetics; this is partly owing to the safety by which they are individually characterized, and partly also to the advantages which may be secured by their administration in combination or succession.

Under such circumstances it would seem desirable that everyone who is in the habit of administering anæsthetics should possess a thorough knowledge of the mechanical procedures by which general anæsthesia may be most efficiently produced by means of these agents; and the following pages are therefore submitted to the profession in the

hope that they may prove of service to those who are desirous of obtaining information upon this particular subject.

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10, GEORGE STREET,
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October, 1888.

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SELECT METHODS

IN THE ADMINISTRATION OF

NITROUS OXIDE AND ETHER.

CHAPTER I.

A.—Introductory Remarks.

MUCH discussion has from time to time arisen concerning the best methods* for the administration of nitrous oxide and ether, either separately or in combination.

Notwithstanding this fact, many differences of opinion still exist; and, by reason of the numerous

* By a *method* of administration is meant a systematic plan by which certain results may be obtained. It does not follow that, because a particular apparatus is employed, a particular method of administration will result. With Clover's portable regulating ether-inhaler, for example, ether may be administered by several methods differing from one another in one or more points.

appliances which have been devised for the administration of the anæsthetics in question, great confusion has been created. It therefore seemed desirable to the writer to institute a series of comparative trials of all the known methods of inducing anæsthesia by means of nitrous oxide and ether, and to take careful notes of the results observed. The questions which had to be considered were:

(1) *What is the best method of administering nitrous oxide?*

(2) *What is the best method of administering ether?*

(3) *How may these anæsthetics be most efficiently administered in combination or immediate succession?*

And (4) *Is it possible to devise an apparatus or a combination of existing apparatus by which each and all of the selected methods may be put into operation?*

(1) For successfully administering *nitrous oxide*, experience proved: (*a*) that the face-piece should accurately and comfortably fit the patient's face, and should be made of such a material that it could be thoroughly cleansed when necessary; (*b*) that valves of thin indiarubber were more efficient than any others, as they produced less noise, were more accurate, and, as they presented very little

resistance, the patient never experienced any difficulty in filling or emptying the chest; (*c*) that with an accurately working stopcock and with these valves the administration could be so managed that the transition from air to gas was hardly noticed by the patient; (*d*) that the supply-bag should be as near the face-piece as possible; and (*e*) that many advantages resulted from the valves being under the control of the administrator, so that the supply-bag could at any moment be converted into a 'supplemental-bag'—*i.e.*, the patient could, when desired, be made to breathe backwards and forwards into the bag*—advantages which will be subsequently explained (see p. 27).

(2) For the successful exhibition of *ether*, Clover's portable regulating inhaler proved the most efficient apparatus. The flute-shaped central tube, however, was found, in many of the inhalers supplied by the instrument-makers, to be faulty in its fitting, and so the modification suggested by Messrs. Barth and Co. (Fig. 1, *ct*) was adopted. In addition to this improvement it seemed desirable to have some means of ascertaining,

* My first plan of securing this control over both valves was to have a sliding rod in the face-piece. By moving this rod the valves could be thrown into or out of action (see *Lancet*, May 9th, 1885). Subsequent experience proved the superiority of having the valves away from the face-piece, *i.e.*, in the stopcock (see p. 19).

without removing the cork or plug, the amount of ether in the apparatus at any given moment; and this was done by the substitution of a tubular glass plug (Fig. 1, *p*), through which the ether could be seen. Lastly, by having a simple triangular hole in the tube of the small bag (Fig. 1, *b*) air could be allowed without removing the face-piece during the administration. Prolonged attempts were made to secure a more compact and lighter ether reservoir; but, although many models were made, they were found to be possessed of such disadvantages that it became necessary to fall back upon Clover's original pattern (Fig. 1, E).

(3) For the successful administration of *nitrous oxide and ether in combination or succession* many points had to be borne in mind. For *adding a few breaths of ether vapour to nitrous oxide* it was found convenient: (*a*) to administer the gas as above described, transmitting it through the Clover's ether apparatus, but not allowing any ether to gain access to the gas-current till the close of the administration, when (*b*), by slightly rotating the ether-dome, a small quantity of ether vapour could be mixed with the gas, the anæsthesia so produced being partly due to nitrous oxide and partly to ether. For administering *nitrous oxide as a preliminary to deep etherization*, it became clear after many experiments: (*a*) that it was highly de-

sirable to secure a portable apparatus, and one which would not in any way alarm the patient by its appearance; (*b*) that many advantages resulted from the employment of a limited volume (about two gallons) of nitrous oxide; (*c*) that the only way in which satisfactory nitrous oxide anæsthesia could be secured by this quantity of gas was to allow the patient to expire about one-half, and then to breathe the remainder backwards and forwards; (*d*) that the control over the valves already alluded to readily allowed of the administration of the two gallons of nitrous oxide in this way, for by attaching the valved stopcock of the gas-bag to the ether chamber, the two gallons of nitrous oxide could be administered through the ether-dome in the manner required; (*e*) that when nitrous oxide anæsthesia was fairly established, by the administration of the gas in this manner, ether should be gradually but increasingly admitted; and (*f*) that when any asphyxial symptoms presented themselves air should be admitted in small quantities at a time, so that these symptoms could be controlled and thus nitrous oxide anæsthesia could be made to pass satisfactorily into deep ether narcosis.

(4) After prolonged trials of various appliances for administering nitrous oxide and ether, I adopted an apparatus which will be described below. It

consists essentially of a modification of Clover's portable regulating inhaler, fitted with special arrangements for combining nitrous oxide with ether.

B.—Description of the Apparatus required.

The apparatus* which I shall now describe is one by means of which all the conditions which have been mentioned as necessary for the successful administration of nitrous oxide and ether, either separately or in combination, may be fulfilled.

It is so made that it can be arranged in a variety of ways, according to the special requirements of the case. The description has been made as intelligible as possible; but it is feared that, in the absence of actual practical acquaintance with the apparatus, some difficulty may be experienced in correctly understanding the various parts enumerated.

F is a simple **face-piece** without valves. Three sizes are necessary. F fits either the stopcock

* Messrs. Barth and Co., of 54, Poland Street, Oxford Street, W., are the manufacturers of the apparatus.

(S), when gas only is required (see Fig. 2); or the central tube (*ct*) of the ether-dome (E), when ether

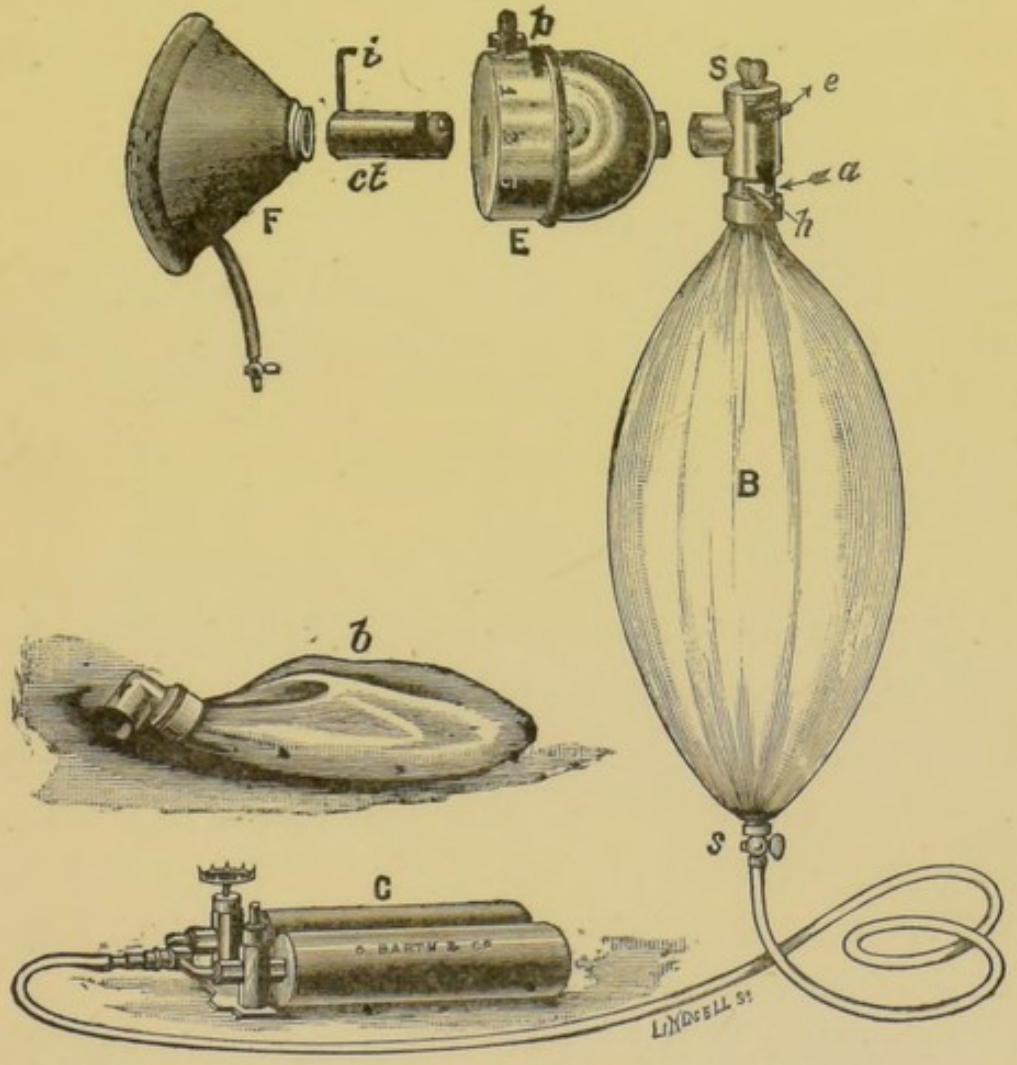

FIG. 1.—*A complete apparatus for the administration of nitrous oxide and ether, either separately or in any desired combination.*

or gas and ether are necessary (see Figs. 3, 4, and 5).

Ct is the **central tube of the ether-dome.** It

plugs tightly into F, and revolves easily in E, so that when the face-piece is fixed the rotation of E will not move *ct*. *Ct* possesses two slots in it, each of which occupies nearly half the circumference of the tube. These slots serve, in the manner to be described, to direct the air or gas current, to any desired extent, over the ether.

To *ct* is fixed an indicatory rod *i*, which, when E is made to revolve on *ct*, points to certain figures on the cylindrical portion of E, and indicates the extent to which the current is passing over ether.

E is **Clover's ether-dome** modified in one or two particulars. It is made of metal, and may be described as consisting of three constituent parts soldered together, viz., a *hollow sphere;* a *wide tube passing through this sphere;* and a *cylindrical cap or cover fitting over and completely enveloping one half of the sphere.*

The *sphere* is the reservoir for the ether, and, in consequence of it being half covered, as above described, by the cylindrical portion of the dome, one hemisphere only is visible in the finished apparatus. Ether is introduced into the sphere by removing the plug (*p*), which closes a short tube communicating directly with the interior of the sphere. A little reflection will show that this short

tube passes through the space (without communicating with it) which is formed by the cylindrical portion of the dome covering one-half the sphere. The plug (*p*) is furnished with a short piece of glass tube, through which the ether may be seen.

The wide *shaft* or *tube* which passes through the sphere is seen only to a very slight extent in the woodcut. In it *ct* and S fit accurately, but move easily. When the face-piece, the ether-dome, and the stopcock are fitted together, the rotation of the ether-dome upon the central tube will hardly affect the stopcock, which is made to move very easily in the ether-dome. The tube or shaft passing through E possesses, like *ct*, two slots about half-way along it—slots which correspond in size to those of *ct*. When the indicator *i* points to o on the dome, it will be found that the slots of *ct* have no communication whatever with those in the other tube. But when the dome is made to revolve round *ct*, so that the indicator comes successively to 1, 2, 3, and F on the dome, the two slots of *ct* gradually become overlapped by the two slots of the other tube ; so that when the indicator reaches F, the two slots of the one tube exactly correspond to the two slots of the other tube. So long as the indicator points to o, the slots of the two tubes do not communicate with each other, and so the current is a *direct* one, no part of it passing

into the sphere containing the ether. When the indicator reaches 1 on the dome, one quarter of the current is made *indirect—i.e.*, is made to pass over the ether, and on again ; whilst three quarters remain direct—*i.e.*, do not pass over the ether at all. When the indicator points to 2, two quarters, or one half, of the current is made indirect—*i.e.*, becomes etherized—whilst the other half remains direct. When the indicator points to 3, three quarters of the current will pass over the ether and one quarter only will remain direct and will not pass over the ether. When the indicator points to F, the whole of the current is an indirect one—*i.e.*, it passes over the ether in the sphere, and then on again.

It seems hardly necessary to mention that these alterations in the course of the current will take place in response to the rotation of the dome quite independently of what is being breathed, and independently also of the manner in which the patient may be breathing—in other words, whether he is breathing through valves or not. When the ether-dome is used, the patient necessarily breathes backwards and forwards through it, whether the valves of the stopcock (S) are in use or not ; and the degree to which the air or gas current is diverted is regulated by the rotation of the dome.

The *cylindrical portion of the dome* covers one-half of the sphere for the ether, so that a space

between the cylinder and the hemisphere results. This space is partly filled with water, and is hermetically sealed. In cold weather it is advisable to immerse the ether-dome in warm water for a few minutes before use, in order that the water in the hermetically-sealed space may take up sufficient heat to maintain the requisite degree of vaporization of the ether in the adjacent sphere.

S is the **stopcock of the gas-bag** B. This stopcock may be either applied directly to the face-piece F, when gas only is required (Fig. 2), or may be fitted to the ether-chamber, when the combination of gas and ether is necessary (Figs. 4 and 5). In the stopcock there are two thin rubber valves, one of which acts during inspiration, the other during expiration. The tap surmounting the stopcock solely controls these valves ; when it is turned so that the expiratory valve becomes apparent through the large slot in the upper portion of the stopcock (as in the figure), the valves will act and each expiration will escape at *e*. When the tap is turned so that this slot closes (as in Fig. 5), the valves are rendered inactive and to-and-fro breathing results. The little handle *h* near the bag simply determines whether air or gas is breathed. When the air-hole is opened (as in the figure), air enters at *a*, but no gas is breathed ;

when the handle is turned so that the air-hole closes, gas is breathed instead of air.

B is the **gas-bag** with a small stopcock (*s*), to which may be fitted the tube leading from the gas-bottles (G).

b is a **small bag** which fits into E, and which is used when ether only is required (Fig. 3) or when once etherization has become established in gas-and-ether narcosis. The tube which fits into the ether-dome possesses a triangular opening in its upper surface. By pushing this tube into E as far as it will go, the opening becomes covered; but by drawing it out, so that the air-hole becomes exposed, air may be admitted without removing the apparatus from the face.

G is the **gas-bottles,** which are worked by a foot-key. Each bottle holds twenty-five gallons of gas in a state of liquefaction.*

* I have selected Barth's patent gas-bottle as the most efficient with which I am acquainted. The bottles are made in two sizes: one size containing 25 gallons, the other 50 gallons of nitrous oxide.

C. — Combinations of Apparatus above described.

I.

The *face-piece* (F),
stopcock (S),
gas-bag (B),
and *bottles* (G),
fitted together, constitute an apparatus for the administration of **nitrous oxide** (Fig. 2).

II.

The *face-piece* (F),
ether-dome (E),
and *small bag* (*b*),
fitted together, constitute an apparatus for the administration of **ether** (Fig. 3).

III.

The *face-piece* (F),
ether-dome (E),
stopcock (S),
gas-bag (B),
and *bottles* (G),
fitted together, constitute an apparatus for the administration of **nitrous oxide with a few breaths of ether** (Fig. 4).

IV.

The *face-piece* (F),
ether-dome (E),
stopcock (S),
and *gas-bag* (B),

the last-named being filled and disconnected from the gas-bottles (G), constitute an apparatus for the administration of **nitrous oxide as a preliminary to deep etherization** (Fig. 5).

CHAPTER II.

THE ADMINISTRATION OF NITROUS OXIDE.

A.—Arrangement of Apparatus.

(SEE Fig. 1.) Select an appropriate face-piece and fit it to the stopcock. Turn the tap of the stopcock so that the valves may act, and see that the expiratory valve works freely. Connect the gas-bag to the gas-bottles by means of the long india-rubber tube. Pass a small quantity of nitrous oxide through the gas-bag to free it from all air. Turn the handle of the stopcock so that the air-hole is open. Partly fill the gas-bag with gas.

Whenever it is practicable, the apparatus should be thus arranged before the patient is admitted to the room in which the operation is to take place.

B.—Details of the Method of Administration.

Method 1.

(1) *Accurately adapt the face-piece to the patient's face;* air will enter at the air-hole in the stopcock, and escape by the expiratory valve. It is always

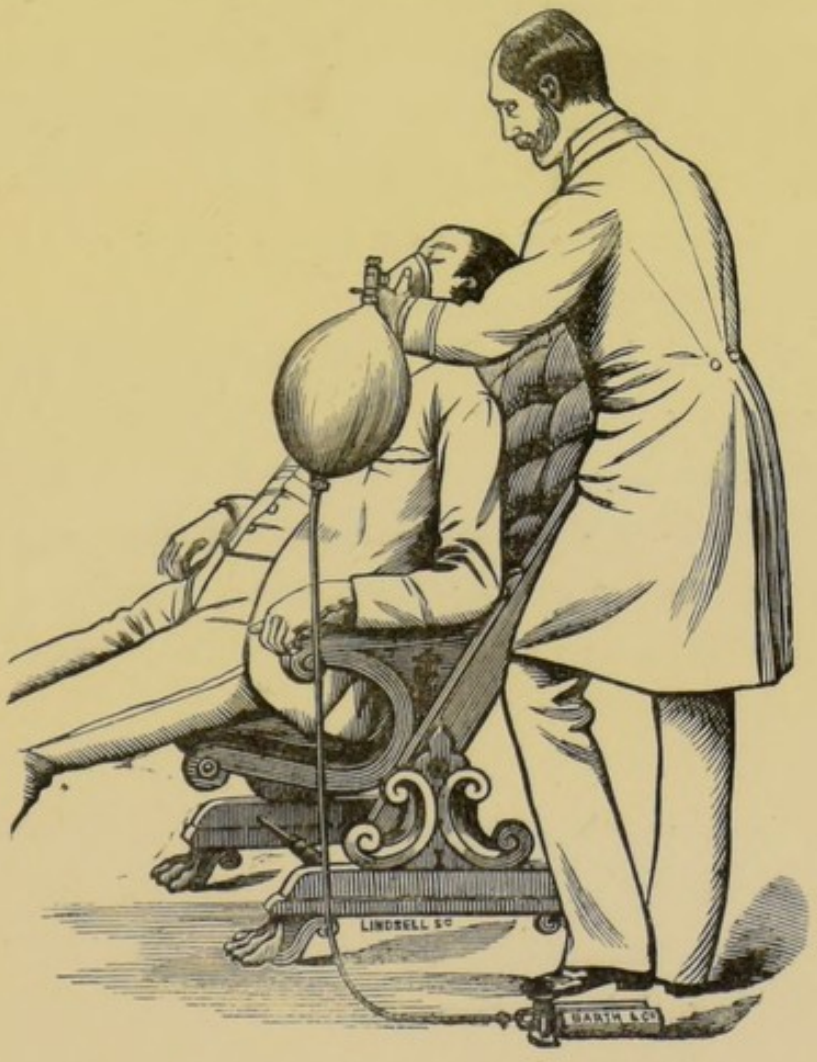

FIG. 2.—*The administration of nitrous oxide for a dental operation.**

* From a photograph very kindly taken for me by Mr. W. Hern.

desirable to allow the patient to breathe air several times through the apparatus before admitting nitrous oxide. Test the accuracy of the fitting of the face-piece by intermittently and rapidly placing the forefinger over the air-hole during inspiration ; if the face-piece fits well, the noise produced by the suction exerted upon the finger will be audible.

(2) *Turn the handle of the stopcock so that the air-hole becomes closed and gas from the gas-bag enters the air-passages.* The actual moment at which the transition from air to gas takes place will hardly be perceived by the patient.

(3) As the bag diminishes in size *gradually admit more gas* by working the foot-key of the gas-bottles (Fig. 2).

(4) *When arhythmical respiration, true stertor or clonic movement of the extremities commences, air should be allowed* by removing the face-piece.

Method 2.

Conduct the administration as above, each expiration being permitted to escape, until signs of anæsthesia commence to appear. (By this time the lungs will have been more or less washed out, as it were, with nitrous oxide, and very little residual air will be left in the air passages.) The bag being nearly or quite full, stop the supply of gas to the gas-bag, and rotate the tap govern-

ing the valves in the stopcock so that the valve-action becomes suspended. This latter procedure changes the 'open' to the 'close' form of respiration, the patient now being made to breathe backwards and forwards into the bag. The narcosis becomes as satisfactorily and as fully established as in Method 1, but the time occupied is a trifle longer. This method is almost identical with that which results from using Clover's 'supplemental bag.'

Method 3.

The inhalation may be so conducted that anæsthesia, more or less profound, may be kept up for a considerable time. The administration is commenced in the ordinary manner; but when the respiration tends to become in any way embarrassed (from want of oxygen) air must be admitted, either by turning the handle which governs the air-hole of the stopcock or by removing the face-piece for one or two inspirations. By the repetition of these manœuvres anæsthesia may be maintained for half an hour or more;* but, as will be pointed out below, this method is not to be recommended except in particular cases.

* See *British Medical Journal*, Feb. 14th, 1874; *Lancet*, i. 1870, p. 800; *British Journal of Dental Science*, June, 1874, p. 281.

C.—Clinical Considerations in the Application of the above Methods.

Nitrous oxide is a particularly appropriate anæsthetic for short operations ; hence its extensive use in dental surgery. The available period of anæsthesia in operations within the oral cavity—*i.e.*, the anæsthesia which persists after the removal of the face-piece—is, on the average, about thirty seconds. In dental practice it is therefore not advisable to trust to the administration of nitrous oxide alone when it is contemplated that the operation will exceed this period. All operations lasting thirty seconds or less, except those in which total muscular relaxation and quietude are necessary, may with much advantage be performed under nitrous oxide, administered by Method 1 or 2.

Should the supply of nitrous oxide unexpectedly fall short either before or during the administration, or should the administrator wish to secure an anæsthesia which is a trifle longer* than that

* See *Journal of British Dental Association*, June 15th, 1886, 'Duration of Nitrous Oxide Anæsthesia.' By anæsthetizing a patient on six different occasions, three times by the ordinary method (Method 1), and three times by Method 2, I found that the average available period of anæsthesia in the former set of administrations was 39 seconds, whilst in the latter it was 56 seconds. The respiratory functions continue for a longer time when to-and-fro breathing is per-

usually obtainable by the ordinary plan of administration, Method 2 may be adopted. From a hygienic point of view there is undoubtedly an objection to this method of administering nitrous oxide; for it is almost impossible in actual practice, after each administration, to thoroughly cleanse the bag which has been used for to-and-fro breathing on a previous occasion. It is, however, of great advantage to have command over the expirations; for, in the event of the gas-bottle failing to work or its contents falling short, the administration may still be carried to a successful termination, which might be impossible if the valves were not under control.

In those cases in which it is desired to keep up the narcotic action of nitrous oxide, Method 3 may be used. Generally speaking, it is more satisfac-

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mitted towards the end of the administration, because the residual air is not so rapidly disposed of, a little remaining behind and thus supporting breathing for a longer period than when the ordinary method of administration is employed. It is probable that in consequence of the longer period of respiration more nitrous oxide enters the circulation, and hence a longer time is occupied in its escape. It is, I hold, a mistake to suppose that by adopting the modification in question a greater degree of asphyxia results; the asphyxial symptoms of nitrous oxide narcosis (irregular respiration, clonic spasm, etc.) are longer delayed and not so pronounced as when each expiration of nitrous oxide is allowed to escape.

tory to put a patient under ether than to administer nitrous oxide for a prolonged period. Tonic spasm is frequently present during operations thus conducted, and in some cases it is practically impossible to procure the necessary degree of quietude by the intermittent administration of the gas.

D.—General Remarks on Nitrous Oxide Narcosis.

In order that the administration may be successfully conducted, it is essential, in the first place, to secure the confidence of the patient, and to perform the various manipulations above described with as little noise and fuss as possible. In the next place, it is absolutely necessary that all air should be excluded during the administration ; in other words, the face-piece must fit accurately, and the apparatus must not leak. Lastly, after the commencement of the administration, the bag should be kept full, but not overfull, by working the foot-key of the gas-bottles.

The phenomena which the patient exhibits when nitrous oxide narcosis has become fully established will be found to vary somewhat in different cases. Dilatation of the pupils, stertor, and cyanosis usually occur ; but not one of these signs can be absolutely depended upon as indicating the neces-

sity for terminating the inhalation. Speaking generally, it may be said that the administration should be discontinued when the respiration *commences* to become arhythmical and embarrassed, or clonic movements of the extremities begin to manifest themselves. The speedy subsidence of these phenomena when air is admitted by the removal of the face-piece is one of the most remarkable features of the administration.

CHAPTER III.

THE ADMINISTRATION OF ETHER.

A.—Arrangement of Apparatus (*Clover's Portable Regulating Ether-Inhaler*).

(SEE Fig. 1.) Pour away from the dome any ether that may have remained from a previous administration. In cold weather immerse the dome in warm water for a few minutes before use; this has the effect of raising the temperature of the water in the hermetically-sealed water-jacket (see description of apparatus, p. 19), so that the evaporation of the ether in the adjacent sphere is sufficiently brisk. Be careful to get rid of any water that may have

gained admission to the ether-sphere during the warming process. Select a face-piece of an appropriate size ; fit it to the ether-dome ; and attach the small bag to the latter. Turn the indicator to o, remove the plug, pour in 1½ oz. of pure ether, and insert the plug. The apparatus is now ready for use.

B.—Details of the Method of Administration.

(1) *Accurately, but gently, adapt the face-piece to the face of the patient*, and allow the latter to fill the bag with his own expirations. This is best done by partially removing the face-piece during inspiration and applying it more closely during expiration.

(2) *Allow the patient to breathe backwards and forwards for about twenty respirations*, no ether as yet being admitted.

(3) *Very gradually rotate the ether-dome*, so that the indicator passes slowly towards 1 (Fig. 3).

(4) *Rotate the ether-dome about half a degree during each half-minute*, unless the patient should exhibit signs of irritation from the vapour (swallowing, tendency to cough, etc.), in which case rotate the dome back a little, and more gradually attempt to increase the strength of vapour.

(5) When cyanosis appears, *admit a small quantity*

of air, either by raising the face-piece for an inspiration, or by pulling out the metal tube from the ether-dome so that the air-slot upon it becomes partially or wholly patent.

(6) *Patients vary widely in the quantity of ether which is needed.* In the case of strong, robust persons the ether-indicator may have to be kept at 3 or F for some time before narcosis becomes

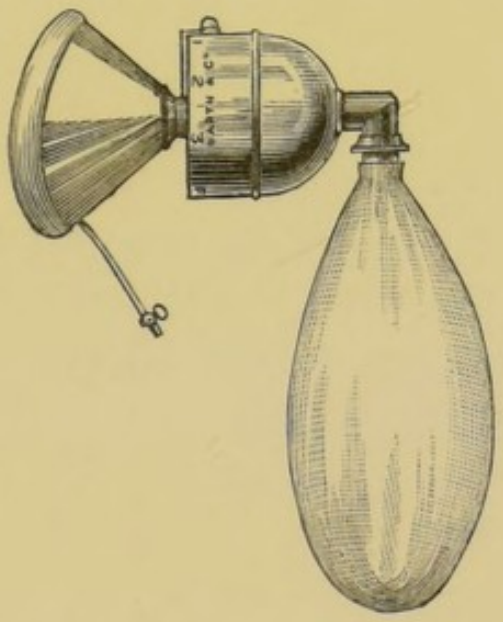

FIG. 3.—*The administration of ether by Clover's method. The apparatus thus arranged constitutes a Clover's Portable Regulating Inhaler.*

fully established; whilst in the case of weakly individuals and children it may never be necessary to proceed beyond 1, or at the outside 2, throughout the administration.

(7) When once narcosis has become established, *air should be given at frequent intervals,* the quantity

being regulated by the colour of the patient's face and lips.

(8) In protracted cases and in weakly persons *the dose of ether should be very materially lessened when once full anæsthesia has been produced.*

C.—Clinical Considerations in the Application of the above Method.

The production of ether narcosis by Clover's method depends partly upon the ether inhaled and partly upon the deprivation of oxygen. Although the inhaler may be used in such a manner that very little air is allowed—the patient being kept more or less cyanosed throughout—it is questionable whether this particular plan of employing the apparatus should be generally recommended for the maintenance of ether narcosis.* It would seem to be preferable to use the inhaler in such a way that cyanosis—except during the earlier steps of the administration—is allowed to manifest itself only occasionally, and then but to a slight extent. Such a proceeding necessarily entails the administration of considerably more ether than when the inhalation is conducted according to Clover's instructions; but this hardly constitutes an objection.

* Clover said, 'If any interruption in the breathing occur, or if the pulse should be indistinct, the face-piece need be only removed for one inspiration. The dark colour of the blood is a less reliable test of the need of air than the symptoms mentioned.'

As a method of inducing (as opposed to maintaining) ether narcosis, the method above described in detail is second only to that in which nitrous oxide is used to precede etherization (Chap. V.). When it is impossible to obtain nitrous oxide for the latter purpose, the above method of inducing ether anæsthesia should be adopted. It is almost as rapid when properly managed as that in which nitrous oxide is used to precede ether; but it is not nearly so pleasant to the patient. For the maintenance of ether narcosis no better plan exists.

The great advantages of Clover's inhaler over those inhalers by which a copious supply of air is admitted throughout are as follows:—struggling, excitement, and coughing are far less frequently met with; the air-passages are less irritated by the ether; much less ether is required; and the strength of vapour can be easily regulated.

Cases, however, occasionally present themselves in which it is better to administer ether from a cone or towel than to partially deprive the patient of fresh air, as by Clover's method.

Amongst the conditions which should be taken to contra-indicate etherization by Clover's method may be mentioned (1) profound collapse (as in certain cases of strangulated hernia, severe hæmorrhage, etc.), and (2) extreme obesity. In the former class of cases a very small quantity of

ether gradually given will suffice to induce anæsthesia; and any interference with the due supply of air, or the incautious administration of too much ether, will be likely to increase the difficulties under which the heart is labouring and to induce fatal syncope. In the latter class of case the deprivation of air is also badly borne, and if it be determined to employ ether it is best to administer it very cautiously and with plenty of air.*

It is obvious that whenever ether is contra-indicated, Clover's method of administering it must also be considered inapplicable; but the merits and demerits of ether as an anæsthetic cannot be discussed on this occasion.

D.—General Remarks on Ether Narcosis.

During the administration of a general anæsthetic —and ether is the agent now under consideration— there is a gradual lowering of reflex action; and, in order to successfully induce and maintain general anæsthesia by means of ether, this important fact must be borne in mind. Acts of swallowing, inhibited breathing, and coughing,

* The A. C. E. mixture (1 part of pure alcohol, 2 of chloroform, and 3 of ethylic ether) is very well borne by patients of this class. For further remarks on '*The Production of Anæsthetic Sleep in Patients suffering from Grave Constitutional Disorders*,' see *Lancet*, May 26th, 1888.

which may arise during the initial stages of the administration, are, of course, reflex phenomena; and the struggling which is occasionally met with is often of the same nature. When once deep anæsthesia has become established, reflex action is more or less completely annulled; and in unnecessarily deep narcosis no kind of stimulation to sensory nerves will produce any reflex effects.

The order in which reflexes become abolished varies in different subjects. Amongst the last to disappear are the nasal, pharyngeal, laryngeal, corneal, rectal and vaginal. Generally speaking, it is not desirable to secure the persistent abolition of these reflexes, always supposing that no inconvenience results from an occasional evidence of their existence. For example, etherization may, in a certain case, have been carried to such an extent that total muscular flaccidity and an absence of lid-reflex has resulted; but yet, by suddenly increasing the strength of the ether vapour, the patient performs an act of deglutition, or coughs. In such a case it would not be necessary to render the patient more profoundly anæsthetic; it would, in fact, be desirable to catch an occasional glimpse of the pharyngeal (swallowing) or laryngeal (coughing) reflex, if no inconvenience resulted to the operator from their occurrence. It is not meant by this that the patient should be allowed to cough.

By a little experience, the tendency to cough may be detected and the anæsthetic pushed in such a manner that the cough is either entirely prevented or only one modified act of coughing occurs. I will add another example, because the point under consideration is, perhaps, one of the most important in connection with the administration. Cases frequently occur in which it is found that, having once rendered the patient deeply unconscious, *i.e.*, free from all obvious reflex acts, the return of the lid-reflex is not inconsistent with perfect quietude and absence from coughing or vomiting. Now, in this instance, there is no necessity to push the anæsthetic beyond this stage; but should the commencement of the reappearance of the lid-reflex co-exist with commencing cough or movement, more ether must, of course, be given, and the lid-reflex kept in abeyance.*

Apart from asthenic and asphyxial states, the circulation under ether is always satisfactorily maintained. Alterations in the respiratory rhythm may occur from the following causes:—from

* I am in the habit of teaching that the patient's head should, when convenient to the operator, be kept upon its side, and that the administrator should stand behind his patient with the ether-inhaler in one hand, the other hand being free for (1) pushing the jaw forwards when necessary; (2) watching for any upward movements of the larynx in deglutition; (3) feeling the temporal or facial pulse, and (4) touching the cornex from time to time.

varying strengths of vapour (temporary closure of the glottis); from acts of swallowing, produced by mucus or ether vapour irritating the pharynx; from the lips falling together; from the jaws becoming fixed in spasm and the teeth clenched; from the tongue gravitating backwards; from some degree of falling together or spasm of the aryteno-epiglottidean folds, with or without simultaneous spasm of the sphincter muscles of the larynx; or, lastly, from foreign substances (blood, pus, etc.) in the air-passages. These conditions cannot, however, be here discussed; it is unnecessary to do more than to refer to them.

Whatever means may be adopted for placing the patient under ether (see Chap. V., as well as early part of present chapter), the same rules will hold good for keeping up a safe and efficient narcosis. The following are the most important points to be borne in mind:

1. *Keep your patient on the threshold of returning reflex action.* When once reflex actions have become abolished, it is advisable, if the circumstances will permit, to so regulate the narcosis that by the withdrawal of the anæsthetic for a short time some evidence of returning reflex action will present itself. It is held by competent authorities that it is far safer to deeply anæsthetize a patient

for an operation than to induce partial anæsthesia ; and the rule here given is in no way opposed to this doctrine ; it is only intended to prevent an unnecessarily deep narcosis.

(2) Bear in mind the important fact that *patients vary widely in the quantity of ether they require* ; and whilst it should be our aim to produce the same degree of narcosis in all cases, it must not be forgotten that this degree is to be obtained by the expenditure of very different quantities of the agent.

(3) *Watch the movements of the bag carefully*, in order to appreciate the extent to which etherized air is entering and leaving the chest. The movements of the thoracic and abdominal walls may take place for a time without any current passing into or out of the lungs, and hence cannot be depended upon.

(4) *Watch the colour of the patient's face and lips.*

(5) *Keep the finger on the temporal or facial pulse in all conditions of very feeble circulation*, from whatever cause arising. It is unnecessary to watch the pulse under ether so long as the colour of the ears and cheeks is good. Should there be marked asthenia (as from recent and severe hæmorrhage, protracted illness, etc.), the circulation will demand as much attention as or even more attention than the respiration.

CHAPTER IV.

THE ADMINISTRATION OF NITROUS OXIDE WITH A SMALL QUANTITY OF ETHER.

A.—Arrangement of Apparatus.

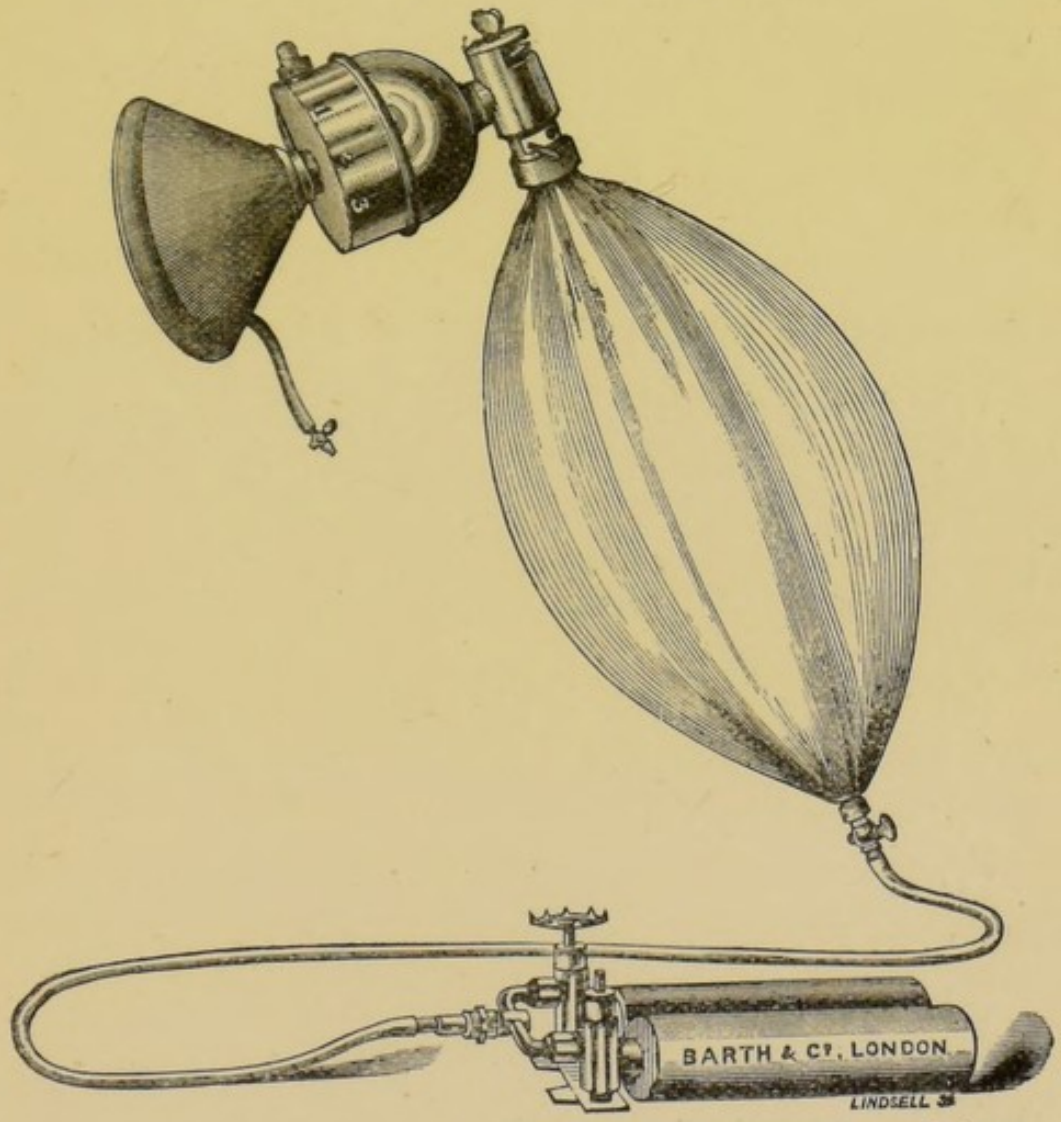

FIG. 4.—*Apparatus arranged for the administration of nitrous oxide with a small quantity of ether.*

(SEE Fig. 1) Select a face-piece of appropriate size and fit it to the ether-dome, which should be prepared for use in the manner described in Chap. III. Be very careful that the indicator points to 0, so that no ether vapour is breathed at first. Connect the gas-bag to the bottles, and having partly filled the gas-bag, adapt its stopcock (arranged so that its valves may act) to the ether-dome. It will be obvious that this is exactly the same arrangement of apparatus as that required for giving nitrous oxide alone, with the exception that the ether-dome is interposed.

B.—Details of the Method of Administration.

(1) *Accurately adapt the face-piece to the patient's face;* air will enter at the air-hole in the stopcock, and escape by the expiratory valve. By applying the face-piece during an expiration no odour of ether will be detected.

(2) *Turn the handle of the stopcock so that the air-hole becomes closed, and gas from the gas-bag enters the air-passages.*

(3) *As the bag diminishes in size, gradually admit more gas by working the foot-key of the gas-bottles.*

(4) *When the patient commences to show signs of nitrous oxide narcosis, rotate the ether chamber till its indicator points to* 1 *or* 2. Three to ten breaths of ether vapour may thus be added to the nitrous

oxide before the face-piece need be removed for the admission of air.

The difference between this method and that which will be next described (Chap. V.) must be distinctly understood. As was pointed out when dealing with nitrous oxide, a time arrives during the administration of gas when air must be admitted. Now, ether vapour will not supply free oxygen to the patient; and so a similar need for air arises when ether vapour is added to nitrous oxide. In the method just described no air is admitted throughout the administration, but the inhaler is removed when the respiration indicates the need for air. The patient's system then remains for a short time charged with *both* anæsthetics. In the method next to be considered the same phenomena will of course arise and indicate the need for air; but in this case, as it is proposed to give more ether, and to secure a longer unconsciousness, a very limited quantity of air is admitted from time to time, ether being increasingly given. To put the difference in other words, it may be said that in the above method the anæsthesia which results after the removal of the face-piece depends *partly upon nitrous oxide and partly upon ether;* whilst when nitrous oxide is used as a preliminary to deep etherization, the anæsthesia

which results *depends only upon the ether*, the nitrous oxide having escaped during the transition from nitrous oxide narcosis to that of ether.

C.—Clinical Considerations in the Application of the above Method.

It will be seen that in this method a small quantity of ether is thrown into the continuous gas-current just at the close of the administration. This procedure appreciably prolongs the anæsthesia of nitrous oxide, and is especially of use in certain dental operations. The narcosis, which usually persists from forty-five to ninety seconds after the removal of the face-piece, is due partly to nitrous oxide and partly to ether.

It is exceptional for any unpleasant symptoms to arise after this form of anæsthesia.

Finding much difference of opinion with regard to the merits and demerits of administering a 'whiff of ether' after nitrous oxide, I conducted about 200 administrations at the Dental Hospital in the manner above described, and was agreeably surprised with the results. I found that if more ether than that which is advised was given, headache and nausea were liable to result; but with a very small quantity of the agent administered towards

the close of the nitrous oxide narcosis the anæsthesia was longer than when nitrous oxide alone was employed, and the recovery was almost, if not quite, as satisfactory.*

On very rare occasions transient nausea and headache have occurred, even with a small dose of ether; and therefore this method of inducing anæsthesia should not be preferred to that in which nitrous oxide alone is employed. It should, indeed, be reserved for those dental cases in which it is questionable whether the period of anæsthesia from nitrous oxide will suffice for the performance of the operation.

It is always desirable to inform the patient, after the administration, that it was necessary to add a small quantity of ether vapour to the gas; for, if any unpleasant after-effects should by chance arise, they would not then be attributed to the nitrous oxide.

* In some cases which I have met with the patients have expressed themselves as experiencing a more pleasant after-effect than that which they had on previous occasions noted after nitrous oxide alone.

CHAPTER V.

THE ADMINISTRATION OF NITROUS OXIDE AS A PRELIMINARY TO DEEP ETHERIZATION.

A.—Arrangement of Apparatus.

(SEE Fig. 1.) Select an appropriate face-piece. Attach it to the ether-dome prepared as described in Chap. III., p. 29; and see that the indicator points to 0. Fill the gas-bag and detach it from the tube leading to the bottles. Arrange the stopcock so that its valves may act. Place the full gas-bag near at hand.

In order that the patient may not be alarmed by the arrangement or the appearance of the apparatus, it is desirable, if the circumstances should allow, that everything should be adjusted beforehand, and that the apparatus should be placed out of sight when the patient enters the room in which the operation is to be performed.

B.—Details of the Method of Administration.

(1) *Accurately but gently adjust the face-piece* (with the ether-dome attached) to the face of the patient. Air is then freely breathed backwards and forwards through this portion of the apparatus. By applying the face-piece during an expiration no odour of ether will be detected.

(2) When confidence has become established, noiselessly *fit the full gas-bag to the ether-dome.* Air is still breathed, but now through the valves of the stopcock.

(3) *Turn on nitrous oxide by moving the handle of the stopcock* so that the air-hole closes and gas is breathed instead of air.

(4) When about two-thirds of the nitrous oxide have escaped by the expiratory valve, *reverse the tap of the stopcock* so that the valves may no longer act, and the patient may breathe the remaining quantity of nitrous oxide backwards and forwards into the bag.

(5) *Gradually admit ether vapour* by slightly rotating the ether-dome at frequent intervals. A little reflection will show that at this juncture (see Fig. 5) the patient is breathing backwards and forwards: (1) a limited volume of nitrous oxide; (2) a small quantity of residual air (nitrogen, oxygen, and carbonic anhydride); and (3) an increasing quantity of ether vapour.

(6) When cyanosis, muscular twitching or respiratory embarrassment testifies to the presence of nitrous oxide narcosis, *cautiously admit a small quantity of air* by moving back the handle of the stopcock for an inspiration or two. This manœuvre will allow the above phenomena to subside and breathing to continue. The stage now reached

is the most difficult to manage during the administration, failure to rapidly establish etherization being most commonly due to the admission of too much air. As a general rule air should not be admitted before a good deal of ether has been

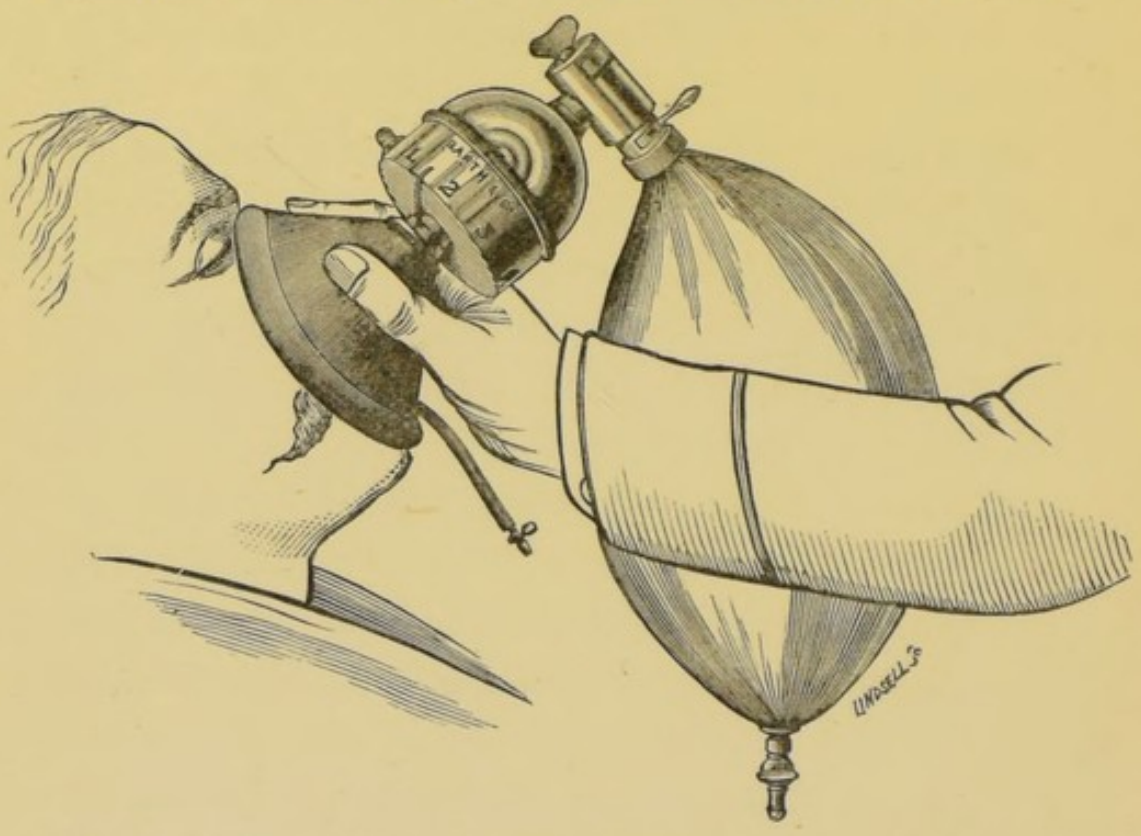

FIG. 5.—*The administration of nitrous oxide and ether, the nitrous oxide being used as a preliminary to deep etherization.*

inhaled, and then it should only be allowed in small quantities. If too much air be given the patient will commence to recover reflex action, and will not tolerate ether vapour; whilst, if too little be given, respiration will not continue. Should the respiratory embarrassment which characterizes

full nitrous oxide narcosis become marked early in the administration, air must of course then be admitted for the maintenance of respiration.

(7) With strong and robust patients it will be found necessary to *rotate the dome till the indicator reaches* 3 or F, and to admit a very limited supply of air. It will be understood that nitrous oxide gradually escapes from the lungs when air is admitted, and a period soon arrives when no gas is left in the to-and-fro current.

(8) When once etherization has become established, *conduct the remainder of the administration as with Clover's portable inhaler* (Fig. 3), which, indeed, the apparatus now becomes.

It will be found convenient, when the patient has become fully anæsthetized, to replace the gas-bag by the smaller and more handy bag used in Clover's method (Fig. 1, *b*).

In anæsthetizing children by gas and ether, the quantity of nitrous oxide required is small ; a child of six or seven years, for example, not needing more than half a bag of gas, or even less.

C.—Clinical Considerations in the Application of the above Method.

This method is the best which can be adopted for establishing etherization during ordinary surgical operations. By its means patients become rapidly

and quietly anæsthetized, and when the administration is properly conducted there is an absence of all coughing, struggling, and excitement, symptoms which are by no means infrequently observed when other methods of inducing etherization are adopted, or when chloroform is the anæsthetic used. Further than this, the apparatus is, in a certain sense, portable, a comparatively small volume of nitrous oxide being required to induce anæsthesia before admitting ether. By filling and detaching the gas-bag before the administration commences—a proceeding which is impossible in other methods—the patient is not frightened by the noise made by nitrous oxide issuing from the gas-bottles; and, as the administrator need not direct any attention to the supply of nitrous oxide during the administration, he is more at liberty to watch the behaviour of his patient under the anæsthetic.

The above method is suitable for inducing anæsthesia in every case in which Clover's portable inhaler may be employed. It is to be especially recommended in the case of extremely nervous or excitable patients, and especially also in strong muscular subjects, who, unless etherization be preceded by nitrous oxide, frequently struggle violently, or even become unmanageable.

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