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H. EDMUND G. BOYLE

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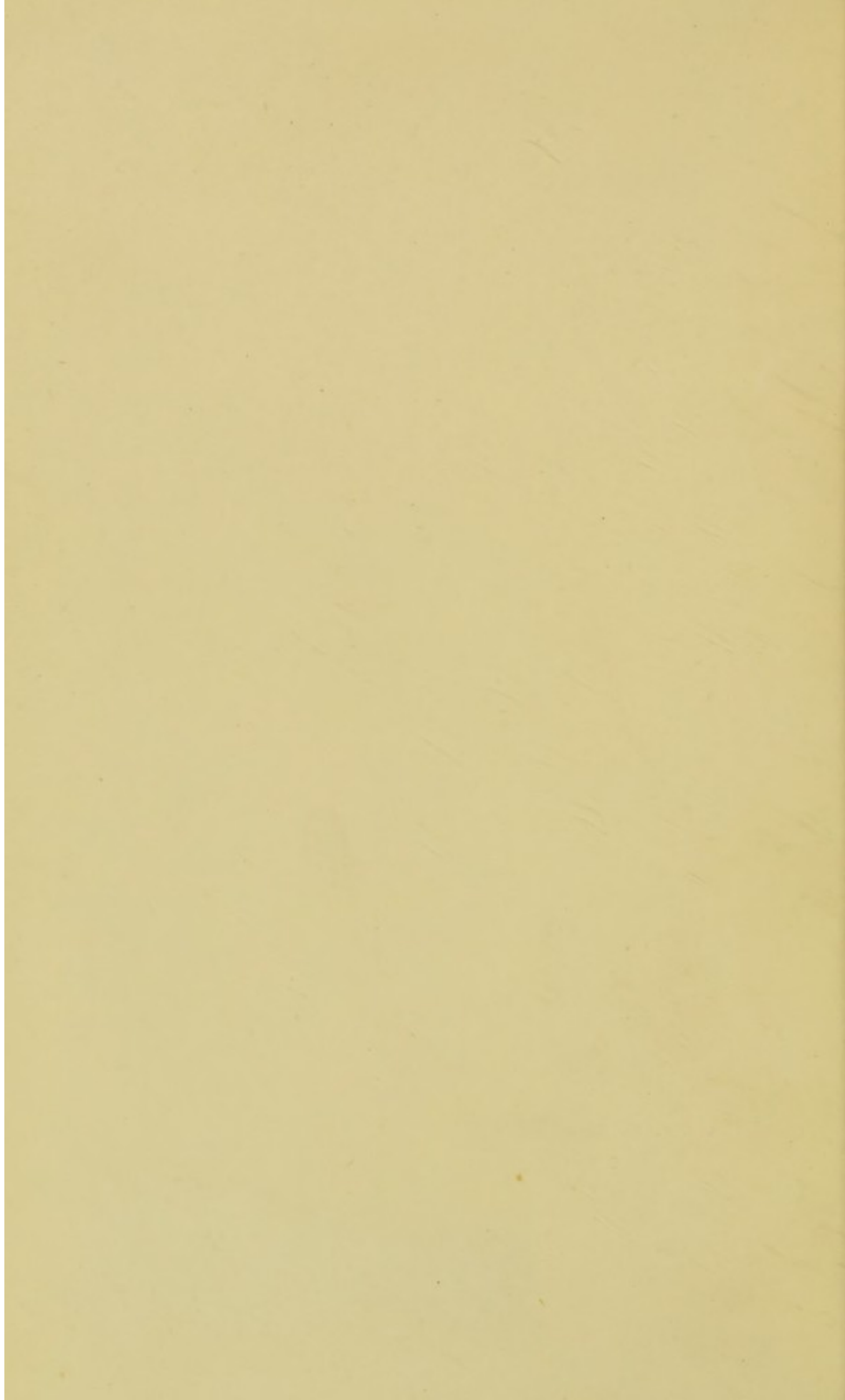
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PRACTICAL ANÆSTHETICS

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PREFACE TO THE SECOND EDITION

IN the present edition the whole book has been thoroughly revised and several additions and corrections have been made at the suggestion of other teachers—whom I thank cordially for their interest and friendly criticism.

The Open method of administering ether has been re-written and a chapter on Spinal Analgesia added.

I have to thank Messrs. Mayer & Meltzer for giving me the use of blocks to illustrate my modifications to Hahn's tube and to the laryngotomy tube, for a like courtesy I have to thank Messrs. Allen & Hanbury and the Dental Manufacturing Co.

Once again I have to thank my friend Mr. R. B. Etherington Smith for many suggestions.

1911.

PREFACE TO THE FIRST EDITION

THE object of this little book is to furnish a short guide to those who have not the leisure to study such valuable works as Sir F. Hewitt's *Anæsthetics and their Administration* and Mr. Gill's *CHCl₃ Problem*.

I have endeavoured to treat the administration of anæsthetics from a practical point of view alone, and to enumerate the rules which, from my experience of teaching, I have found to be most valuable for the guidance of the student.

The Theory and Physiology of Anæsthesia have only been mentioned briefly when they have a direct bearing on important details of practice.

I am very much indebted to Mr. Richard Gill for his practical teaching in the past, and also to Sir F. W. Hewitt for the free use I have made of his recent writings.

I have not thought it necessary in so small a

volume to give a list of references to all my authorities.

I have to thank Messrs. Barth & Co., Arnold & Sons, Duncan Flockhart & Co., and Down Bros., for the loan of blocks, and E. Bridle for taking photographs.

Lastly my best thanks are due to my friend and colleague, Mr. R. B. Etherington-Smith, for much valuable advice and assistance in the preparation of these pages for the press.

H. EDMUND G. BOYLE.

27

The first thing I did was to go to the bank

and get some money out of my account

and then I went to the post office

and sent a letter to my mother

and then I went to the library

and borrowed a book

and then I went to the store

and bought some

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CHAPTER I

GENERAL CONSIDERATIONS

BEFORE describing the various methods by which general anæsthesia may be induced, it is advisable to define the term "anæsthesia," and to consider some of the general duties of the administrator.

Anæsthesia.

The condition of general anæsthesia is one in which there is :—

1. Insensibility to pain.
2. Unconsciousness.
3. Diminished reflex action.
4. Absence of movements of the voluntary muscles.

Duties of the Anæsthetist.

The first and most important duty of the administrator of the anæsthetic is absolute attention to his case. He must not allow himself to be

distracted by events occurring outside his own sphere of action ; if he does so, he will find that it is impossible to observe the many phenomena of anæsthesia, and that the time for action, signalled as it were by these phenomena, may have passed before he has discovered that something must be done. It is not meant by this that the anæsthetist should be ignorant of what is being done by the surgeon—his knowledge of the progress of the operation will often modify his method of administration : but he must be carefully on his guard against becoming absorbed in watching the operation, and so forgetting his patient. I know of no better advice to a man beginning the study of anæsthetics than this :—Keep your whole attention on what you are doing, and do not allow outside influences to interfere with your own work.

The anæsthetist must remember that he holds the life of every one of his patients in his hand. Consequently, if at some critical moment he be found flurried and at a loss what to do, the result may be disastrous. In this branch of the profession, perhaps more than in any other, promptness and

rapidity of action, a cool head and a steady hand are most essential.

Examination of Patients.

A drawback under which the anæsthetist labours is that as a rule he is called upon to administer an anæsthetic to a patient of whom he has no previous knowledge. The patient's general habits of life, whether or no he is a heavy drinker or smoker, has suffered from any pulmonary, cardiac or renal disease, diabetes and the like, all these are points which should be known before the anæsthetic is administered. The surgeon who has charge of the case will usually be in a position to supply this necessary information, but, if not, the more important details can be ascertained by a few leading questions, and the heart and lungs can be examined. The latter precaution should not be neglected, for apart from the fact that it enables the anæsthetist to reassure the patient as to his fitness to take an anæsthetic, it also provides against

having to confess ignorance of the condition of the chest should an accident occur.

① Before beginning the administration of any anæsthetic it is advisable to ascertain how the patient breathes : he may have nasal or laryngeal obstruction, and it is a good plan, therefore, to make him take one or two deep breaths and to observe any such abnormality. It is, of course, obvious that should there be nasal obstruction, the mouth must be kept open during the operation ; should there be laryngeal obstruction, tracheotomy instruments must be close at hand.

② Inquiries should next be made as to artificial teeth, and if present they must be removed : they are a source of grave danger, the most dangerous kind being the small plate with one or two teeth which can easily fall back and obstruct the larynx.

Closely fitting teeth frequently cause trouble to the anæsthetist, if he has not taken the precaution of inserting a dental prop or the corner of a towel before starting the administration. Trouble may also arise with edentulous people from the lips falling in, but this is easily overcome by placing

the end of a fine towel in the mouth. This serves two purposes :—

1. It keeps the lips apart and allows air to enter freely.
2. It soaks up saliva and mucus.

Fear of the Anæsthetic.

Fear of an anæsthetic is a very real factor, and probably accounts for more deaths than is commonly supposed. There are many patients to whom the taking of an anæsthetic is a much dreaded ordeal ; they not only have a deeply rooted fear of it, but also are firmly convinced that they will die under it. It is with such patients that some of the fatalities of anæsthesia occur. It must be remembered that many people have sufficient self-control to enable them to outwardly conceal their fear. Therefore nothing must be done which might startle a patient, and if he is obviously frightened every effort should be made to reassure him. In every case, whether or no the patient be nervous, there should be absolute quiet in the room during the induction period. Talking,

moving about, opening and shutting of doors, preparation of instruments and lotions—all these should be forbidden until the patient is unconscious. It is sometimes wise to allow a nervous patient to hold the hand of a nurse or friend until anæsthesia is complete ; this may help to reassure him. But, with this possible exception it is most important that the patient should not be touched or addressed by any one but the administrator. It is only too common to find the doctor or nurse feeling the pulse, talking to the patient, raising and dropping the arm, and so on ; such interference should not be permitted. The reason for taking these precautions is that before consciousness is lost sounds and actions are perceived by the patient in a much magnified form—they tend to alarm him, and to interfere not only with a tranquil induction period, but also with the subsequent maintenance of good anæsthesia.

Preparation of the Patient.

Whenever an anæsthetic is to be given it is desirable that the patient should be properly pre-

pared beforehand. It may not always be possible to carry this out, but as careful an attention as occasion permits should be paid to the preparation.

For an ordinary operation, such as a radical cure of hernia or excision of glands in the neck, the best course is to give a purgative (Ol. Ricini \mathfrak{z} ss.) twenty-four hours before the time fixed for the operation, and if necessary a second dose twelve hours later. A soap and water enema may also be given with advantage a few hours beforehand. If the operation is to take place at 9 a.m., which is the best time for the purpose, no solid food must be given after the evening meal, and that should be a light one. A small cup of beef-tea at 6 a.m. is all that should be allowed, and this can usually be dispensed with. For operations later in the day—e.g. 1.30 p.m.—the patient may take a light breakfast at 7 a.m., and nothing more, except perhaps a cup of beef-tea or of milk and water (5 ounces of milk to 2 ounces of water) at 10 a.m. Patients prepared in this way are found to take the anæsthetic better, more safely, and with less unpleasant after effects than those who have not been so treated.

For some operations, such as those on the rectum, a more thorough preparation is necessary ; but this matter is in the surgeon's province, and need not be detailed here.

In every case care must be taken to keep the patient warm during the operation. For this purpose long woollen stockings and other warm clothing should always be employed in so far as the site of the operation permits. The table should be well warmed, and where there is no water-jacket for this purpose, hot water bottles can be utilized.

The temperature of the operating theatre must be kept up to 70° F., and in many cases considerably over this point : it is important that adequate ventilation be ensured as well as warmth of the atmosphere.

Apparatus.

In addition to the actual apparatus required for the administration of the anæsthetic, the anæsthetist should always have at hand :—

1. Two mouth-props (Fig. 1).
2. A Mason's gag—that pattern in which the

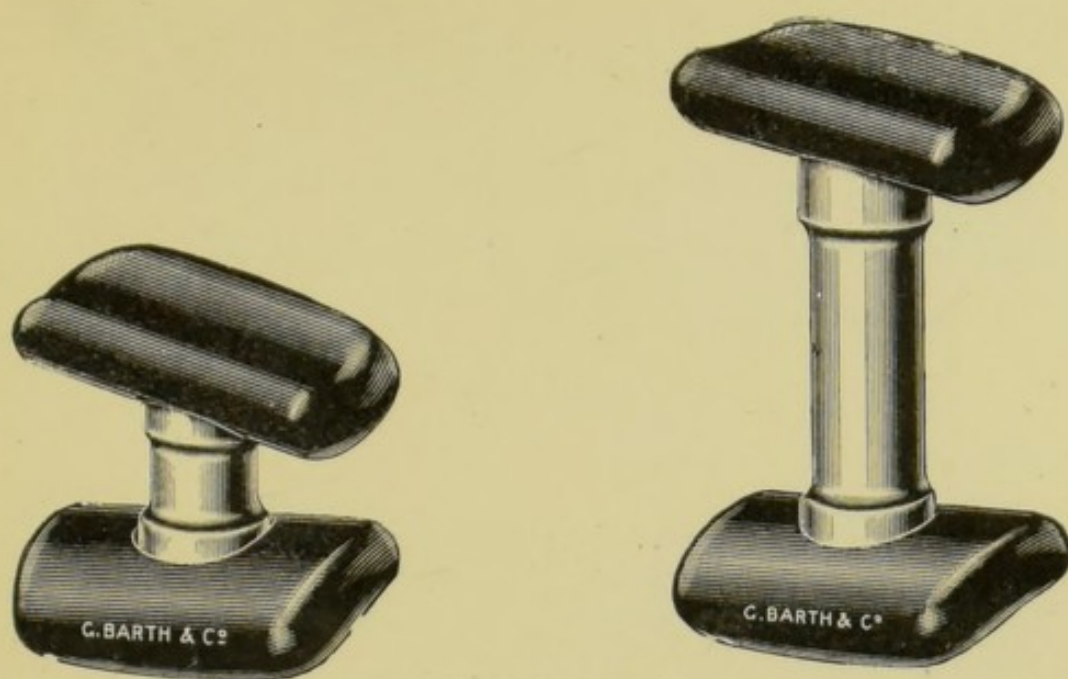


FIG. 1.—Mouth-props.

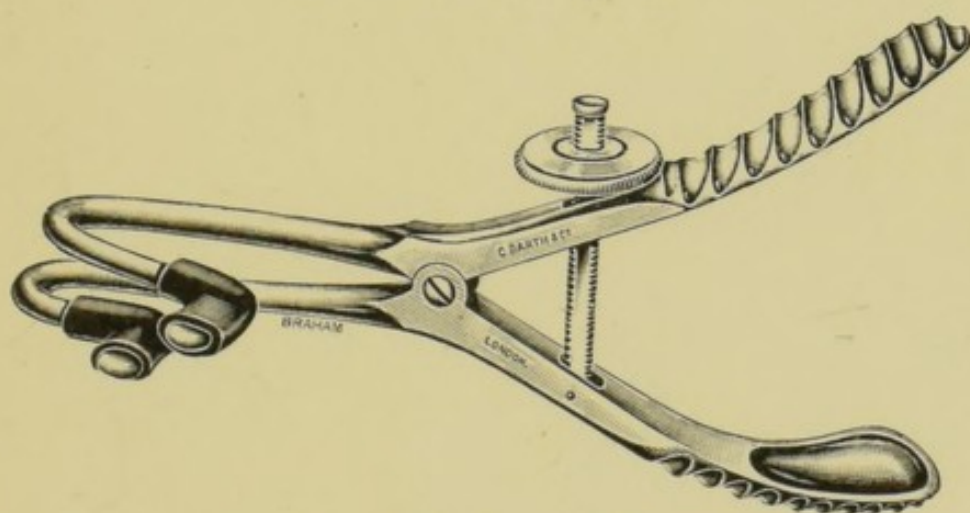


FIG. 2.—Mason's Gag.

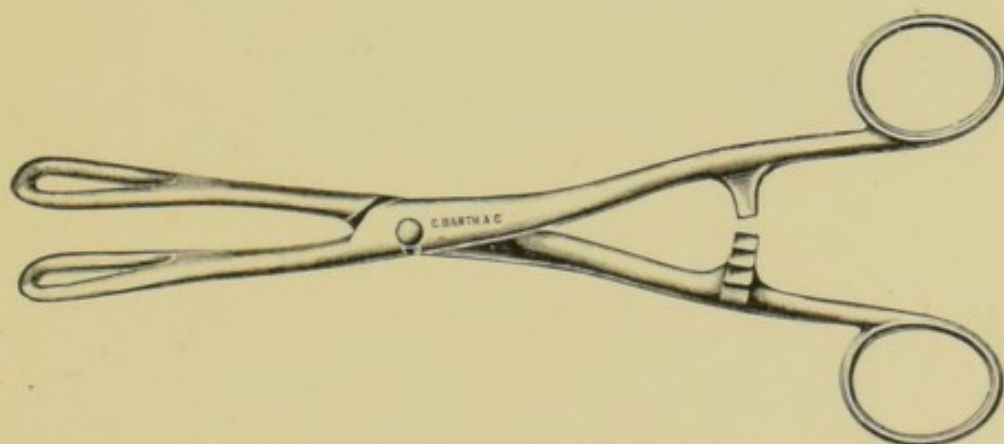


FIG. 3.—Tongue Forceps.

blades fall one behind the other when closed is the best, being the easiest to place in position (Fig. 2).

3. Tongue forceps (Fig. 3).

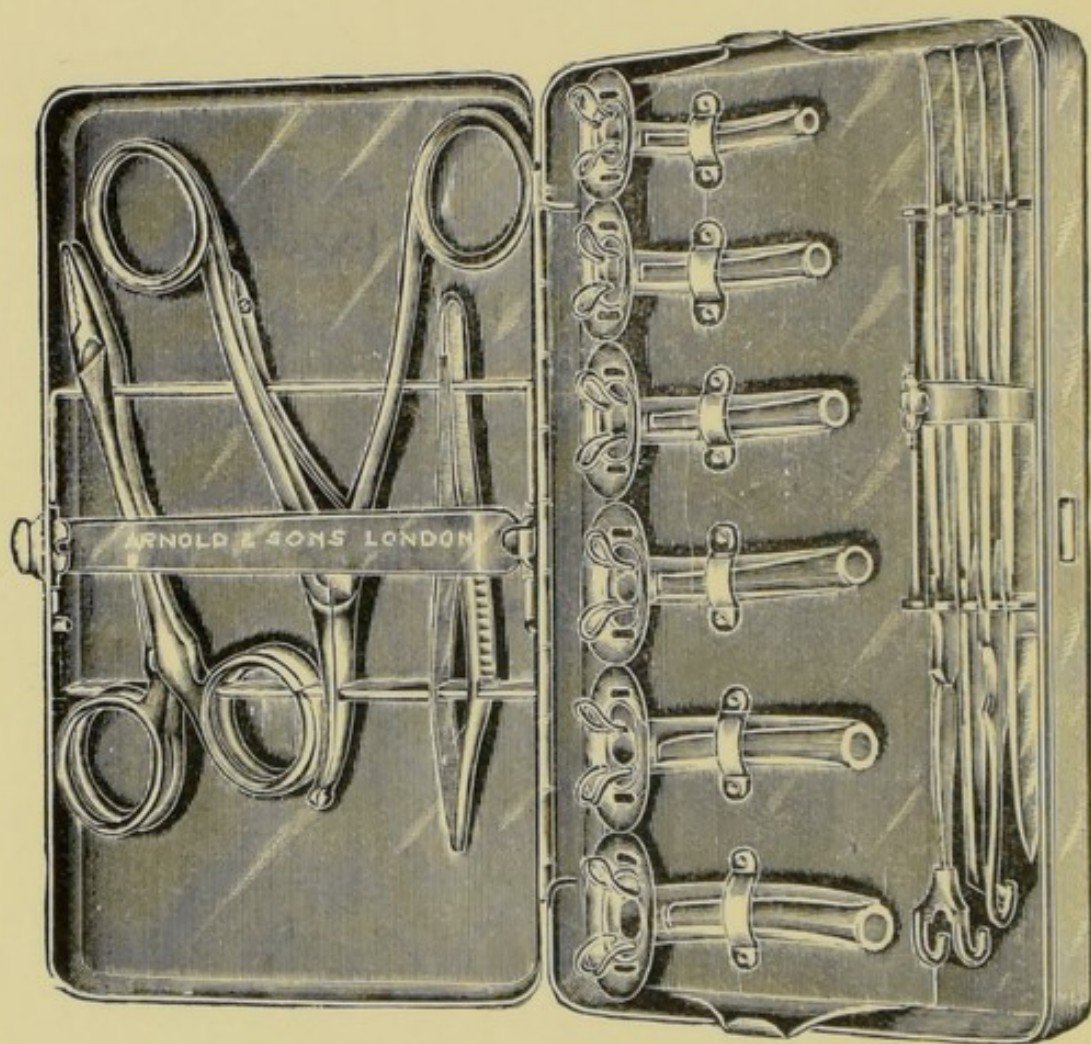


FIG. 4.—Tracheotomy Case.

4. A wooden wedge.

5. Hypodermic syringe, and a bottle of Liq. Strych. Hydrochlor.

6. Tracheotomy case (Fig. 4).
7. Two sponge holders, and some small marine sponges.

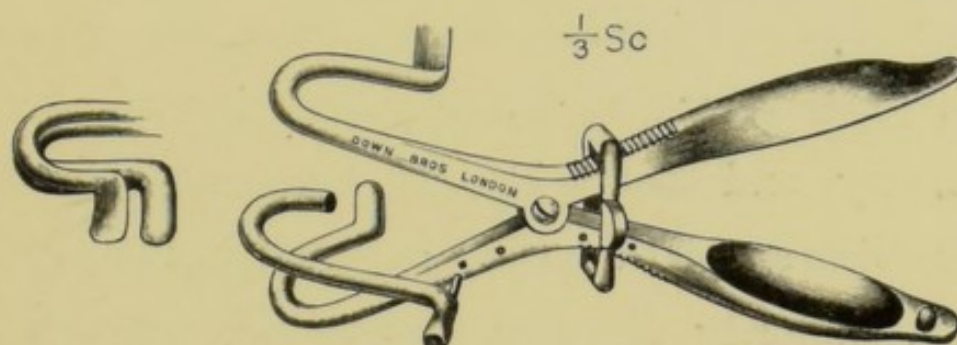


FIG. 5.—Mr. G. H. Colt's Gag.

This figure depicts a new gag made by Messrs. Down Bros. to the directions of Mr. G. H. Colt, late senior resident anaesthetist at St. Bartholomew's Hospital. The chief points claimed for this gag by Mr. Colt are as follows:—

1. It has been constructed on scientific lines, in that the various measurements have been carefully worked out from observations taken on 500 patients.
2. The weight of the gag is only $4\frac{1}{2}$ ounces, whilst the strength and rigidity have not been diminished.
3. The length is $6\frac{1}{4}$ inches, this being the maximum that permits the gag to be used for a child without the handles touching the pillow.
4. The tooth plates are of the overlapping variety, and are specially designed to prevent them from slipping when in position; moreover they are sufficiently short to be out of the surgeon's way in cases of tonsillotomy.
5. The anæsthetic tube can be easily placed in any desired position, and is made of malleable metal.

Position.

The position of the patient will be regulated in the main by the surgeon: the anæsthetist must learn to accommodate himself to the one chosen. The sitting position for dental, some intra-oral and nasal operations, the lateral, semiprone, prone, lithotomy and Trendelenburg positions—all these will receive special mention in subsequent chapters. In the majority of cases, the sitting position excepted, anæsthesia is induced with the patient in the dorsal decubitus, the required change being made subsequently. The patient should be allowed to lie as comfortably as possible and not forced into any strained attitude, but the pillow beneath the head should be a small one. In the case of ether administrations, it is well to direct the patient to turn the head to one side, preferably to the right: this makes the application and holding of the face-piece more easy, allows excess of saliva and mucus to run out of the mouth, or at least to collect in the cheek, and to some extent prevents the falling back of the jaw and tongue. Gas, gas and ether, gas and oxygen, or ethyl chloride

may be given in the sitting position. Chloroform, or any mixture containing chloroform, must never be used to induce or maintain anæsthesia while the patient is sitting; such a proceeding is highly dangerous. It may sometimes be necessary to raise up a patient who has been already anæsthetised. This is permissible, unless chloroform has been employed, but the recumbent position should always be resumed as speedily as possible.

The Moving of Anæsthetised Patients.

The anæsthetist may be called upon to give an anæsthetic to a patient lying in bed. He should never do so unless there are good reasons against placing the un-anæsthetised patient upon the operating table.

None of the difficulties that may arise in the course of the administration can be so promptly or efficiently dealt with as when the patient is on the table. The width of the bed, the flexibility of the mattress, and the rails at the head and foot, are all serious impediments to the anæsthetist when danger threatens.

When the induction has to be undertaken with the patient in bed, he should not be removed to the operating table before the stage of true anæsthesia has been reached. Such moving of patients, although it is a very general practice, is not to be recommended, particularly when chloroform is being employed. It carries with it a risk of syncope. If it has to be undertaken, it is better that the patient should be completely anæsthetised, and no departure from the horizontal position must be allowed.

After Treatment.

The duties of the anæsthetist do not end with the application of the dressings at the close of the operation. In hospital practice, it is true, a competent nurse takes charge of the patient when he has been removed from the table, but the anæsthetist should be prepared to give her any special warnings or instructions that may be required. In private practice, moreover, he should supervise the carrying of the patient to bed. The patient

should not be transferred to the stretcher until some signs of returning consciousness are manifested—presence of the corneal reflex, swallowing movements, etc. He should be lifted gently with as little alteration as possible from the horizontal position. The stretcher should be carried feet first if any steps or slope have to be ascended, so that the patient's head may never be suddenly raised. This is a most important item, neglect of which may lead to fatal syncope. The patient is placed in a bed previously well warmed, and containing hot water bottles carefully arranged. The head should not be raised, and in cases of collapse should be considerably lowered by placing blocks under the foot of the bed.

In all cases where the nature of the operation and the condition of the patient admit of it, he should be placed on his side. This causes a more rapid recovery from the anæsthetic, diminishes the tendency of the tongue and mandible to fall back, renders the action of vomiting more easy and less violent, and almost abolishes the danger of vomited matter entering the larynx. When for

any reason the lateral position cannot be employed, the patient's head should at all events be turned to one side. During the removal of the patient to bed the anæsthetist should take charge of the head, watch carefully the character of the respirations and for the onset of vomiting, and act accordingly. He should not leave the bedside until he is satisfied that, so far as the immediate effects of the anæsthetic are concerned, his patient is safe. The after-treatment of nitrous-oxide cases requires little mention : as a rule the patient recovers consciousness almost immediately, and feels no ill effects. He should be allowed to remain in the chair for five or ten minutes, and after resting quietly for a quarter of an hour may usually be allowed to get up or go home. In very rare instances the recovery from gas is much prolonged, and vomiting may occur.

The Vomiting that occurs after the use of other anæsthetics varies considerably in different cases. The varieties are due to several factors, among which the principal are ;—

1. The patient.
2. The anæsthetic employed.
3. The administration.
4. The preparation.

Some patients will vomit violently and for many hours after ether, chloroform, or A.C.E. mixture, in spite of the exercise of great care and skill on the part of the anæsthetist: others are found to have a particular idiosyncrasy to one of these drugs but not to the rest: others again never vomit, no matter what the anaesthetic, nor how long its administration. The last-mentioned individuals are for the most part alcoholics, or strong young men in good condition. After an administration of ether the patient usually vomits early—before he has completely recovered consciousness. The vomit consists of bile-stained fluid from the stomach, together with saliva and mucus that have been swallowed. Vomiting is more likely to occur after ether than after chloroform, but in the former case it is not usually prolonged. In fact the early vomiting that occurs before the patient has recovered consciousness may be the only manifesta-

tion of this sequela. Prolonged ether is more likely to cause vomiting than a short anæsthetic, more especially if the administration has not been skilfully managed and cyanosis has been allowed to occur.

Chloroform properly given is not so frequent a cause of vomiting as ether. The vomiting, moreover, begins later, but it may continue for many hours. This prolonged vomiting that occasionally follows chloroform anæsthesia is most distressing to the patient and extremely difficult to combat. The administration of ethyl chloride is not infrequently followed by vomiting, and this fact alone makes nitrous oxide a more suitable anæsthetic for dental and similar work.

The manner in which the patient has been previously prepared is a most important factor. Should food have been taken a few hours before the operation, and the rules for preparatory treatment neglected, copious vomiting is almost certain to follow. The different anæsthetics may be classified according to the relative frequency with which they are followed by vomiting.

Frequency of Vomiting.

The order is as follows :—

1. Ether.
2. Chloroform and mixtures containing chloroform.
3. Ethyl chloride.
4. Nitrous oxide (very rarely causing vomiting).

The prevention of vomiting is aimed at by attending to the proper preparation of the patient and by careful administration. The turning of the patient's head to one side, by allowing the mucus and saliva to run out, lessens the tendency to vomit which is induced by the swallowing of these secretions. Furthermore, a prolonged or badly given ether administration will cause much salivation, etc., and so increase the subsequent vomiting. In such a case as the last, however, the vomiting is of much benefit to the patient by clearing away the mucus from the air passages and the fluids from the stomach. The treatment of this sequela is usually confined to withholding food for about three hours, and giving small pieces of ice to suck or drachms of hot water to drink. The early vomiting that occurs, especially after ether, is

advantageous rather than otherwise and causes no distress, as it comes on before the patient has recovered consciousness. It is the persistent vomiting that requires treatment and is so difficult to check. Teaspoonfuls of very hot water will be found, as a rule, of more service than ice to suck. If a drink of several ounces of water is given, it will cause vomiting; the fluid should therefore be confined to sips under ordinary circumstances. If, however, vomiting continues unabated and becomes distressing, it is often a good plan to allow the patient to drink six or ten ounces of water. This will be returned in a few minutes, but may check the continuance of the vomiting, for it acts by washing out the stomach to some extent. It may occasionally be advisable to wash out the stomach thoroughly by passing an œsophageal tube, but it is better practice to make trial of the simpler, less disturbing and unpleasant method before proceeding to this remedy. Instead of giving plain water sodium bicarbonate (grs. xv. to the ounce) may be dissolved in it with advantage. Many other remedies have been and are employed, but cases

should be treated, broadly speaking, on the same lines that are followed for vomiting from other causes.

The administrator will find that as his skill and experience increase with practice, so will his cases of vomiting after the anæsthetic diminish. He should make it a rule to find out as far as possible what the sequelae of every anæsthetic have been: he will thus add a considerable store to his knowledge, and to his judgment in selecting the anæsthetic best suited for the case and for the occasion.

Shock and Collapse.

It is not proposed to discuss here at length the causes or varieties of shock which may occur during anæsthesia as the result of the operation.

It is well, however, to distinguish between two conditions, either of which may arise during or after the administration.

I shall apply the terms "shock" and "collapse" in referring to these different states.

Shock of some degree follows most injuries and

surgical procedures. It is not usually obvious, but is recorded on the temperature chart. The slight fall of temperature for the few hours following the operation and the subsequent reactionary rise above the normal, may be observed in nearly every uncomplicated case, even though there have been no other symptoms. The shock is to be regarded as reflex in origin, dependent upon, and directly proportional to, the injury sustained by the nervous system. The shock which accompanies cutaneous burns in children is of the same nature, and its degree is proportional to the area of cutaneous nerve distribution involved. We should expect that the use of anæsthetics would diminish the extent of operative shock: this is probably the case. Nevertheless, it would seem that when in a semi-anæsthetised condition the patient is even more susceptible to shock than when not anæsthetised at all. It is not remarkable that the reflex mechanism of shock should be more in evidence under these circumstances, but the fact has a most important bearing on the administration. It is a dangerous practice to permit the surgeon to make

his first incision before true surgical anæsthesia has been induced ; moreover, for certain operations such as cholecystectomy, nephrectomy, pylorotomy and the like, in which the great sympathetic plexuses are liable to be disturbed, a deep degree of anæsthesia is safer for the patient than a light one. If the patient is insufficiently under the influence of the anæsthetic, the shock consequent upon the first incision or subsequent manipulations may reflexly produce inhibition of the cardiac or respiratory mechanisms, or of both together. For certain operations a very light anæsthesia is required—operations on the thyroid gland come into this category. Even in these it is wise to induce anæsthesia in the ordinary manner, and to allow some relaxation of its depth as soon as the operation has begun. The risk of fatal shock at the first incision is thus obviated. At other times the patient's general condition, dyspnœa, or other embarrassment, forbids the induction of true surgical anæsthesia ; in such cases the risks of shock are far less grave than those of anæsthesia and are outweighed. It has already been pointed out that

an inconspicuous degree of shock is attendant on all surgical procedures and requires no special attention. Severe surgical shock, on the other hand, may produce a state of collapse. The shock may affect primarily either the respiratory or the circulatory system—more frequently the former: in severe cases both will be eventually implicated. The reflex mechanism alluded to above produces laryngeal spasm, which, if unrelieved, must terminate in failure of the respiratory centre, and secondarily of the circulatory mechanism also. The commencement of the operation before anæsthesia is complete may affect the circulation as well as the respiration. Though fortunately not so common, the result is more serious, namely cardiac arrest from reflex inhibition. The circulatory changes that may occur as the result of the administration of an anæsthetic are, with this exception, confined to the stage of deep anæsthesia. Furthermore, they are seldom, if ever, encountered except when chloroform is used.

Chloroform causes a fall in blood-pressure owing to its toxic effect upon and the consequent dila-

tation of, the vascular musculature. Physiological experiments have shown that circulatory disturbance can be produced by nerve stimulation. The first effect of stimulation of sensory nerves is usually one of vaso-constriction and rise of blood-pressure, but it is found that after a time the reverse effect is produced, the pressor fibres being more readily exhausted than the depressor. Moreover, the depressor fibres can be excited from the first by the use of mechanical and special stimuli.

Now in deep chloroform anæsthesia with its already low blood-pressure, a depressor effect will produce a far more marked result upon the general circulation than if the blood-pressure had been normal to begin with.

This is still further intensified by the toxic properties of chloroform, which hinder the heart from accommodating itself to sudden alterations in blood-pressure. A fall in blood-pressure may be produced either by paralysis of the vaso-constrictor centre from the direct action of chloroform upon it, or as a reflex depressor effect, due to surgical stimuli.

It follows from these facts that shock may be manifested during deep chloroform anæsthesia through circulatory disturbance—herein lies the main danger of chloroform overdose.

The condition of shock, if severe, leads to that of **Collapse**. In the latter the patient is pale, with small, frequent, perhaps imperceptible pulse. The extremities are cold, the pupils dilated, the eyelids half-closed. There is cold, clammy perspiration and shallow breathing.

Collapse is usually due to the serious nature of the operation, to loss of blood, or to the previously debilitated state of the patient, which renders him unfit to withstand the shock. It is not often a direct result of the anæsthetic; but it has been pointed out above that it may be consequent upon too light an anæsthesia, or upon a full dose—probably always an over-dose—of chloroform.

The treatment of severe surgical shock and collapse is as follows :—

1. The anæsthetic must be discontinued if this is still being administered.

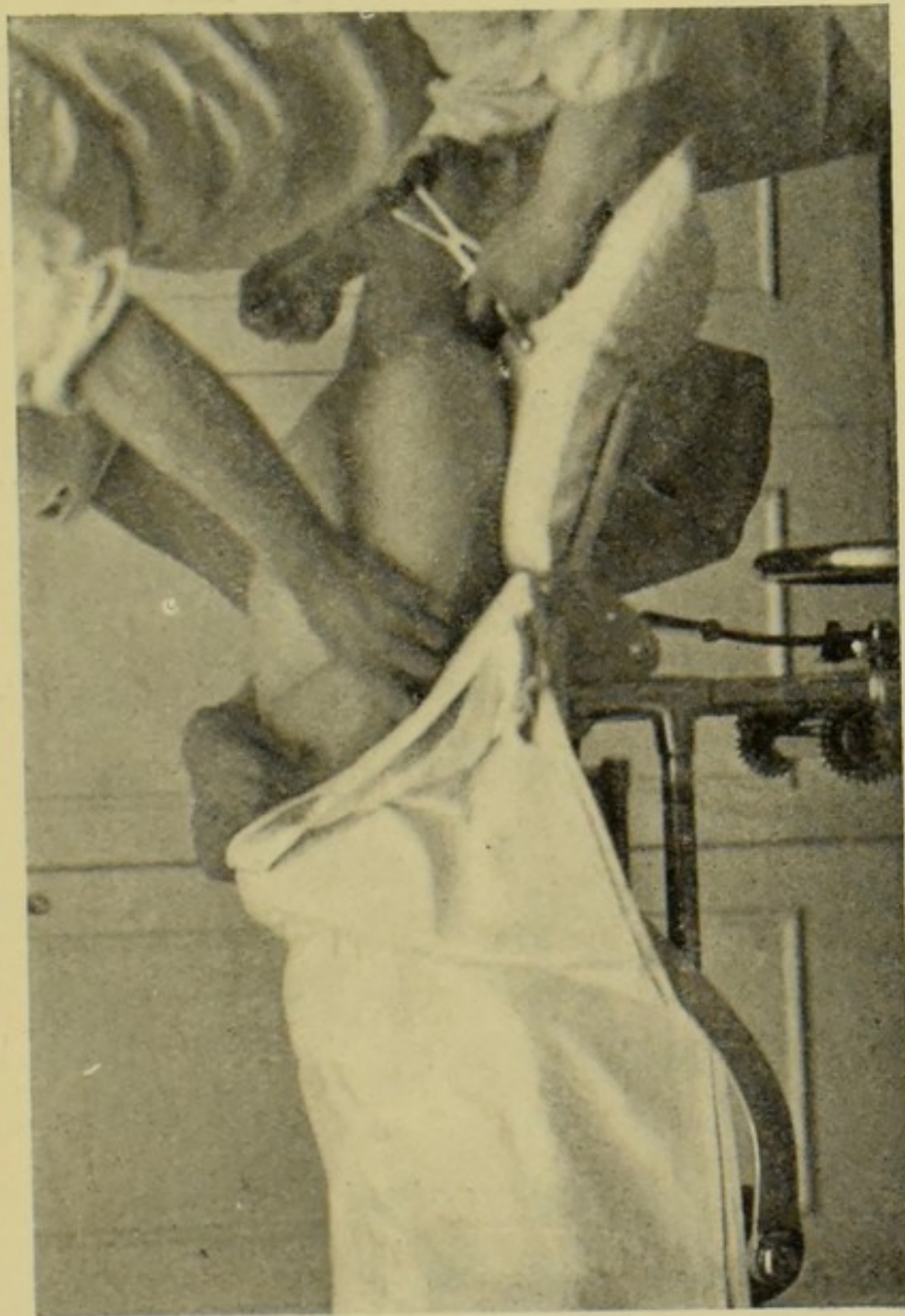


PLATE I.

Silvester's method of performing artificial respiration.
First Position—expiration.

2. The head must be lowered and the feet raised. Children may be held up by the feet. Paralysis of the respiratory centre, from anæmia secondary to circulatory failure, may be overcome by this means.
3. A hypodermic injection of strychnine (gr. $\frac{1}{32}$) should be given.
4. Brandy may be administered.
5. An injection of normal saline solution per rectum or intravenously is especially valuable in cases of collapse due to hæmorrhage.
6. Warm cloths should be applied to the abdomen, chest and head, and hot bottles to the feet.
7. Auto-transfusion, i.e. bandaging of the legs and arms from below upwards, may be employed.
8. Pituitary extract.

Artificial Respiration.

Silvester's Method.—When artificial respiration is necessary, the mouth must first be opened by a gag and the tongue drawn forwards by tongue forceps. The patient is then pulled up the table,

so that the head hangs over the end in a fully extended position.

The lower end of the table should at the same time be raised. The anæsthetist must hold the gag in position and continue to exert traction on the tongue, while an assistant or the surgeon performs artificial respiration. The person who undertakes this task stands behind the patient's head, and grasps the arms just above the elbows. He presses the arms firmly against the chest and continues the pressure for one or two seconds. He then lifts the arms and extends them fully beyond the head. After maintaining this position for about two seconds he again brings the arms to the sides and exerts pressure as before.

The extension of the arms causes air to enter the lungs by increasing the diameter of the chest: the pressure of the arms against the sides expels air from the lungs.

Artificial inspiration and expiration are thus effected, but the movements must not be hurried. They should not be repeated more than twelve or fourteen times a minute, otherwise sufficient time

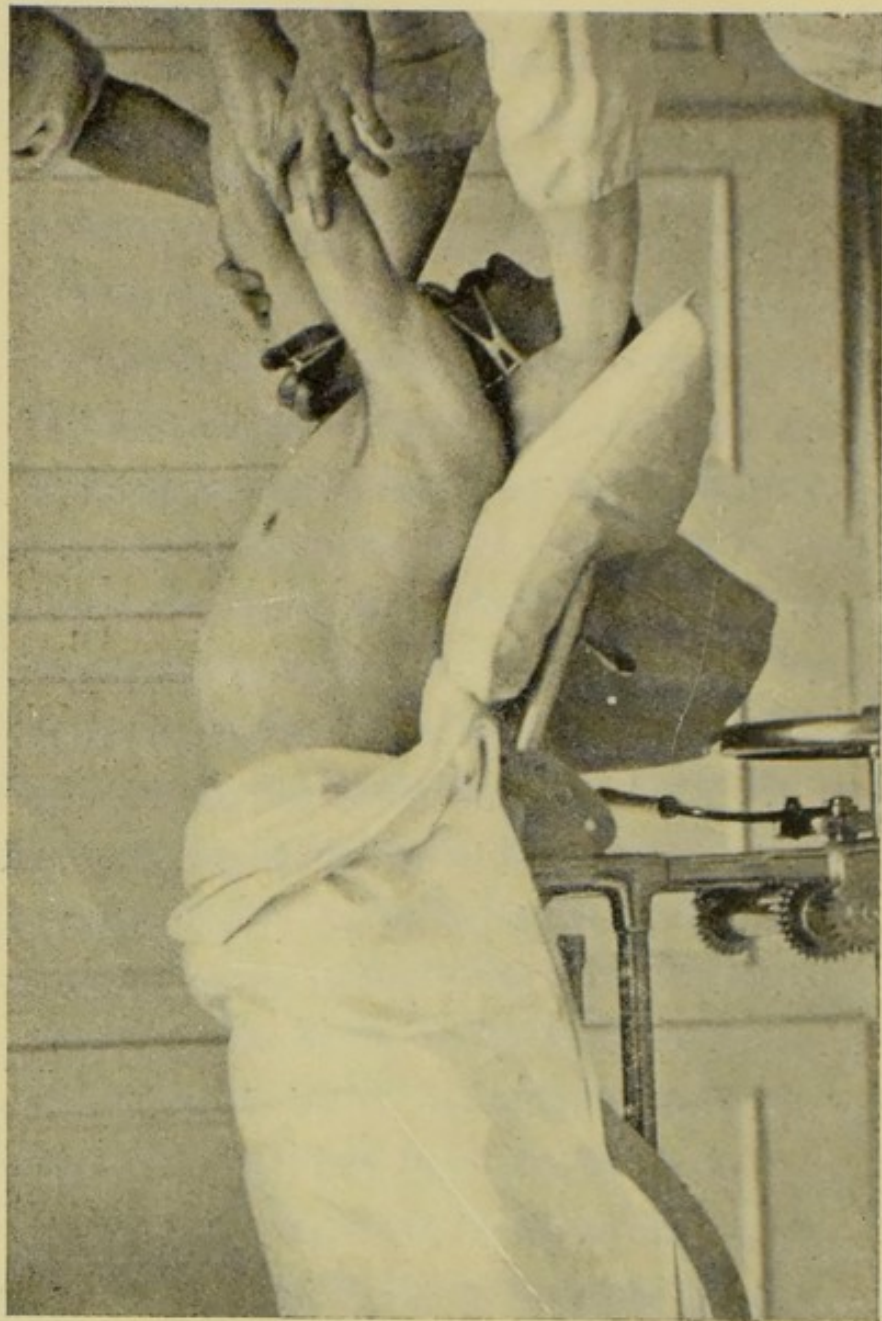


PLATE II.
Second Position—inspiration.

will not be given for the full entry and exit of air.

Other methods of performing artificial respiration are employed, but Silvester's is probably the most effective. Simple compression of the chest at intervals may, however, be found useful. It is performed by standing in front, or better still by kneeling on the table astride of the patient. The outstretched hands are placed on either side of the chest over the lower ribs and the costal arch, so that the two thumbs are over the xiphisternum. The chest is forcibly compressed for two seconds and then suddenly released. The pressure is applied about twelve times a minute.

This last method may be useful in certain cases of cerebral abscess. In such it may be necessary to continue artificial respiration while the surgeon is removing the cause of the respiratory failure by evacuating the abscess.

CHAPTER II

NITROUS OXIDE

Apparatus.

THE apparatus necessary for the administration of nitrous oxide consists of one or two cylinders, foot-key, stand, union, indiarubber tube, indiarubber bag, valved stop-cock and face piece. The accompanying illustration shows how these are connected together. The manufacturers supply gas compressed in cylinders of 25, 50 and 100 gallons capacity ; the small size, being more portable, is the most convenient for private practice, the large size is best suited for hospital work. It is always advisable to use two cylinders connected together by a double union, as shown in the illustration, in case one should fail. The indiarubber bag should have a capacity of about two gallons and is connected to the face-piece by the valved stop-cock. There are various patterns of stop-cock, the one illustrated

being simple and efficient. When the lever is in position A, the patient is breathing pure air through the aperture ; when the lever is moved to position

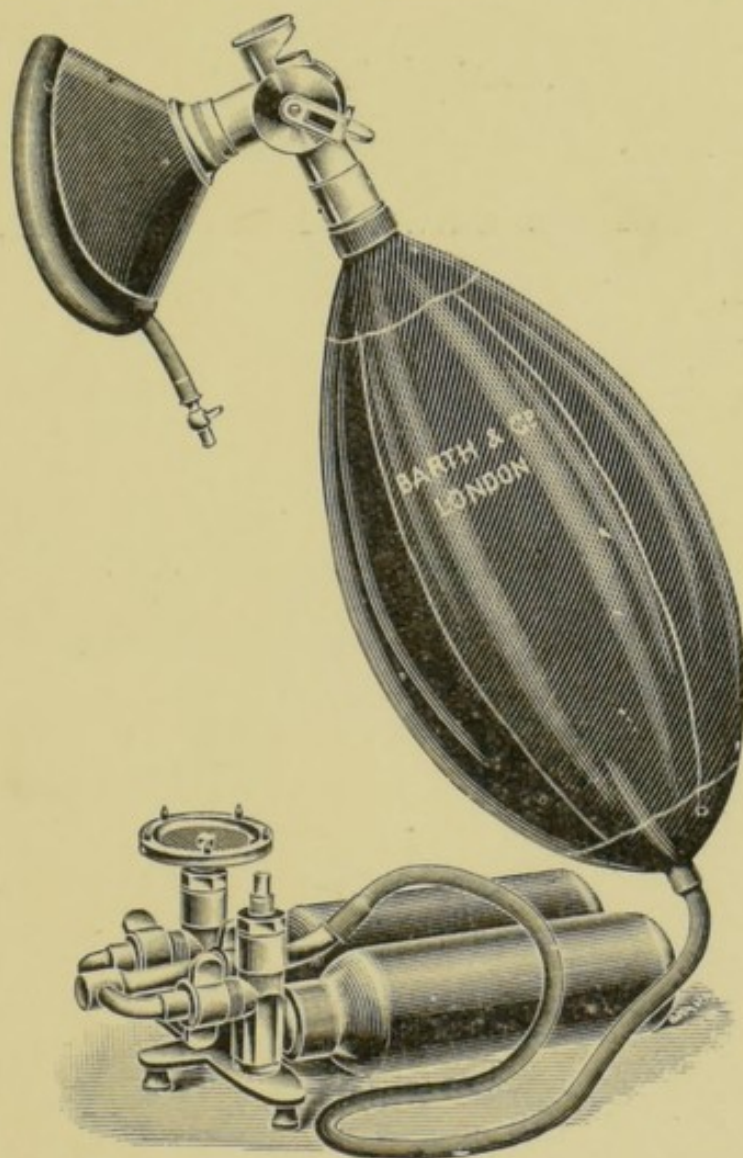


FIG. 6.—Apparatus for the administration of Nitrous Oxide

B, pure nitrous oxide is inhaled from the bag, and the expired gases pass out through the valve ; when the lever is moved over still further into position

C, the expiratory valve is cut out of action, and to and fro breathing, into and out of the bag, takes place.

Administration.

The methods of administering nitrous oxide vary somewhat with the nature of the operation to be performed.

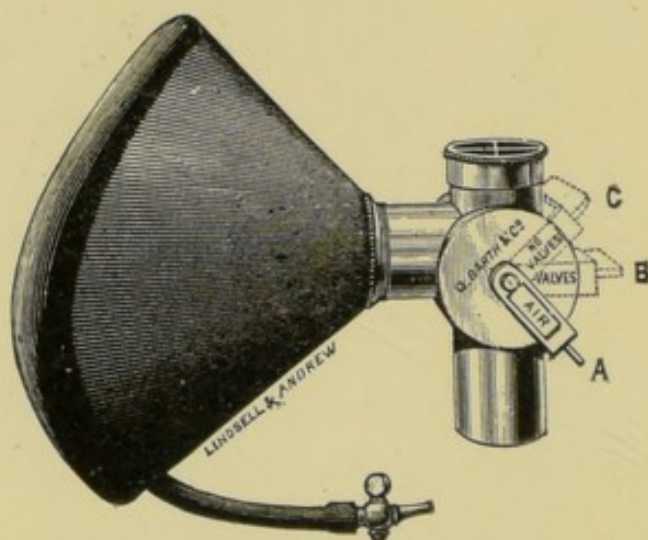


FIG. 7.—Stop-cock and face-piece of Nitrous Oxide Apparatus, showing the three positions of the lever.

The method to be employed for the extraction of teeth will be described first.

Dental Extractions.

The patient should be seated in the dental chair with the head resting comfortably against the

head-piece, that is to say, the head should be neither flexed nor extended unduly.

The patient's feet should not rest on the foot-piece of the chair, but should hang loosely on either side of it. The reason for this precaution is, that should opisthotonos occur with the feet on the foot-rest, there will be difficulty in preventing the patient from falling on to the floor ; this accident will not occur if the feet are hanging loosely, one on each side of the foot-piece. The clothing about the neck and waist having been loosened, the patient should be told to grasp the arm-rests.

The anæsthetist stands behind and to the left of the patient. Having first filled the bag about three-fourths full of gas, he inserts a dental prop, and then adjusts the face-piece, holding it in his left hand so that his little finger comes under the patient's chin.

Having once placed the face-piece in position, it must be kept there and not taken off or moved about to see if it fits ; such movement is particularly uncomfortable for the patient. When the face-piece is applied, the lever is in position A, and

the patient is allowed to take one or two breaths of pure air through the aperture ; the lever is then gently turned over into position B so that the patient is breathing in gas from the bag, and expiring through the valve. At the same time that the lever is moved, a gentle stream of gas is turned on from the cylinder, and care must be taken not to do this too suddenly, as a sudden rush of gas into the bag makes a noise which is very alarming to the patient. The patient is now inspiring gas and expiring into the air, and the anæsthetist must watch for and observe the various signs by which he knows that the state of anæsthesia has been attained.

The respirations are at first jerky and irregular, but soon become deep and regular, and after continuing so for some seconds become again of a jerky character. The first indication of this latter change is that instead of a regular, long expiration there comes a short sharp one followed by a similar inspiration. At almost the same time there is slight stertor. As soon as this has been observed the gas should be turned off from the cylinder, the

patient allowed to take two or three more breaths of gas, and the face-piece then removed, the lever being at the same time turned back to position A.

The patient is now ready, and the anæsthetist must steady the head for the operator ; the manner in which he does so will depend upon the tooth to be extracted, whether from the upper or the lower jaw. He must also be prepared to insert a gag should the surgeon wish to extract a second tooth from the side on which the prop is placed.

As soon as the operation is over, or better when consciousness is returning, the patient's head should be held slightly forward so that the blood can run out of the mouth. The prop should not be pulled away : it is a better plan to allow the patient to do this for himself, since frequently the sudden removal of the prop gives to the half-conscious patient the idea of a tooth being extracted, and causes him to cry out and to accuse the operator of having given him pain.

It may be necessary, as mentioned above, to insert a gag during the operation, especially if the prop slips or if the operator wishes to move it in

order to complete his work. In such a case a Mason's gag should be inserted quickly on the side opposite to that on which the operation is to be performed; in so doing care must be taken neither to break teeth nor to include a portion of the lip, both of which accidents have been known to occur and to lead to unpleasant consequences.

NITROUS OXIDE AND AIR.

The method of administering nitrous oxide gas for operations in which more time is required than for the extraction of teeth, is slightly different to that given above.

The patient is arranged comfortably, either sitting in a chair or lying on the operating table according to the wish of the surgeon.

The bag is first filled three-fourths full, the face-piece then accurately placed on the face, and the patient allowed to inspire gas and expire into the air as before.

As soon as the change from regular deep respiration and the slight stertor are noticed, the operation can be commenced. After two or three more

inspirations of gas the lever should be turned back to position A for a few seconds so that the patient gets two breaths of pure air: the lever is then turned over again to position B for three or four more inspirations of gas, and subsequently back again to position A to allow the breathing of more air. The exact proportions of air to gas will vary considerably with every case, and no absolute rule can be stated. This the anæsthetist must determine for himself, and practice will alone teach him to gauge it correctly. If too much gas is given, the patient becomes stertorous and cyanosed, and jactitates; if too little, anæsthesia is lost. The points to be aimed at are to keep the patient motionless and of a good colour; accordingly the instant that muscular twitchings begin, air must be given.

It is not really sufficient, however, to wait for the occurrence of cyanosis or jactitation before increasing the amount of air; the experienced anæsthetist will anticipate these events and maintain a quiet anæsthesia while keeping the patient's colour good throughout. The art of so doing can

only be learnt by practice, and until he has had a considerable experience of short cases the administrator will be well advised not to attempt to give a prolonged gas: he can hardly hope to do so successfully until he is absolutely conversant with all the phenomena which occur during a short administration.

The anæsthetist should never be guided by rules of time or of number of inspirations given. No two patients are quite alike, and what may be sufficient for one may be far too much or too little for another. The various phenomena must be observed as they arise, and as soon as the patient presents the condition of anæsthesia described above, the operation should be commenced.

With regard to other signs it may be noted that the conjunctival reflex is usually lost or at least much diminished. The corneal reflex, however, commonly remains. The eyeballs are usually fixed, but occasionally there is nystagmus; the pupils are, as a rule, dilated. These eye conditions, although interesting, need not be relied upon to furnish information as to the patient's condition,

for provided that the respiratory changes have occurred anæsthesia has been induced.

“To and Fro Breathing.”

There is yet a third method of administering nitrous oxide gas to which allusion must be made, although it will not be found so generally useful as the preceding.

The administration is begun as before, but when the second stage is reached, that is to say when the patient's breathing has become deep and regular, the lever is turned over into position C. The effect of this will be to cause the patient to expire into the bag as well as to inspire from it, so that the supply of gas from the cylinder must be turned off at the same time that the lever is altered, otherwise the bag will become over distended. It is clear that by adopting this method of procedure, the patient is made to inspire not only nitrous oxide but also carbonic acid, and that the proportion of this latter gas will progressively increase with the length of the administration.

This to and fro breathing, as it is called, may be

used in long as well as in short cases, that is to say it may be employed as a variation of the gas and air administration already described.

It is not, however, to be recommended, for it adds partial asphyxia to nitrous oxide anæsthesia. The chief if not the only advantage of the method seems to be that it economizes gas.

Summary of the Signs of Nitrous Oxide Anæsthesia.

From what has been said above it follows that the stages of anæsthesia induced by gas may be divided into three :—

In the *first* the breathing is irregular and still under voluntary control ; after a duration of about half a minute it passes into the second.

In the *second*, the breathing is regular and deep, the pupils become gradually dilated and the third stage is reached about one minute after the beginning of the administration.

In the *third* stage, there is slight stertor, the respirations become again jerky and irregular and the condition of anæsthesia has been reached.

We might describe even a fourth stage, i.e. the condition that would result from a continuance of the administration after anæsthesia has been produced. Jactitations would occur with increasing violence until opisthotonos with tonic contractions of all the respiratory muscles ensued ; there would be at the same time increasing cyanosis and all the signs of embarrassment of the right side of the heart ; in fact, death would eventually supervene with much the same train of symptoms as precede asphyxia.

Nasal Administration.

Gas may be given by means of a nose-piece (Paterson) or a catheter (Harvey Hilliard). By either of these methods the anæsthetic may be prolonged for a considerable time ; they are both of great value in cases where a longer anæsthesia is required for operations about the mouth than can be obtained by one administration of gas, or of gas and oxygen.

Paterson's apparatus consists of an aluminium mask suitably shaped to fit over the nose : the mask

is furnished with an air-pad similar to that on the ordinary face-piece. Leading from the mask are two rubber tubes which are connected with a stop-cock, nitrous-oxide bag and cylinders. The stop-cock differs only from the pattern already described in that it is not provided with an expiratory valve, but it retains the air-aperture which can be closed by the movement of the lever, and also the valve which prevents breathing into the bag.

In addition to this nose-piece there is an entirely separate mask to fit over the patient's mouth—this mask containing an expiratory valve. When the nose and mouth pieces are both in position the patient can inspire through the nose and expire from the mouth. The administration is conducted as follows. The patient is instructed to inspire through the nose and expire through the mouth ; a dental prop is then inserted between the teeth and the two masks placed in position after the patient has taken a few trial breaths in the manner indicated. Should nasal obstruction be present this method is obviously inapplicable.

As in ordinary gas administrations the anæsthet-

ist starts with the bag three-fourths full and with the stop-cock lever in position A. After one or two breaths the lever is turned over to position B, so that nitrous oxide is inspired from the bag and nose-piece, and expired by way of the mouth-piece. The remainder of the administration is conducted precisely on the lines laid down for nitrous oxide and air, the air being admitted when required by moving the stop-cock lever. It is frequently necessary to keep the bag rather over distended and so force the gas into the patient's nostrils.

When the patient is ready for the surgeon, the mouth-piece is removed but the nose-piece still held closely in position. The patient will continue to inspire the nitrous oxide air mixture through his nostrils, and to expire through his mouth. Indeed, it is with good patients often possible to dispense with the use of the mouth-piece altogether. By this method gas anæsthesia for dental and other intra-oral operations can be maintained for several minutes—for the same length of time, in fact, that the nitrous oxide and air mixture can be administered for operations in which the face-piece need not be removed.

For convenience of manipulation the stop-cock should be suspended by a hook from the back of the dental chair or from the anæsthetist's coat. When the operation is about to begin, and the mouth-piece has been removed, it is advisable to hold the nose-piece from above so that the forearm can aid in steadying the head. An assistant is of great service; indeed, should the insertion of a gag become necessary his presence cannot well be dispensed with. His duties should be to steady the patient's head for the operator, to hold the gag, sponge out the mouth, etc., leaving the anæsthetist free to manage the actual administration alone.

Trewby's Modification of Paterson's Apparatus.

Trewby's apparatus is shown in the accompanying illustration. It will be seen that the nose-piece and mouth-cover are connected together by the rubber tube D, and that both are fitted with expiratory valves, A and E.

At the upper part of the nose-piece is a projection (on which is situated the expiratory valve A); this

can be pushed forwards to B, and by so doing the entry of gas is cut off and an air slot is opened.

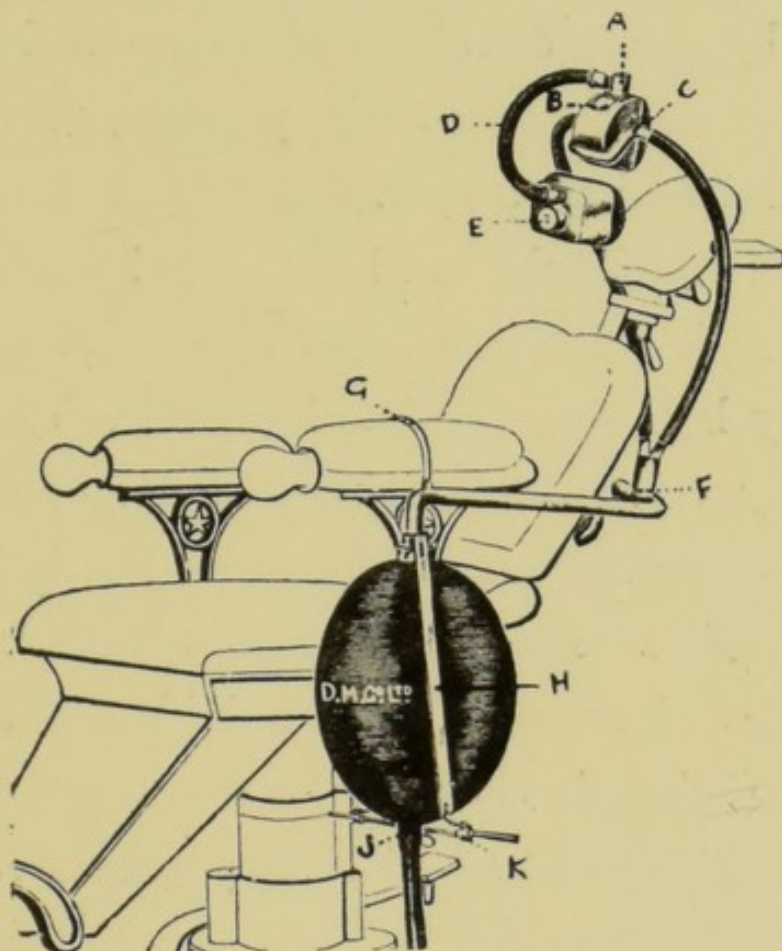


FIG. 8.—Trewby's apparatus for the administration of Nitrous Oxide.

When the patient has been anæsthetised, the tube D with the attached mouth-cover is swung to the left; this cuts off the gas to the mouth-cover at A, but does not interfere with the admission of gas to the nose-piece. The bag is hooked on to the arm of the chair at G, and a weight at F makes the nose-piece self-retaining. A regulator for the bag

is shown at H ; this consists of two bands of metal connected together by a ring above and by a spring below ; by means of this regulator gas is delivered at the nose-piece under slight pressure, even if the bag should be half empty.

A small metal tube can be attached to the nose-piece through which oxygen can be given if necessary.

Trewby lays stress on the importance of having expiratory valves in both nose and mouth-pieces in order to prevent to and fro breathing during the administration. His apparatus has the additional advantages of enabling the administrator to shut off gas and give air or oxygen at a moment's notice, and of supplying the gas at a gentle pressure.

Indications for Nitrous Oxide.

Nitrous oxide anæsthesia is suitable for the following cases :—

1. Dental extractions.
2. Minor operations such as opening of abscesses.
3. Any operations of short duration in which it is not essential that the patient should be absolutely still and his muscles relaxed.

Contra-indications.

1. Those cases (i.e. Angina Ludovici) in which there may be swelling or engorgement of the upper air passages.
2. Cases of advanced morbus cordis, especially mitral disease.
3. Rectal cases.
4. Cases in which complete muscular relaxation is required.

Difficulties and Dangers of Nitrous Oxide Administration.

The safety of nitrous oxide as an anæsthetic is vouched for by the fact that many thousands of administrations are conducted daily, while fatal cases are extremely rare. Indeed it has been stated by an eminent authority on the subject, that "death ought never to occur as a result of gas."

At the same time there are a few details worthy of consideration, the neglect of which may lead not only to difficulties, but even to death.

1. Obstruction to Respiration.

Any impediment to free breathing, such as enlarged tonsils and adenoid growths, laryngeal

stenosis, etc., introduces the risk of asphyxia. The entry of foreign matter (such as vomit, blood, pus, extracted teeth, etc.) into the larynx, causes the same danger.

When respiratory obstruction, from some such cause as one of these, has occurred, a condition of apnoea ensues. This usually passes off as soon as the obstruction has been removed, but the treatment should be preventive, i.e. due attention to any restrictions to breathing (such as tight clothing) and the avoidance of nitrous oxide in unsuitable cases.

Cessation of respiration will also occur if gas be administered for too long a time without the admixture of air, that is to say if the patient be unduly deprived of oxygen.

2. Cardiac Failure.

Cases have been reported in which cardiac failure has occurred under gas. The correct treatment is said to be artificial respiration, venesection and inversion of the patient. Such a fatality must be extremely rare, and will probably never occur unless some cardiac trouble pre-exists.

Nitrous oxide is not a good anæsthetic for patients suffering from mitral disease. It may be given if the lesion is fully compensated, but the recumbent position should always be insisted upon. If the disease is advanced so that the cardiac reserve-force is small, or is uncompensated so that the right side of the heart is already embarrassed, then the deprivation of oxygen which necessarily accompanies a nitrous oxide administration may be sufficient to produce a fatal result.

GAS AND OXYGEN.

Oxygen may be given with nitrous oxide gas by means of a special apparatus devised by Sir F. Hewitt.

Apparatus.

For a detailed description of this apparatus the reader is referred to Sir F. Hewitt's book, *Anæsthetics and their Administration*; it will here suffice to state that it consists of a double gas bag, and a special stop-cock, so arranged that, to the pure nitrous oxide inhaled by the patient a variable quantity of oxygen can be added by the anæsthetist as he requires it.

The amount of oxygen given is shown by an indicator and scale, marked from 1 to 10.

In skilled hands this anæsthetic is perhaps, within certain limits, the best at our disposal.

The patient can be kept quiet for several minutes, the operation performed under complete anæsthesia without any need for haste on the part of the surgeon, and the patient recovers consciousness almost immediately with, except in the rarest instances, no unpleasant after effects.

Furthermore, it is a safe anæsthetic and not unpleasant to the patient.

Administration.

The administration of nitrous oxide gas and oxygen is somewhat similar to that of nitrous oxide and air ; it is conducted as follows :—

The two bags are filled three parts full, the one with nitrous oxide, the other with oxygen : the face-piece is adjusted to the face and the patient allowed to breathe air gently through the aperture at the top. After one or two inspirations of air, to accustom the patient to the feel of the face-piece,

the lever is turned over so that inspiration is taking place from the gas bag and expiration into the air.

After the patient has taken three or four breaths of gas the lever is turned over slowly still further, until the indicator points first to 1, then 2, and then 3. Oxygen is thus mixed with the nitrous oxide inhaled, while expiration continues to take place through the valve into the air. The exact proportion of oxygen given varies very widely in different cases; it is determined by the patient's colour. The anæsthetist aims at keeping the patient from becoming cyanosed from the beginning to the end, but he must not err on the side of giving too much oxygen. Anæsthesia is usually induced in two or three minutes, and by that time the oxygen indicator will probably point to 4. It is best to keep the patient a little short of oxygen until anæsthesia has been well established, and to gradually increase the proportion as the administration proceeds. If well administered to a suitable patient it should never be necessary to increase suddenly the proportion of oxygen: in other words, the anæsthetist must anticipate events,

and increase or decrease the oxygen before marked cyanosis or over-oxygenation of the blood, if it may so be termed, have occurred. To accomplish this successfully requires considerable practice—experience alone can teach it. After the operation has been in progress for three or four minutes the indicator may point to 6 or 7, in fact as a general rule the longer the administration, the greater the proportion of oxygen that should be given. Rarely, however, will it be necessary to increase the oxygen beyond 7, even during operations lasting fifteen or twenty minutes, but in such long cases it may occasionally be beneficial to give a breath or two of pure air. It is also worthy of note that more oxygen will be required for children and weakly subjects than for healthy and robust individuals.

Signs of Anæsthesia.

The signs of anæsthesia are quiet, regular breathing—there should be no stertor—loss of conjunctival reflex, and slightly dilated pupils.

The corneal reflex, as in nitrous oxide anæsthesia, usually persists.

As soon as these signs are present the operation may be begun, and the administrator must then observe his patient very closely, in order to maintain the condition unchanged. The slightest approach to cyanosis, stertor or jactitation calls for more oxygen, but as already stated, the experienced administrator will seldom be compelled to suddenly alter his mixture. In most cases, indeed, as soon as the condition of anæsthesia has been reached, it will be found that with a little care the proper amount of oxygen can be determined which will suffice for the greater part of the operation.

The most common error made by the beginner is to give an excess of oxygen, with the result that the patient recovers consciousness and becomes excited. To recapitulate what has been said above, the administrator's success depends upon his power to foresee what the effect of his administration at one moment will be some moments later. *same
time*

Indications for Gas and Oxygen.

1. Dental extractions.
2. Minor operations in which relaxation of all

the muscles is not essential, surgical dressings, etc.

3. Patients who have a marked antipathy to ether and chloroform.
4. Certain cases in which ether and chloroform are contra-indicated.
5. It is particularly suitable for such short operations as the removal of fibro-adenomata of the breast.

Contra-indications.

Gas and oxygen is not suitable to :—

1. Alcoholic subjects.
2. Strong muscular men.
3. Rectal and vaginal operations or examinations.
4. Abdominal surgery.
5. Any operation in which there will be much subsequent pain.
6. Examinations under an anæsthetic in which complete muscular relaxation is required.

After Effects.

The absence of unpleasant effects following the administration of this anæsthetic is one of the

strongest arguments in favour of its use. Consciousness is not restored quite so quickly as after nitrous oxide alone, but this is probably attributable to the fact that the administration is usually more prolonged. Vomiting does occasionally occur, and rarely momentary hysterical excitement ; these events are both more likely to supervene when an excess of oxygen has been given at the close of the operation to restore the patient to consciousness.

Difficulties and Dangers.

Gas and oxygen is probably the safest anæsthetic known ; no fatalities caused by it have been reported up to the present time, although many thousands of administrations have been carried out. It is true that this anæsthetic has not been indiscriminately used by the inexperienced man, but has remained almost entirely in the hands of the expert : nevertheless, the dangers may be said to be practically non-existent, though the successful administration presents some difficulty. The careful selection of suitable cases is almost as important as the possession of the requisite skill. For instance,

an attempt to give gas and oxygen to an alcoholic subject for a rectal or vesical operation would almost certainly end in failure. It is evident that the addition of oxygen removes the dangers, slight though they may be, which accompany nitrous oxide anæsthesia. Thus gas and oxygen may be safely given in many of those cases in which nitrous oxide alone is contra-indicated owing to the risks consequent upon deprivation of oxygen.

CHAPTER III

ETHER

Properties.

PURE ether ($C_4H_{10}O$) is a highly volatile, inflammable, colourless liquid. It is neutral to litmus paper, and has a specific gravity between $\cdot 720$ and $\cdot 722$. The vapour density is rather more than double that of air. The vapour has a pungent odour; it is highly inflammable and, when mixed with air, explodes on contact with a flame.

The following preparations of ether are made :—

1. **Æther B.P.** (prepared from ethylic alcohol)
—suitable for local anæsthesia only.
2. **Methylated Ether** (prepared from methylated spirit)—suitable for local anæsthesia only.
3. **Æther Purificatus B.P.** (prepared from ethylic alcohol)—suitable for general anæsthesia.

4. Rectified Ether (prepared from methylated spirit and purified)—suitable for general anæsthesia

There is little to choose between the two latter preparations—some anæsthetists prefer the official drug, others the rectified ether. The latter is probably quite as good as the former if carefully prepared. Unpurified ether must never be used as a general anæsthetic. To prevent decomposition ether should be kept in the dark, in a cool place, and in tightly stoppered bottles. Owing to its highly inflammable nature it must never be used in the neighbourhood of a flame or even of a cautery.

Administration.

When ether is used as an anæsthetic it is usually given in conjunction with nitrous oxide, but occasionally, either because gas is not at hand or for some other reason, anæsthesia is induced by ether alone. The following are the methods by which this may be done:—

- 1. The Open Method**—i.e., ether given on some form of mask covered with gauze or other suitable material.

2. The Closed Method—by means of a Clover's inhaler.

In addition to these ether has been administered in conjunction with oxygen, and rectal etherisation has been resorted to. We will not, however, concern ourselves with either of these performances.

The Open Method.

The open method of administering ether has been in vogue in America for many years, and many anæsthetists in this country are now strongly urging its claims.

The anæsthesia obtained by this method is quiet, the breathing is deeper than with chloroform, but not so deep as with ether administered by the closed method. The colour remains good ; there should be no cyanosis.

There is not the same depressing effect on the blood pressure as with chloroform ; after the anæsthetic the patient soon recovers consciousness, and sickness is neither so frequent nor so severe as after some of the other methods.

Some writers have advocated giving morphia $\frac{1}{6}$ gr. and atropine $\frac{1}{120}$ gr. hypodermically, from 30 to 45 minutes before the anæsthetic.

This practice has much in its favour, for it is found that patients to whom this injection has been given require less ether to maintain anæsthesia, whilst the secretion of mucus is lessened and the tendency to after sickness considerably diminished.

Method of Administration.

A piece of thin rubber sheeting about 2 inches by 7 inches is placed over the patient's eyes : the tissue should be slightly moistened with water before it is applied, and it will then form a mask to protect the eyes from the ether. An oval pad of gauze is then placed over the face, and the Schimmelbusch mask, covered with about sixteen layers of gauze, is placed on the pad.

The patient should now be told to breathe quietly through the nose and mouth, and at the same time a few drops of ether are allowed to fall on to the mask. The amount of ether is gradually increased

until there is an almost constant stream of drops falling on to the gauze. The anæsthetist must be careful during this stage to see that the patient does not try to breathe deeply, for should this be permitted struggling is almost certain to occur.

With a little care the anæsthetist can keep the patient breathing quietly; quite gradually the breathing will deepen, become more and more regular until **automatic respiration** ensues, and with it true anæsthesia.

The continuance of the anæsthesia is now fairly easy, if the breathing, colour and pulse are observed. As the eyes are covered, but little help can be obtained from them, but as a rule a well-marked corneal reflex obtains throughout the anæsthesia. Anæsthesia having been induced, small quantities of ether are now given at frequent intervals, and the administrator will find that as his skill increases, so will the amount of ether required decrease.

It is hardly necessary to add that as with other anæsthetics attention must, of course, be paid to

keeping the air-way patent, any obstruction to which must at once be remedied.

In abdominal work it is often possible to keep the patient quiet and relaxed with but little ether so



FIG. 9.—Jackson's Drop Bottle.

long as the intestines are being manipulated, but if the mesentery is pulled upon, or the parietal peritoneum handled, more ether must be given and a deeper anæsthesia obtained. It is well to increase

the amount of ether just before the sewing up of the abdominal wall commences, for although a "light" anæsthesia will sometimes answer for intestinal anastomosis, it will not as a rule suffice for the closing of the abdominal wall.

The form of drop bottle employed is immaterial ; the one known as "Jackson's" and made by Mayer & Meltzer is of a convenient size and pattern.

The advantages of ether by the open method are :—

1. Safety.—Many thousand open ether administrations have been given in America and elsewhere, and the death-rate *at the time of operation* is said to be almost negligible. What the actual death-rate is *after* the operation is very difficult to ascertain, but that there is a definite percentage of deaths, due to lung affections following the administration of open ether, must, I think, be admitted. Accurate information on this point is very difficult to obtain.

2. Cleanliness.—From this point of view the apparatus required for open ether is certainly in

advance of that for any closed method yet advocated.

3. The Easy Method of Administration, combined with the safety at the time of the operation, makes this method the most suitable for those men who are not skilled anæsthetists, but who are occasionally called upon to give an anæsthetic ; for this reason it is a method that I should strongly recommend to the general practitioner.

Disadvantages of Ether by the Open Method.

1. The risk of producing subsequent lung troubles.

2. The amount of ether requisite for anæsthesia. This is at times large, and for a long operation several ounces will be necessary.

3. The amount of ether vapour that pervades the operating theatre. This can and does become a real trouble, for not only does the patient inhale

large quantities of ether, but so too do the surgeon and anæsthetist.

4. Open ether is not suitable to alcoholics or bronchitic people. The former are very difficult to anæsthetise, and the latter are liable to lung complications after the operation.

The Closed Method.

The best apparatus for this is a Clover's inhaler or some modification of it. A description and illustration of this inhaler is given below.¹ The apparatus is employed for ether alone in the following manner. A face-piece of suitable size is attached to the inhaler, an ounce and a half or two ounces of ether poured into the chamber, and the stopper securely replaced. In very cold weather it is sometimes advisable to previously warm the chamber by filling it with hot water for a few moments : the vaporization of the ether is thus hastened.

The chamber having been partially filled with

¹ *Vide Gas and Ether, p. 74.*

ether, and the indicator placed at 0, it is well to blow through the face-piece in order to expel any ether fumes that may be in the central cylinder. The bag is then fixed in position with the tap closed. The patient's head being turned to one side, the face-piece is adjusted at the end of an inspiration, the indicator still remaining at 0, so that the bag becomes partially filled by the expired breath. The face-piece may be slightly raised at the end of the first expiration, and replaced again so that the bag becomes filled still further by the second expiration. After the third or fourth breath the ether is turned on very slowly, so that the indicator is at first not more than one-eighth of the distance between 0 and 1. By degrees the patient becomes accustomed to the vapour, and the amount of ether is increased. If any coughing, straining, or holding the breath occur, the ether must be turned back at once to 0, and gradually increased again from the beginning. In this way the ether should be increased in quantity till the indicator reaches 2; it may be kept at this point, provided there is no coughing or straining,

until the patient is anæsthetised. It must be borne in mind that until the administrator has obtained a fair amount of skill in the use of this method a slight degree of cyanosis will occur during the time that anæsthesia is being induced by this method ; the admission of air in any quantity before the patient has become anæsthetised will almost certainly lead to excitement and struggling. At the same time, should the stage of induction be prolonged and cyanosis become marked, the face-piece must be occasionally raised to allow of the inspiration of air.

As soon as the condition of anæsthesia has been produced, one breath of air to every four of ether vapour should be given ; this will suffice to maintain perfect anæsthesia without cyanosis. The amount of ether necessary for a continuance of this condition will vary in different cases. As a rule, it is not necessary to keep the indicator at any point beyond $1\frac{1}{2}$, indeed 1 is almost always sufficient.

There should be no cyanosis, and with this in view it is better to increase the quantity of ether

given, rather than to decrease the allowance of air.

During the early stages of the administration the respirations become increased both in rate and amplitude until they become deep, regular and noisy. It is, above all, by observing the character of the respirations that the anæsthetist learns his patient's condition and regulates his actions.

The Stages of Ether Anæsthesia.

The following stages may be described as occurring during the administration of ether :—

1. **The Stage of Confusion of Ideas.**—Sensations of tingling, numbness, tinnitus, light, etc., occur; movements of the eyeballs and swallowing are noticeable.

2. **The Stage of Excitement.**—Partial loss of consciousness supervenes, that is to say, the patient's actions are not under his own control. Struggling and shouting may occur, especially in alcoholic subjects, and forcible restraint tends to increase rather than to diminish these. The respira-

tions become deeper, more noisy and irregular. Spasm may occur during this stage.

3. The Stage of Anæsthesia.—The signs are :

- (a) Deep, regular, automatic and stertorous breathing.
- (b) Insensitive corneæ.
- (c) Pupils of medium size, active to light
- (d) Pulse increased from the normal both in volume and frequency.
- (e). Colour heightened, but not dusky.

The initial sensations are due to the stimulating action of the drug upon the higher centres : the imagination is excited for the moment, but the centres being unequally stimulated, incoherence results. The ideas which are present at the time the administration begins become exaggerated ; hence the importance of not alarming the patient in any way (Chapter I, p. 6). After a few moments the stimulation of the higher centres changes to depression, but the lower centres (motor, cardiac and respiratory) become in their turn stimulated, and struggling may occur. Finally the motor centres also become depressed, and anæsthesia

is reached. These three stages overlap considerably, and there are no abrupt boundary lines between them.

The Signs of an Over-dose of Ether are :—

1. Failing respiration ; the breathing becomes more and more feeble, the expiration prolonged and wheezy, the inspiration short and jerky.
2. Dilated pupils.
3. Dusky colour.
4. Half-closed eyelids.
5. Failing pulse ; it should be noted that the pulse remains of moderately good volume in spite of the over-dose : in other words, the circulation is not affected coincidently with the respiration—a very important fact, since a slight over-dose, if recognized early, and dealt with promptly, can always be remedied.

Ether Rash.

Attention has been called by Dr. Edgar Willett to a roseolous rash which occasionally appears just

after anæsthesia is complete. It is most common in young patients, especially women, and usually covers the neck and arms, but sometimes extends to the abdomen and thighs. It passes off after a few minutes, and is of no significance.

Ether Tremor.

A tonic muscular spasm sometimes occurs in strong young men during ether administration. It comes on in the second stage, taking the place of the clonic contractions which are more commonly met with ; it may, however, take place during complete anæsthesia.

GAS AND ETHER.

The Apparatus necessary for the administration of nitrous oxide and ether is shown in the accompanying illustration (Fig. 10). It consists of :—

1. A Clover's portable ether inhaler with T piece attachment and bag.
2. Face-piece. (Two or three different sizes should be included in the outfit.)
3. Two cylinders (25 gallons) of nitrous oxide,

four feet of rubber tubing, stand and foot key.

4. Ten ounces of ether.
5. Measure for filling the inhaler. It is convenient to have this with a larger spout than that usually supplied, to prevent spilling ether when refilling the inhaler in the course of an operation.

In addition to the above, the anæsthetist should have at hand the instruments mentioned in Chapter I.

Clover's Portable Inhaler.

To understand the mechanism of the inhaler it is essential to take it to pieces—which can be done by detaching the bag and unscrewing the ring at the top of the chamber—and then study it with the help of a verbal or written description. It consists of a spherical ether chamber, through the centre of which passes a hollow shaft open at either end. The wall of this shaft contains a recess on one side, and two openings on the other; both the recess and the openings occupy a little less than half the circumference of the shaft. The openings

communicate directly with the ether reservoir, the recess does not.

Fitting into the shaft is a tube which is kept in position by the screw ring at the top, and on to which fits the T piece of the bag above, and the face-piece below. The tube is free to revolve in the shaft, and carries an indicator, which points to the scale marked upon the exterior of the ether chamber. The tube is open at either end, but closed by a partition near its middle, and two apertures are cut in the side of the tube, so that the one communicates with the upper, the other with the lower half of the tube. The apertures in the tube and shaft are so arranged that when the parts of the apparatus are connected together, and the indicator is at 0, air can pass from the bag into the upper part of the tube, and by way of the recess in the shaft into the lower part of the tube and out at the face-piece.

When, however, the ether reservoir is rotated on the tube so that the indicator points to 1, the apertures in the shaft coincide mainly with the recess, but partly also with the apertures in the shaft leading to the ether chamber. As the reser-

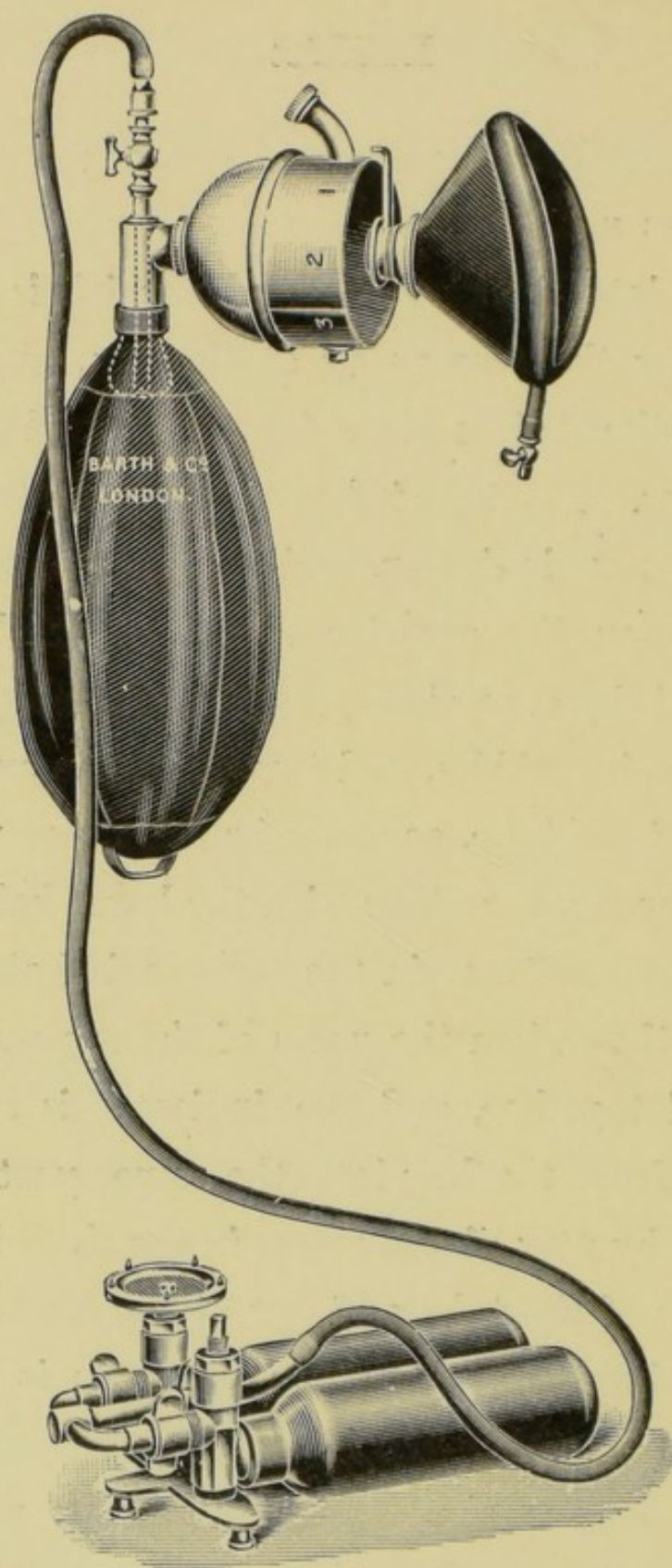


FIG. 10.—Clover's portable Ether Inhaler, with small bag, gas cylinder and tubing complete.

voir is rotated further, a greater portion of the openings into the reservoir, and a smaller portion of the recess in the shaft, come to coincide with the apertures in the tube ; till when the indicator points to F. (full), the recess is entirely cut off, and all the air from the bag reaches the face-piece by way of the ether chamber.

The lower half of the ether reservoir is surrounded by a closed chamber containing water ; the function of this jacket is to prevent the reservoir from becoming too cold from the evaporation of the ether. As already mentioned, it is sometimes a good plan to warm this water by filling the reservoir with hot water for a few moments before use.

In addition, there is an opening into the ether reservoir through which it can be filled, and which is closed by a vulcanite stopper.

The metal T piece directly connects the interior of the bag with that of the central tube ; it contains also a horizontally placed tube of small bore, projecting well into the bag at one end, and here guarded by a wire cage ; the other end opens into the air and is closed by a tap.

This arrangement is devised so that the apparatus can be used for gas or ethyl chloride in conjunction with ether, or for ethyl chloride alone: its utility will become more apparent when the administration of ethyl chloride is described.

Hewitt's Ether Inhaler.

A very good modification of Clover's portable inhaler has been devised by Sir F. Hewitt. The essential features are the same, but the bore of the central tube is much larger, and the regulation of the ether vapour is effected by a lever which takes the place of the indicator, and not by rotating the reservoir. The T piece is also modified so that air can be admitted through an aperture at the top, and an expiratory valve is fitted, which can be put in or out of action at will. Although somewhat more complicated than Clover's inhaler, it possesses several obvious advantages.

Method of Holding the Inhaler.

The Clover's inhaler is held in position by grasping the face-piece with the right hand so that the little finger comes under the chin to support the jaw, and

the thumb, index, middle and ring fingers rest on the mask in the manner shown in the illustration. The metal portion of the inhaler—i.e. the ether reservoir—rests upon the dorsal surface of the hand. When it is required to admit air the face-piece is tilted so that the upper or nasal portion is raised, while the lower portion, which rests upon the chin, is kept in position between the ring and little fingers. The anæsthetist's left hand is free to press forward the lower jaw from behind the angle, with the index and middle fingers.

The air-pad of the face-piece should be neither over nor under distended. By opening the tap, allowing the air-pad to fill at the pressure of the atmosphere, and then closing the tap, the correct tension will be obtained.

The face-piece should fit accurately, and air should not be allowed to get in or out at the sides, for much of the success in administering gas and ether depends upon this close fitting of the face-piece.

If the patient should have a beard it will be found to be an excellent plan to smear the pad of the face-piece with vaseline before starting the ad-

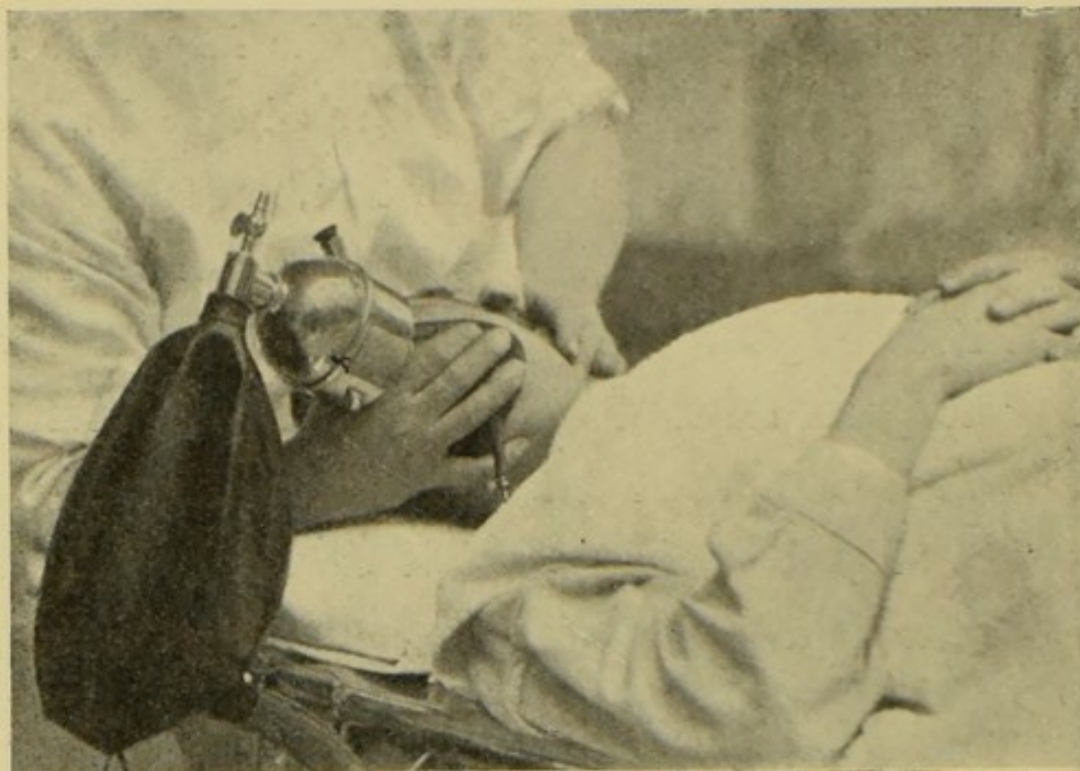


PLATE III.

Method of holding Clover's portable Ether inhaler, showing the correct position for the patient's head and the administrator's hands.

ministration : otherwise it is difficult to prevent the entrance and escape of air under the pad.

With patients who have nasal obstruction, narrow highly arched palate or closely-fitting teeth, it is advisable to place a dental prop in position before beginning the administration. For edentulous patients either a prop or the corner of a towel should be inserted into the mouth.

The Administration.

The actual method used matters little, provided that the administrator knows and understands it. Different methods are employed by different anæsthetists—one is to induce anæsthesia first by gas in the manner described in Chapter II, and when the patient is deeply under to remove the gas apparatus and substitute a Clover's inhaler : another is to utilize the Clover's inhaler from the beginning. The latter is the method that I prefer and shall describe first.

Administration with Clover's Portable Inhaler and Small-Bag.

As soon as the patient is ready, the apparatus is

fitted up and an ounce and a half of ether poured into the reservoir. The gas is then turned on from the cylinder, care being taken to see that the tap on the T piece is open, and that the indicator points to 0. The bag will only become partly filled since gas will escape through the face-piece, taking with it any fumes of ether that may be in the central tube of the inhaler. Having run a little gas through the apparatus and turned the patient's head to one side, the face-piece is lightly applied. For the first two breaths the face-piece should not actually rest upon the face, but the patient should be allowed to breathe a mixture of gas and air. The face-piece is then gradually allowed to come into contact with the face, until it fits it closely; it must never be forced heavily against the face, but should be held so that it fits accurately without pressure. This gradual application of the face-piece is more pleasant for the patient than a sudden one; the latter is apt to impress him with the sense of suffocation. When the patient is breathing freely to and fro into the bag, it is quite easy, by gently raising the face-piece at the end of inspiration, to allow

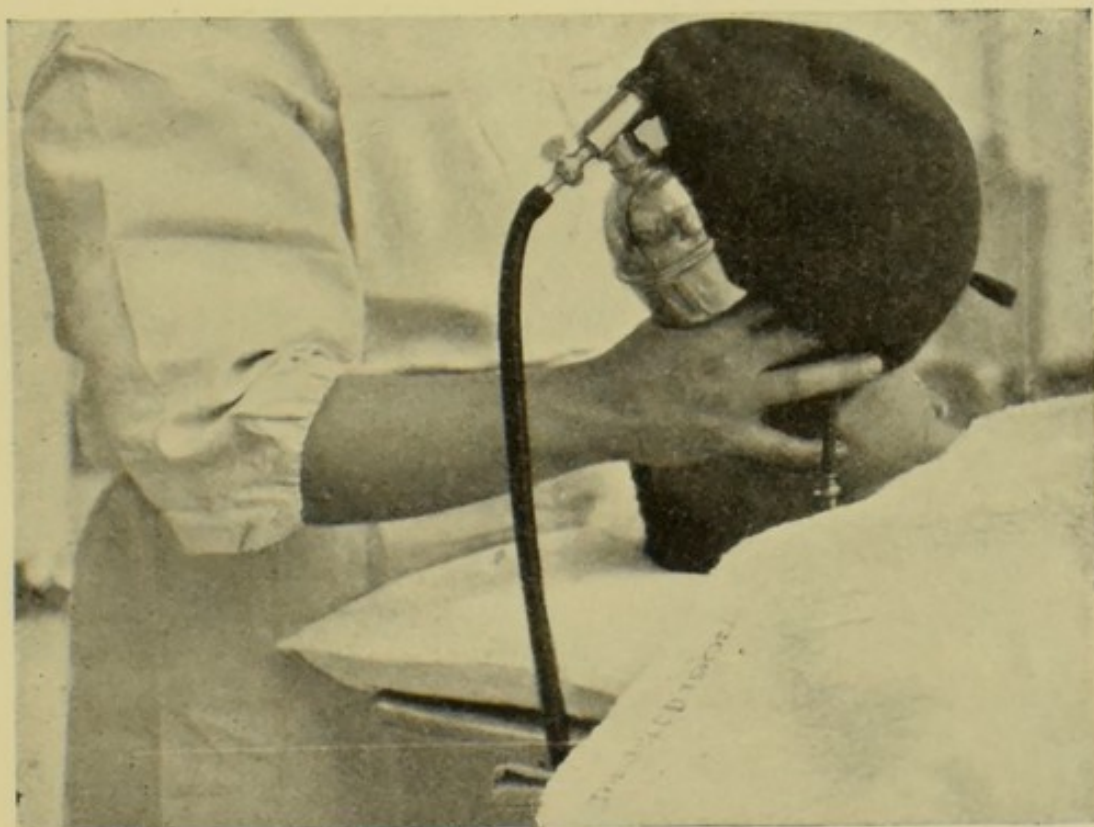


PLATE IV.

Gas and Ether administration with Clover's portable inhaler
and small bag.

expiration to take place into the air and to refill the bag with gas as it is required. This should be done at every expiration for the first six or seven breaths; after that only occasionally—once every four breaths. As soon as the breathing becomes deep and regular the ether is gradually turned on, the reservoir being first rotated a quarter of the distance between 0 and 1, after four more inspirations a similar distance further, and so on until the indicator points to 1.

The nitrous oxide is then turned off at the cylinder, the tap on the T piece closed, and the tubing removed. The amount of ether is still gradually increased until the indicator is about midway between 1 and 2.

It is scarcely ever necessary to give more ether than this; indeed in the majority of cases 1, or even less than 1, will prove quite sufficient.

As soon as this point has been reached, the patient should be ready for the surgeon; but if there is any holding of the breath or undue cyanosis a little air must be given—one or two breaths will suffice. It must be borne in mind, that if too

much air is given, or if air is given too early, the patient will almost invariably struggle, and the initial stage of excitement will be considerably prolonged. On the one hand struggling, on the other cyanosis have to be avoided ; hence it is important to get the patient under the influence of ether as rapidly as is consistent with his safety and comfort. If, however, the ether is turned on too soon, or increased too rapidly, it will cause coughing, straining and holding of the breath ; this will necessitate a temporary reduction in the amount of ether given, and the time required for inducing anæsthesia will be prolonged instead of shortened.

If any coughing or straining occur, the routine practice should always be to turn the ether back to 0, and slowly increase it again from the beginning. Furthermore, if ether is turned on rapidly instead of by the graduated method described, even after the patient has become completely anæsthetised by nitrous oxide, it is almost inevitable that the secretion of much mucus in the mouth, larynx and trachea, will be thereby evoked, and that this will cause trouble both immediately

to the anæsthetist, and subsequently to the patient also. When the anæsthetic is skilfully given, there is a smooth, steady and uneventful transference from nitrous oxide to ether anæsthesia, but considerable practice is required before this ideal can be realized.

When the patient has been anæsthetised with ether in this manner, the administration is continued by giving one breath of air to every four of ether vapour, reducing the quantity of ether as far as the requirements of the case will allow.

It will usually be necessary to keep the ether at 1 for the first few minutes; subsequently it can often be kept below this point. The bag should be kept about three-fourths full and the face-piece must fit closely but lightly. If the bag is too empty it can be readily filled by raising the face-piece after an expiration, and replacing it before the next expiration begins: if the bag is too full the reverse procedure will remedy it, namely raising the face-piece after an inspiration and replacing it before the next. In addition to the management of the inhaler and the regulation of the

amount of ether vapour given, attention must be directed towards keeping the air passages open.

This must be effected by preventing the jaw and tongue from falling back. The mandible should be pressed forwards with the fingers behind the angle, pressure being directed from that point towards the symphysis.

The mouth must not be shut by pulling up the mandible against the upper jaw, but the tongue prevented from falling back, and the air way kept patent, by exerting pressure in the manner described. Nearly all the difficulties that arise in the course of gas and ether administrations are attributable to obstruction of some kind; hence the importance of keeping the air way clear; there is little cause for fear if air is passing freely into and out of the lungs.

The Signs and Stages of Anæsthesia, of over-dose, etc., are similar to those already detailed in connexion with the administration of ether alone. (Chapter III, pp. 71, 72.)

In continuing the administration of ether it must not be forgotten that the reservoir will require

replenishing after about fifteen minutes. An ounce and a half of ether—the amount held by the measure—will usually be found to last for fifteen minutes or a little more. If it is desired to continue with ether for longer than this, the measure should be filled from the bottle with one hand, while the other retains the inhaler in position. The stopper should then be removed from the ether reservoir, the inhaler lifted off the face, and the fresh ether poured in. The stopper is then replaced and the face-piece adjusted again. It is not advisable to attempt to refill the reservoir with the apparatus in position; if this is done, ether may be spilled over the patient's face, especially as an expiration will tend to blow the fluid out of the aperture in the reservoir, unless the indicator be at 0. There is no disadvantage in removing the face-piece for this purpose, as it can be accomplished in a very few moments.

During the administration the aperture in the reservoir should always be on the upper rather than the lower aspect; there is no difficulty in arranging this, even if it is desired to change the

position of the patient, since the reservoir can be rotated from right to left or from left to right with the same result.

It should be borne in mind that after refilling the reservoir a greater surface of ether becomes exposed to the circulating air; hence, to maintain the same strength of ether vapour as before, the amount, as shown by the indicator, should be slightly reduced.

Administration with Clover's Portable Inhaler and Large Nitrous Oxide Bag.

Some anæsthetists prefer to use the nitrous oxide bag and valved stop-cock in conjunction with Clover's inhaler for the induction of anæsthesia by gas and ether.

Although the actual technique differs in small details in the practice of different anæsthetists, there are only two distinct methods to be distinguished.

In either case the large nitrous oxide bag with valved stop-cock is fitted to the Clover's inhaler in place of the small bag. The ether reservoir is partially filled with an ounce and a half of ether

as before, and arranged so that the indicator points to 0.

In the first of the two methods the patient is anæsthetised with nitrous oxide alone, in the manner described in Chapter II—no ether being administered until signs of anæsthesia are produced. In other words, the bag being filled three-fourths full of gas, and the face-piece adjusted, the stop-cock lever is turned over from position A to position B, so that nitrous oxide is being inspired, and expiration is taking place through the valve.

As soon as anæsthesia has been thus induced, the ether vapour is admitted by rotating the reservoir, the stop-cock lever being at the same time turned over to position C, so that the expiratory valve is put out of action. The gas, which has up to this point been flowing into the bag, is now turned off at the cylinder. The amount of ether vapour admitted should be increased fairly rapidly, so that after a few seconds the indicator points to 2. As soon as the anæsthesia of nitrous oxide has changed to that of ether, the large gas bag should

be changed for the small Clover's bag. The proportion of ether given can be subsequently decreased gradually, the same method of procedure being adopted as already described in connexion with the administration by the small bag alone.

In the second method no attempt is made to anæsthetise the patient with gas before admitting the ether, but the latter is turned on as soon as the breathing becomes deep and regular, that is to say, when the taste of ether will not be noticeable to the patient. When the ether vapour is admitted, or shortly before this, the stop-cock is turned over to position C, so that to and fro breathing, into and out of the bag, takes place.

The remainder of the administration is conducted in the manner already described, the small bag being substituted for the large one as soon as ether anæsthesia has been induced. If the large nitrous oxide bag is to be used the latter method is to be preferred—it is the one most commonly made use of. The administration will then be very similar to that with the small bag alone, but, for my own part, I believe the use of the large

nitrous oxide bag to be unnecessary, to have no special advantages, and to be more complicated and difficult, besides requiring more apparatus for its application.

The method of inducing anæsthesia by nitrous oxide alone, and then substituting ether, is sometimes carried out by employing a separate gas apparatus and Ormsby's inhaler, instead of in the manner described. Whatever apparatus be employed, little can be said in favour of the method. The smooth and steady induction of anæsthesia can seldom be brought about; jactitation, spasm and cyanosis are certain to be frequent concomitants.

After Effects of Ether.

When discussing the advantages and disadvantages of an anæsthetic, it must be remembered that there is a period after the operation to be considered, as well as the time of the operation itself.

Now although ether is a safer anæsthetic than chloroform as regards immediate risk at the time

of administration, it carries with it some disadvantages. It has been shown beyond doubt that ether pneumonia does occur, and though this is not very common, it is not at all rare for patients to suffer from bronchitis for some days after a long ether administration.

After an ordinary straightforward ether anæsthesia, the patient usually vomits once or twice, the vomit consisting of mucus and bile-stained fluid. Even when no more vomiting than this occurs, the taste and smell of ether remain for many hours and continue to distress the patient. Any one who has been anæsthetised with ether will appreciate this discomfort.

Maniacal excitement occasionally occurs after ether. I know of a case in which ether was administered to a young man of twenty for scraping a tuberculous ulcer of the hand: the operation lasted fifteen minutes. For several hours afterwards the patient was maniacal and had to be restrained by attendants.

In young and excitable individuals hysterical fits are sometimes met with; hæmoptysis, hæma-

temesis, and even cerebral hæmorrhage, are said to have occurred. (*See also* Chap. I, pp. 16–21.)

Advantages of Ether.

The induction of anæsthesia by means of gas and ether stands out pre-eminently before all others for the following reasons :—

1. It is the *safest* method of inducing anæsthesia for major operations that we at present possess.
2. Unconsciousness is rapidly produced, and if the anæsthetic is properly given, there should be few, if any unpleasant sensations during its administration.

For these two reasons alone, gas and ether ought to be the routine method of inducing anæsthesia for the majority of surgical procedures. There are occasions on which gas and ether is unsuitable: these will be dealt with later.

Whilst gas and ether is undoubtedly the best method for *inducing* anæsthesia, it is not the best for *maintaining* it. I feel convinced that the teaching of Mr. Richard Gill at St. Bartholomew's Hospital is correct. It is briefly this. Ether

should not be continued for longer than a half to three-quarters of an hour ; after that period the anæsthetic should be changed to chloroform.

In practice the routine that I follow is, to induce anæsthesia by means of gas and ether, to continue the ether for about fifteen or twenty minutes, and then make use of chloroform, or of some mixture containing chloroform, until the end of the operation.

This method of procedure has much in its favour. Anæsthesia is rapidly induced and quietly maintained ; the salivation and secretion of mucus that usually accompany a long ether administration are avoided ; the risk of subsequent bronchitis and pneumonia is practically abolished ; the after discomforts mentioned above are much diminished ; the greater safety of inducing anæsthesia by ether rather than by chloroform is still maintained. These facts will be further referred to in a subsequent chapter.

Indications.

Gas and ether should always be used to *induce* anæsthesia except in such cases as the following :—

Contra-indications.

1. Bronchitis, emphysema, etc.
2. Phthisis.
3. Empyema thoracis.
4. Dyspnœa, Angina Ludovici, etc.
5. Albuminuria and diabetes.
6. Intra-cranial operations.
7. Ophthalmic operations.

It is not suitable for *maintaining* anæsthesia during—

1. Abdominal operations and examinations, since muscular relaxation is not so complete as with chloroform, and the increased respiratory movements inconvenience the surgeon.
2. Operations on the jaws, tongue, mouth, etc.
3. Operations in which congestion and bleeding will interfere with the performance of the operation.

The Cleaning of the Apparatus.

After an administration the face-piece should be carefully washed with soap and water, then with 1 in 40 carbolic, and again with water.

The bag should likewise be washed with water, subsequently in carbolic and again in water.

The ether chamber should be boiled.

All tongue forceps, gags, props, etc., should always be boiled, and treated just as though they were instruments to be used for an operation.

Difficulties and Dangers.

The difficulties and dangers that may be met with during an administration of ether are of either cardiac or respiratory origin. Generally speaking, depression and failure of the heart do not occur with ether except as effects secondary to respiratory embarrassment.

Respiratory failure during anæsthesia may be due to :—

1. Mechanical obstruction.
2. Paralysis of the respiratory centre.

The former can and should always be under the control of the anæsthetist. Due attention to the patency of the air way, to the secretion of mucus and saliva, and to the patient's colour will prevent any interference with the respiration from becom-

ing a real danger. Failure of respiration of central origin—if indeed it ever occurs with ether—never does so unless a large over-dose has been administered. As a rule, whenever respiration fails under ether, the pulse remains of good quality sufficiently long to allow of restorative measures being successfully employed.

If artificial respiration is not performed, cardiac failure will ensue, but this must be a very uncommon event since ample warning of the danger is given.

CHAPTER IV

CHLOROFORM

Properties.

CHLOROFORM is a colourless volatile liquid having the chemical formula CHCl_3 . The official preparation is mixed with ethylic alcohol so that the specific gravity is between 1.490 and 1.495. The addition of alcohol prevents, in some measure, decomposition of the liquid. The density of chloroform vapour is about four times that of air ; it has a penetrating sweetish odour, and is not inflammable. Chloroform may be prepared from ethylic alcohol, methylated alcohol, or acetone. It is stated by some observers that these different varieties of the drug produce precisely similar effects. The majority of anæsthetists, however, prefer to employ ethylic chloroform and believe it to be the safest preparation. This opinion is substantiated by experiments. Some animals are extremely susceptible to chloro-

form and are readily poisoned by the inhalation of its vapour. A far greater percentage die under the administration of methylated chloroform than under that of ethylic chloroform, although the same care is exercised in each case. Chloroform should be kept in the dark and in firmly stoppered bottles—it is decomposed by a strong light.

The following tests are useful in practice :—

Pure chloroform—

1. Is colourless.
2. Is neutral to litmus paper.
3. Evaporates without residue.
4. Has a sweet, penetrating but not irritating vapour.
5. Has a specific gravity of 1·490–1·495.

Apparatus and Administration.

Chloroform should never be given from any form of closed inhaler, but always with a free admixture of air : any method of administration, therefore, that does not conform with this must be entirely avoided.

It is not proposed to describe here the various forms of chloroform inhalers that are in existence,

nor yet to discuss their merits and demerits; suffice it to say, that the best known of these inhalers—the Vernon-Harcourt—is most ingeniously devised so that the anæsthetist may know the



FIG. 11.—Mill's Chloroform Drop-bottle.

exact percentage of chloroform vapour that is being inhaled by the patient.

The only method of administration that I shall attempt to describe, is that of giving chloroform by a graduated series of “drops.”

All the apparatus required is a drop bottle—that

known as Mills' pattern is perhaps the best—and a piece of thick lint about 12 inches by 5. The lint is folded down across its long axis, to make a double thickness about 6 inches by 5; it is then further creased lengthwise, and held at the meeting point of the two folds, so as to form a sort of cone.

Induction of Anæsthesia.

The lint is held over the patient's face, which at first it should not actually touch. After the first few minutes the lint is allowed to rest gently on the face, but is not closely applied, air being allowed to enter freely under the edges. The chloroform bottle is held in the right or, to speak more correctly, in the disengaged hand. By inverting the bottle and at the same time shaking it once, a certain amount of chloroform is poured out on to the lint. This amount is spoken of as a "drop" and will be so referred to in the following pages. Two "drops" are given by shaking the bottle over the lint twice, and so on, twenty drops being actually equivalent to about 1 drachm.

As soon as a drop of chloroform has been shaken on to the lint the latter is quickly turned over and the moistened surface held about two inches from the patient's face. As already mentioned, the lint may after a few minutes be allowed to rest lightly on the face, and by using the same hand both to shake the bottle and also to turn the lint, the other is left free to hold the jaw forward or perform any other duty that may be necessary. Some practice is necessary for the acquirement of the manual dexterity to accomplish this neatly and quickly. My own custom is to hold the bottle, when at rest, between the palm of the hand and the tips of the fourth and fifth fingers. When chloroform is required, the bottle is pushed up in the hand with the thumb against its neck, so that the index finger rests upon the stopper, and the other fingers upon the side of the bottle. The bottle should be completely inverted, and the stream can thus be accurately directed on to the lint. This having been done, the bottle is allowed at once to slip back into the palm of the hand; then the index and middle fingers with their palmar surfaces up-

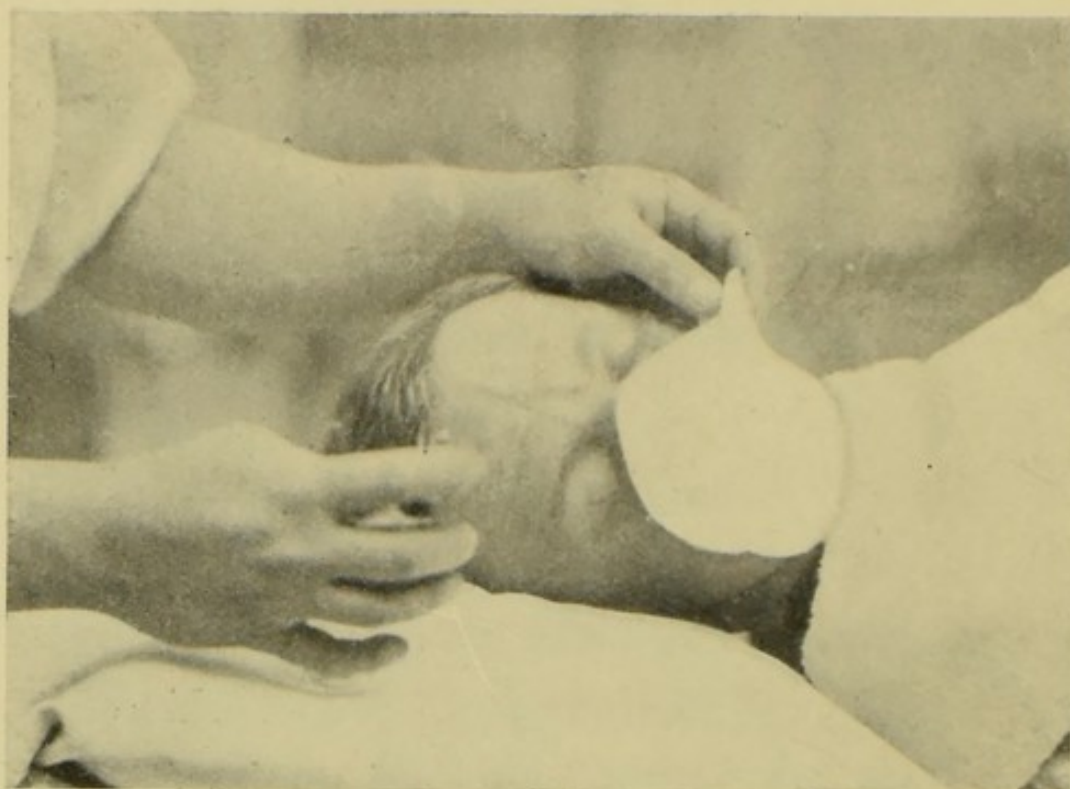


PLATE V.

Administration of Chloroform by means of lint and drop-bottle.

wards are slipped, the former under, the latter over the lint, and by a twisting movement the moistened surface is turned next to the patient's face.

If done in this way, the stopper being in the palm of the hand and covered by the thumb, there is no danger of inadvertently spilling chloroform over the patient's face.

Another point to be remembered, is to sprinkle the chloroform as widely as possible over that part of the lint which covers the mouth and nostrils. It should not of course be applied where its vapour will not be inhaled. This distribution of the liquid ensures a more even vaporization and prevents the lint from becoming sodden.

These details of manipulation have been mentioned for three reasons :—

Firstly, it is important that the anæsthetist should have one hand not employed in the administration of the chloroform.

Secondly, if the actions are not performed rapidly a considerable proportion of the chloroform vapour escapes before it is inhaled by the patient.

Thirdly, chloroform will usually blister the patient's face if spilled upon it.

Some administrators make a practice of smearing vaseline on the face before beginning the anæsthetic ; this, although a wise precaution, is really unnecessary if the chloroform is properly given.

In giving chloroform the following points are to be aimed at :—

1. Gradual administration, beginning with a very dilute vapour.

2. Slow but uniform increase in the strength of the vapour.

3. Addition of drops at regular intervals of time.

With these ideals in view, one drop only is given to begin with, and a second drop after twenty seconds. After another twenty seconds two drops are given, and repeated after a similar interval. Twenty seconds later, three drops are given, and so on up to six drops, which in ordinary cases will prove sufficient. In this manner the strength of the vapour begins at the minimum and is increased gradually and regularly. The amount that will be required for each patient to induce anæsthesia

can only be determined by the administrator himself. No dogmatic statements can be made on this point, but for children up to ten or eleven years of age, three drops will usually be found to suffice. When the anæsthetist reaches the stage of giving what he decides is sufficient as a maximum number of drops, he continues to give that number without further increase until the patient becomes anæsthetised, and for some time longer. After the required degree of anæsthesia has been obtained, the amount of chloroform can generally be reduced by degrees until a point is reached at which the anæsthesia can be maintained with a minimum dose. It is again impossible for any one but the administrator to determine what the minimum should be in any particular case, or when the reduction in dosage should be commenced. The expert anæsthetist may at times deem it necessary to increase or diminish the strength of the vapour according to the condition of his patient: his reasons for so doing and the indications he follows, though to him clear, will probably escape altogether the notice of the inexperienced man.

It is in determining accurately the correct maximum and the correct minimum dosage required that the knowledge and skill of the anæsthetist are most called into play.

Signs of Anæsthesia.

When the graduated method of inducing chloroform anæsthesia is employed, the following sequence of phenomena is observed :

1. The respirations gradually increase in frequency, the rate of increase being proportional to the rate at which the strength of chloroform vapour is augmented.
2. The respirations become by degrees more and more regular.
3. The pupil slowly contracts, until it eventually becomes pin-point and inactive to light.
4. The conjunctival and even the corneal reflexes are abolished.
5. When the pupil becomes contracted, the respiratory rhythm changes somewhat suddenly. The breathing becomes deeper and perfectly regular, with soft snoring. In other words, the respiration becomes automatic.

“Automatic respiration is the fundamental sign of the state of unconsciousness. The contracted pupil is the measure of the lowest degree of unconsciousness induced by CHCl_3 —i.e. anæsthesia.” (Richard Gill.)

6. The muscles become relaxed.
7. The pulse is slightly increased in frequency from the normal rate after the onset of automatic breathing.

The normal pulse rate referred to is that of a day, or at least some hours, before the commencement of the administration, not necessarily that observed when the patient is on the table. For at the time that the anæsthetic is begun, the pulse is almost invariably increased in frequency, at times markedly so, owing to the excitement and nervousness that are naturally produced by the expectation of the operation. The stages of chloroform anæsthesia are similar to those of ether (*v.* Ch. III, p. 70), but more prolonged and more easily distinguished.

Maintenance of Anæsthesia.

The condition of automatic breathing having

been reached, the administrator's attention is now directed towards maintaining this condition throughout the operation. Acting on what Mr. Gill has termed "*the law of diminishing resistance*," we find that it is essential for the welfare of the patient that the strength of the chloroform vapour be gradually reduced as the administration proceeds. If the anæsthetist should continue to supply the maximum amount of vapour that was requisite for the induction of anæsthesia, he would find that the character of the breathing became altered.

The respiratory rhythm would become irregular, instead of continuing automatic; the pupil would become dilated, but inactive to light. There would, in fact, be signs of chloroform over-dose; and that this is the true explanation of the phenomena would be speedily proved by the removal of the lint. The respirations would then gradually acquire once more their automatic rhythm, and the pupil return to its inactive contracted state, provided always that the over-dose had not been pushed too far.

It is necessary, therefore, to reduce the strength

of the chloroform vapour from the maximum at some time after the condition of anæsthesia has been produced. If, however, the vapour be too suddenly lessened in quantity, signs of returning consciousness are manifested. Hence the amount of chloroform given must be gradually diminished until the irreducible minimum is reached which will suffice to maintain a proper anæsthesia. It is impossible to give any exact rule as to the time at which the reduction can be commenced, but in the majority of cases the anæsthetist will be able to diminish the chloroform dose after the operation has been in progress for about ten minutes. The reduction should be effected by decreasing the number of drops slowly and regularly, in an exactly similar manner to the graduated system of increase described for the induction of the anæsthesia.

The acquirement of any degree of perfection in the management of this anæsthetic can only be obtained by practice and by acting as administrator under the guidance of an expert. Nevertheless, even the inexperienced man is far less likely to run

into danger if he adopts the graduated method of administration than if he works upon any other system. For his aim will, at all events, be to give the minimum quantity of chloroform vapour; moreover, the slowness and steadiness with which he increases or diminishes his dose, will give him time to act upon signs of excess or lack of chloroform vapour, before any untoward events occur.

Sleep.

It occasionally happens during the gradual induction of chloroform anæsthesia, that the respirations become almost, though not quite, automatic and the pupils contracted at an earlier stage than might have been expected. From the amount of chloroform given, and from the duration of the inhalation, the administrator should know that he has not produced anæsthesia—it is what is called chloroform sleep. This condition occurs more frequently in children than in adults; in the case of the former it is extremely difficult to distinguish the regular breathing of sleep from the automatic respirations of anæsthesia. Moreover, stimulation

of the conjunctiva is usually insufficient to elicit the reflex or to arouse the child. Pinching the skin, especially of the inner side of the arm, will prove an effective method of distinguishing the two conditions, but marks of bruising caused in this way do not subsequently find favour with the parents. It is important to distinguish sleep from anæsthesia, for should the operation be begun too soon the patient will struggle and possibly cry out, the pupil will at the same time be observed to dilate, and shock may supervene.

“Relative” Over-dose.

There is a factor in chloroform anæsthesia which is too often overlooked, with the result that false ideas are formulated with regard to the action of the drug. This factor is imperfect respiratory interchange of gases. During a normal case it does not appear, but should there be any obstruction to the patency of the air way, as from falling back of the jaw and tongue, a laboured and difficult position, excessive mucus, etc., then it calls for early recognition.

Whether the condition so produced is due to deficient oxygenation, or to excess of CO_2 , added to the toxic properties of chloroform in the blood, matters little for our purpose. It will suffice to say that in chloroform anæsthesia the respiratory quotient is normally lowered—both oxygen intake and CO_2 output being diminished, but the latter more than the former. The range of respiratory movements also decreases during chloroform anæsthesia, coincidently with the alteration of the gaseous interchange. This alteration, though perhaps partly accounted for by lessened tissue metabolism, would appear from experiments performed by Bert and others to be due to actual diminution of oxygen and increase of CO_2 in the blood. It is probable, therefore, that should the aëration of the blood be still further altered by mechanical obstruction to the respiratory machine, the toxic effects of chloroform will be greatly increased.

This is amply borne out by experience, and the condition may be appropriately termed “relative over-dose.”

As an illustration of this phenomenon, it will

be well to consider the case of a patient in whom the air way has become suddenly or gradually occluded during a previously normal chloroform administration. The respiration becomes laboured and quickened, the colour dusky, the pupil dilated ; and yet the amount of chloroform vapour has not been increased. As soon as the tongue is pulled forward or other cause of obstruction removed, the respirations resume their quiet automatic character, the colour improves, and the pupil returns to its contracted state. In other words, the dose of chloroform which is correct during normal breathing proves excessive when complicated by imperfect aëration of the blood. Had the obstruction in our hypothetical case not been removed, the result would have been increasingly laboured and slowed respirations, a widely dilated inactive pupil, dusky pallor, feeble pulse and finally death.

The prevention of relative over-dose follows from what has been said as to its causation. Provided that air is passing freely into and out of the lungs, there can be little danger save from absolute over-dose or sudden cardiac failure. Consequently the

respirations must be carefully watched, and any embarrassment promptly attended to. The character of the breathing is a far more trustworthy sign than any other, and should therefore receive more attention. At the same time, the state of the pulse, pupil, and colour should be observed, and any departure from the normal accounted for, and, if possible, remedied.

The treatment of relative over-dose consists in—
+ actual — — 9

1. Withdrawing the anæsthetic.
2. Removing the obstruction to respiration.
Not only should the jaw and tongue be pulled forward, but the throat should also be swabbed out.
3. Briskly rubbing the patient's lips with a towel.
4. Lowering of the patient's head.
5. The employment of artificial respiration, should arrest of breathing have occurred.

It is highly important to recognize and treat these cases early. If this is done, even if respiration has ceased, they usually recover, provided that the

chloroform has not been pushed to a degree of actual over-dose.

Actual Over-dose.

Death from actual over-dose must be exceedingly rare if the graduated method of administration is employed. It is, however, easy to understand that this is not only a possible but a probable event if chloroform be given from a closed inhaler—that is to say, an apparatus which allows of to and fro breathing. If, for instance, a cloth or mask be saturated in chloroform, and then held tightly over the patient's face, a comparatively few breaths of the strong and heavy vapour will suffice to produce an actual over-dose. The effects produced are primarily on the circulatory system, from a much diminished blood-pressure following toxic dilatation of the cardio-vascular musculature. The fall in blood-pressure leads to respiratory arrest from anæmia of the centre, while the heart continues to beat for a time. When, however, a fatal over-dose has been actually administered, both cardiac and respiratory arrest seem to occur at the same moment.

The Signs of Over-dose are :—

1. Failing pulse.
2. Failing respiration.
3. Dilated inactive pupils.
4. Pallor.

These rapidly progress to absolute cardiac and respiratory cessation, and there is little hope of recovery unless early and continued efforts be made.

The treatment has been already alluded to under the heading of "Relative Over-dose."

The Pupil.

During chloroform anæsthesia the pupil should be contracted, but there are numerous conditions which affect it and lead to more or less dilatation. The administrator must distinguish clearly between

1. The dilated, reacting pupil.
2. The dilated, inactive, or sluggish pupil.

The former usually calls for an increased quantity of the anæsthetic and is associated with some lid reflex and swallowing movements.

The latter may signal (1) impending vomiting, (2) over-dose, either actual or relative. Threatened

vomiting requires the administration of more chloroform and may be thereby avoided ; over-dose is, of course, an indication for more air and cessation of the anæsthetic. When vomiting is imminent, the pupil which has been previously contracted dilates suddenly. At the same time pallor, small rapid pulse, contraction of the abdominal muscles and signs of returning consciousness, such as swallowing movements and corneal reflex, are observed. The dilated pupil of over-dose, on the other hand, is accompanied by the other signs of chloroform narcosis already enumerated.

It is thus made evident that the state of the pupil is not an infallible guide to the condition of the patient, but it is useful as an accessory to the other phenomena of anæsthesia.

After Effects.

1. Vomiting.—This has been dealt with in Chapter I, pp. 18–21. It will be sufficient here to remind the reader that vomiting is less common, but is occasionally much more prolonged, after chloroform than after ether.

2. Shock and Collapse.—These have also been referred to fully in Chapter I, pp. 21–28; they are usually a direct result of the operation, not of the anæsthetic. Shock is diminished by true, but may be increased by incomplete anæsthesia. Collapse may be the result of a relative or actual over-dose of chloroform.

3. Pulmonary Complications after chloroform are extremely rare as contrasted with those following ether. Most of those that have occurred have been septic broncho-pneumonia, attributable to the inhalation of blood, etc., during unconsciousness.

4. Delayed Chloroform Poisoning is a very rare condition, although a number of fatal cases have been recorded during the last few years.

It would seem that chloroform may induce fatty degeneration of the liver and muscles, not unlike that of phosphorus poisoning. The symptoms are vomiting, pallor, usually jaundice, excess of acetone and diacetic acid in the urine, coma, and finally death.

The pathology of this “acid intoxication” is at present unknown.

Difficulties and Dangers.

The difficulties and dangers of chloroform may be divided into two classes :—

1. Respiratory :—

- (a) Of central origin.
- (b) Of obstructive origin.

2. Circulatory :—

- (a) Primary cardiac failure.
- (b) Cardiac failure from relative over-dose.
- (c) Cardiac failure from actual over-dose.

1. (a) Failure of respiration from paralysis of the respiratory centre is due to failure of the circulation. The toxic effect of chloroform upon the vascular musculature, and the secondary cerebral anæmia that may ensue, have been already alluded to. The treatment must consequently be that of the cause, i.e. over-dose (pp. 116–119).

1. (b) Failure of respiration of other than central origin is due to mechanical obstruction.

- a.* Falling back of the tongue.
- β.* Excessive mucus.
- γ.* Laryngeal stenosis, growths, etc.
- δ.* Foreign bodies obstructing the air way,

e.g. teeth plates, vomited material, blood, pus, etc.

- ε. Restricted expansion of the lungs, as with empyemata, large abdominal tumours, etc., or with the prone position.

The first treatment of failing respiration due to one of these causes is to remove the obstruction.

Tracheotomy may at times be necessary.

The management of the cases which come under the heading ε is dealt with in Chapters VII and IX.

When the obstruction has been removed, or where none exists, the treatment of failing respiration under chloroform is as follows :—

1. Withdraw the anæsthetic.
2. Lower the head and shoulders. This is a most important action when there is failure of the respiratory centre, in that it is directed towards increasing the quantity of blood going to the brain.
3. Rub the lips briskly with a towel.
4. Pull the tongue forward and keep the air way as patent as possible.

If, however, the respiration does not improve in

spite of these measures, the chest must be compressed. It is well to note that in all cases of chloroform over-dose the first movement of artificial respiration must be directed towards expelling as much of the chloroform vapour as possible, before admitting fresh air. The chest must therefore be compressed first of all, and artificial respiration proceeded with at once if necessary. In cases of asphyxia, phlebotomy should be performed in order to relieve the over distension of the right side of the heart. The importance of early action in these cases cannot be too strongly emphasized: a fatal issue often follows initial delay.

2. (a) The term "*primary cardiac failure*" is applied to the sudden cessation of the heart's action which occasionally occurs during the initial stages of chloroformisation, i.e. the induction period. We will not attempt to discuss whether cardiac arrest follows or precedes respiratory failure: it is sufficient to know that in the vast majority of fatal cases it is impossible to determine the sequence of events—both cardiac and respiratory failure occurring with startling suddenness.

As far as our present knowledge goes, primary cardiac failure may be due to one of three factors—

Firstly, fear on the part of the patient (*v.* Chapter I, p. 5).

This may possibly account for some of those sudden deaths, in the same way that it caused them occasionally in the days before anæsthetics were employed. It is, however, more probable that this factor will come into play just before the stage of anæsthesia is reached, owing to the effects produced by emotion on the respiration and circulation. The effects are more serious when chloroform is being administered than when any other anæsthetic is used, owing to the facts already stated in connexion with “Relative Over-dose.”

Secondly, shock induced by some stimulus applied before anæsthesia is complete (*v.* Chapter I, p. 23).

Thirdly, administration of too strong a vapour. Sudden death can occur during the induction stage from a species of over-dose : that is to say, if a very strong chloroform vapour is inhaled from the commencement of the administration, a fatal

result may ensue even though the total amount of chloroform given may appear comparatively small.

Such an event is more likely to occur when a sudden, instead of a slow and gradual method of administration is employed.

2. (b) and (c). Relative and actual over-dose have been dealt with on pp. 113-118.

The changes that occur with cardiac failure are extremely rapid in their onset.

These are sudden pallor, widely dilated pupils, slow sighing respiration for one or two breaths, diminution of the pulse until it becomes imperceptible, and finally complete absence of any of the signs of life.

There are no certain means by which animation can be restored, but in addition to the efforts directed towards restoring respiration, hot towels should be applied to the head and precordium.

Drugs such as strychnine are of little, if any, use in these cases: even if they would affect the arrested heart they cannot be carried to it in the absence of circulation.

Some authorities have recommended the inhala-

tion of amyl nitrite during artificial respiration : it is improbable that this measure will prove successful, and theoretically it is quite wrongly employed in those cases in which the blood pressure has been already lowered by the toxic action of chloroform. The intravenous injection of suprarenal extract is far more logical, and might prove of service if performed early, i.e. before actual cardiac arrest has supervened.

The administrator must be more concerned with the *prevention* than with the *treatment* of these dangers, especially so because the latter is of no avail in severe cases.

It will not be out of place to repeat here those details of the administration which are most important in preventing such fatalities :—

1. The patient must always be recumbent.
2. Every effort should be made to reassure a frightened patient, and nothing done which might alarm him.
3. The operation must not be begun, nor the patient transferred to the table, nor clothing, preparatory dressings, etc., removed until the patient is fully anæsthetised.

4. The induction of anæsthesia must be slow and regular.
5. No obstruction to respiration must be allowed to persist.
6. During the maintenance of anæsthesia the minimum dosage of chloroform should be given.
7. Due attention must be paid to the preparation of the patient.
3. The anæsthetist must be perpetually on the watch for signs of impending danger.

Junker's Inhaler.

Junker's inhaler is an apparatus by means of which air is pumped through a chamber containing chloroform, and the resulting vapour is inhaled by the patient. It consists of a bottle with a metal screw stopper: through the latter two tubes pass into the former. One tube is long, and extends nearly to the bottom of the bottle; it is connected on the outside with a pump or rubber bellows. The other tube opens just beneath the stopper and is continuous outside the bottle with

a length of rubber tubing. When the bottle is partially filled with chloroform and the bellows are compressed, air is forced into the bottle through the longer tube, traverses the liquid, and emerges through the shorter tube, chloroform vapour being added en route. To the original pattern of this apparatus a mask was attached into which the chloroform-air mixture was pumped and from which the patient inhaled. Even now some writers advocate this method of chloroform administration, but it has the disadvantage of prolonging the induction period to such an extent that vomiting frequently occurs. Moreover, it is sometimes quite ineffective in producing anæsthesia, and is on that account inapplicable to strong people, although possibly suitable for children.

The great utility of Junker's inhaler lies in its adaptability to nasal and oral surgery—that is to say, cases in which the surgeon must not be incommoded by a mask or lint on the face. For such operations a flexible metal tube, capable of being rendered aseptic by boiling, is attached to the exit tube. Anæsthesia having been induced

in the ordinary manner by lint and drop bottle, it is maintained by blowing chloroform through the metal tube into the mouth or nose. A special form of gag has been devised to the blades of which

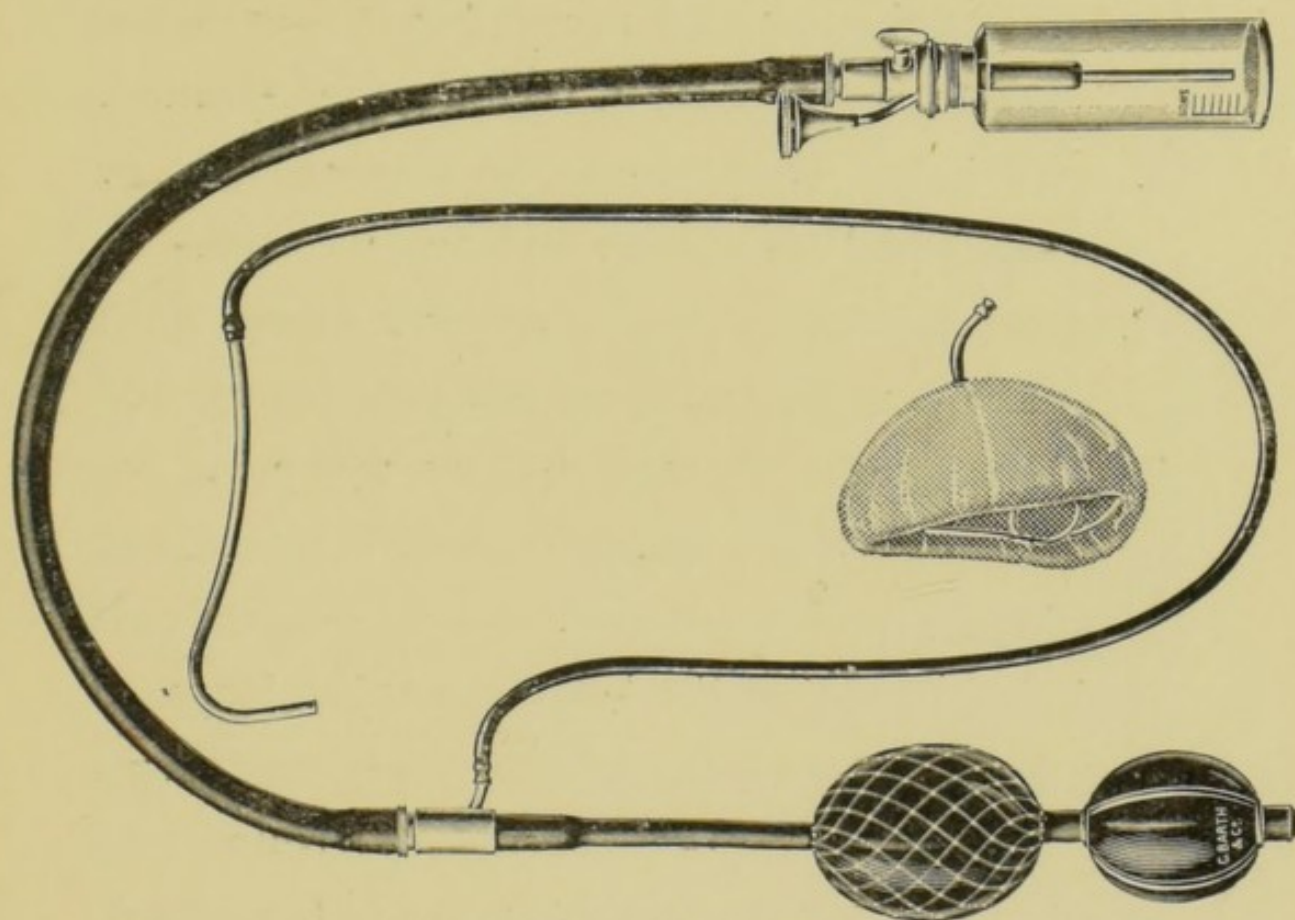


FIG. 12.—Junker's Chloroform Inhaler.

are attached tubes connecting with the exit tubes of the inhaler (Sir F. Hewitt).

In using the apparatus the following points should be borne in mind :—

1. The bottle must not be *filled* with chloro-

form. Half an ounce is usually a sufficient quantity. If the bottle has been over-filled, liquid chloroform will be ejected from the tube when air is pumped in. The working of the apparatus should always be tested before it is employed for an administration.

2. The bottle must always be kept upright, or else liquid chloroform will again escape.
3. After use the surplus chloroform should be at once poured out, the metal tube boiled, and the apparatus suspended by the hook. If left packed in a box the rubber tube becomes kinked and so spoiled.
4. In cold weather the bellows may be found to have become hardened. Warming before a fire for a few moments will restore the natural softness and flexibility of the rubber.

CHAPTER V

ETHYL CHLORIDE

ETHYL CHLORIDE has been used as a general anæsthetic on the Continent for many years, but has only recently been so employed to any extent in this country. Much has been written in the medical press concerning this comparatively new anæsthetic, and, perhaps as a result, a very large and indiscriminate use of ethyl chloride, and several fatal cases have followed.

The cases in which it is employed should be selected and prepared with care. The practitioner will be wise to refrain from its use until he has been personally instructed in its administration by an expert, or has seen it given several times. It should only be used for short cases, never for a prolonged anæsthesia.

PRACTICAL ANÆSTHETICS

Apparatus.

Many ingenious and in some cases complicated forms of apparatus have been devised for the administration of ethyl chloride. The one that I have found simplest, cleanest and most generally serviceable, consists of the face-piece and bag of the Clover's inhaler (*vide* illustration, p. 76). It is essential that the tube contained in the T piece—through which the ethyl chloride is sprayed—should project into the bag and not end opposite to the vertical tube. This prevents the liquid being sprayed into the face-piece or on to the patient's face, and ensures its entry into the bag.

Ethyl chloride for general anæsthesia is supplied by the

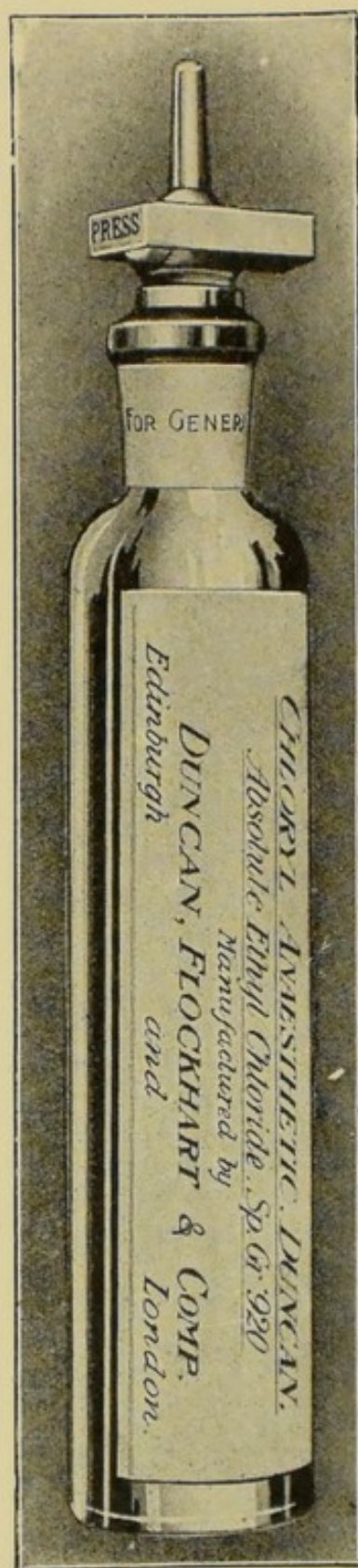


FIG. 13.—Graduated bottle with spring spraying nozzle for the administration of Ethyl Chloride.

manufacturers in sealed graduated tubes with a spraying nozzle. The pattern shown in the illustration will be found to be as good as any other.

Dosage.

For a single administration, 5 c.c. is the average dose for an adult. For children up to four years of age 2 c.c., and for older children, weakly subjects, etc., 3 to 4 c.c. will prove sufficient.

Administration.

The position of the patient may be that most convenient for the surgeon—either recumbent or sitting. The face-piece is attached to the bag and the requisite amount of ethyl chloride sprayed into the latter through the tube.

The tap on the T-piece is then closed.

The patient is directed to take a deep inspiration; at the end of this the face-piece is applied and he is told to breathe into the bag.

His first expiration will probably fill the bag, but if it does not do so the face-piece should be gently raised during the next inspiration and replaced at its close. After this has been done, to and fro

breathing takes place, but a further admission of air should be permitted if much struggling ensues. After a very few breaths the patient's respirations become regular, automatic, stertorous and not unlike those of ether anæsthesia: the eyeballs become fixed, the pupils moderately or widely dilated, the conjunctivæ insensitive, the colour pink. As soon as this condition has ensued the operation may be commenced.

For dental work a sufficient duration of anæsthesia will be obtained if the face-piece is removed after the first two or three stertorous breaths, but for minor surgical operations the face-piece must be kept in position and one breath of air given to every four from the bag.

When signs of returning consciousness present themselves a second dose of ethyl chloride may be sprayed into the bag, if a prolongation of the anæsthesia is required.

Special Points about Ethyl Chloride Administration.

1. Preparatory treatment of the patient is as important before ethyl chloride as before

ether anæsthesia, and its neglect may lead not only to distressing after effects but also to danger during the administration.

2. A dental prop should be inserted between the teeth in all cases, not only when an intra-oral operation is contemplated.
3. This anæsthetic is best suited for the minor surgical operations, tonsils and adenoids, and occasionally for dental extractions. It is especially useful for children and feeble people, but is sometimes also of great service for alcoholic subjects.
4. It must never be given in any case in which there is obstruction to respiration, swelling or engorgement of the neck or throat.
5. No cyanosis must be permitted even during the induction period.

Difficulties and Dangers.

The great and most important difficulty that may accompany the use of ethyl chloride is spasm of the glottis and respiratory muscles. Although this is more likely to arise if undue deprivation of

air be permitted, nevertheless it may occur without the intervention of any such factor. Respiration ceases, the jaw and chest become absolutely rigid, the colour changes to a deep dusky hue. Treatment must of course be directed towards keeping the air way patent, and waiting for the spasm to subside ; but I believe that the administrator is almost helpless either to avert or to check this dangerous condition. The anæsthetist will be well advised to discontinue the administration on the appearance of the very first threatening of respiratory spasm. By this means only, but not always even so, will the safety of his patient be ensured.

On this account I would strongly deprecate the general use of ethyl chloride. It possesses undoubted advantages over nitrous oxide in its portability and rapidity of action, but these advantages are felt by the anæsthetist more than by the patient. As regards safety it cannot compare with gas or with gas and oxygen.

Faintness and vomiting frequently occur as after effects ; the former must be treated by keeping the

patient in the recumbent posture—it is sometimes necessary to maintain this for several hours.

Ethyl Chloride and Ether.

Ethyl chloride may be used in the place of nitrous oxide as a precursor to ether.

The Apparatus required consists of the Clover's portable ether inhaler with small bag and face-piece, and a bottle of ethyl chloride and of ether.

The Administration is conducted as follows:—

1. The ether reservoir is charged with $1\frac{1}{2}$ to 2 ounces of ether.
2. The indicator is turned to 0, and any ether fumes in the central tube blown away.
3. The small bag and face-piece are attached.
4. The tap on the T-piece is opened, the requisite dose of ethyl chloride sprayed into the bag, and the tap then closed.
5. The face-piece is applied to the patient's face. The same method of procedure is followed as with ethyl chloride alone, until stertorous breathing begins.

6. The ether is then turned on to the extent marked by the indicator at $\frac{1}{4}$. This amount is slowly but steadily increased by adding $\frac{1}{4}$ every four breaths, until $1\frac{1}{2}$ is reached.
7. The administration is then continued as with gas and ether or ether alone, one breath of air being allowed to every four from the bag.

It is advisable to turn on the ether slowly in the manner described, for if the strength of the vapour should be rapidly increased, straining and salivation would occur. It has been proved by experience that a greater secretion of saliva and mucus is provoked by this, than by the gas and ether method of inducing anæsthesia. The pupil is of moderate size or somewhat dilated: it is distinctly larger than that associated with a gas and ether administration. Ethyl chloride and ether is not to be preferred to nitrous oxide and ether, for routine work, but it is unquestionably useful for anæsthetising patients, such as alcoholic individuals, who may be expected to give trouble unless the induction period is extremely short.

Somnoform.¹

The anæsthetic somnoform may be dismissed with a few words. It was introduced as a rival to ethyl chloride, which is its chief constituent. The administration and effects produced are alike in the two cases, but somnoform is apt to decompose and becomes then highly poisonous.

Nitrous Oxide and Ethyl Chloride.

The administration of ethyl chloride preceded by nitrous oxide gas has been practised by some anæsthetists.

The results obtained up to the present time do not show that this method has any particular advantages, or that it is likely to prove of much value.

¹ For further information the reader is referred to the author's paper, "Somnoform Anæsthesia." (*St. Bartholomew's Hospital Journal*, Jan. 1904.)

CHAPTER VI

MIXTURES AND SEQUENCES

A.C.E.

THE alcohol-chloroform-ether mixture consists of :—

Alcohol	1 part
Chloroform	2 parts
Ether	3 parts

It should always be freshly prepared and the constituents must be absolutely pure.

Administration.

The mixture is usually administered by means of a Rendle's or similar mask. The sponge contained in the mask is first wrung out in warm water and then soaked in one or two drachms of the mixture. The mask is gradually applied to the patient's face, so that for the first few breaths air is allowed to enter beneath the cushion of the face-piece. After a few moments the mask is accurately adapted to

the face, so that the air inhaled and exhaled by the patient passes entirely through the sponge containing the mixture. Should the mask be closely applied at the outset, coughing and straining would occur, owing to the sudden administration of strong A.C.E. vapour. The respirations increase both in depth and frequency as the induction proceeds, until they become regular, deep, automatic and slightly noisy. The pulse increases a little from the normal, both in force and frequency. The pupil contracts, but does not become as small as when chloroform alone is used. In other words, the anæsthesia obtained with A.C.E. mixture resembles that of ether, rather than that of chloroform. In ordinary cases the patient will present the usual signs of complete anæsthesia after ten or twelve minutes—it is not a good practice to shorten the induction period further than this. At regular intervals of a few minutes the sponge must be removed from the mask, squeezed out dry, soaked in the mixture and replaced. The A.C.E. mixture should be kept close at hand in a small bottle, preferably graduated and securely corked, from

which it can be conveniently poured on to the sponge when required. This mixture was recommended to the profession as being safer than chloroform, by a Commission appointed some years ago to inquire into the question of the risks attendant upon the use of the various anæsthetics.

The methods of administration employed, none of which differ essentially from that described above, are not very scientific. No attempt is made to increase and decrease the dosage with the same accuracy as with chloroform : probably even better results would be obtained if this were done. In practice, however, A.C.E. cannot be conveniently given by means of lint and drop bottle, since the former speedily becomes saturated with the liquid. Moreover, the risks of over-dosage are extremely small if ordinary care be exercised, so that the comparatively crude method of administration, which is even still employed by some for chloroform, proves safe and satisfactory for A.C.E. mixture, though dangerous for the more potent drug. It has been urged by some authorities, as a point against A.C.E. mixture, that the evaporation rates

of its three constituents are different, so that at one time more ether, at another more chloroform is inhaled. Although a perfectly reasonable argument this does not seem to affect the safety or utility of the anæsthetic in actual practice. It is doubtful if the alcohol in the mixture is of any real service, indeed many anæsthetists, among them the author, prefer to use chloroform and ether rather than A.C.E.

Chloroform and Ether.

C.E. mixture consists of :—

Chloroform 2 parts

Ether 3 parts

It should be freshly prepared just before use.

The Administration is similar to that of A.C.E. ; it may be given from a Rendle's mask, or better still from the inhaler introduced by Sir F. Hewitt. For children or feeble patients who will require but a very small dose of the mixture, the lint and drop bottle method may be employed : in most cases, however, this is not satisfactory, since the lint soon becomes sodden.

The anæsthesia of C.E. mixture is not so quiet as that of chloroform : the breathing is deeper and more audible, the pulse fuller, the pupils less contracted. In fact the phenomena are, as we should expect, a combination of those produced by each drug acting alone.

Both A.C.E. and C.E. mixtures are particularly suited to children, and to aged or feeble patients. They are not so suitable for strong and robust individuals, and for alcoholic patients they are almost useless. The very fact of their comparative inefficacy to induce anæsthesia in the robust man, is one of the strongest arguments in favour of their use for children and feeble subjects. For it is clear that an actual over-dose must be a very uncommon event. It is not at all certain that A.C.E. possesses any advantages over C.E. and some observers are inclined to think that the former is more apt to produce a troublesome excitable stage and unpleasant after effects. The latter is readily prepared by the anæsthetist when required, and is easy to administer. It is undoubtedly safer than chloroform, and the practi-

tioner will therefore be well advised to give it the preference whenever it is possible to do so.

It should be remembered that excitement and struggling during induction are more likely to occur than when chloroform is used, especially if a concentrated vapour be suddenly presented to the patient. It is better to administer small doses, frequently and regularly repeated, than to give large doses at long intervals.

SEQUENCES.

Gas-Ether-Chloroform.

The gas-ether-chloroform sequence is one of the most useful methods of inducing and maintaining anæsthesia. The administration of gas and ether and the arguments in favour of its employment as a routine method of inducing anæsthesia have been already considered (Chap. III, p. 94). It now remains to discuss the advantages to be gained by changing ether for chloroform, and the proper time at which this should be done.

Reasons for Changing the Anæsthetic.

1. A long etherisation makes the patient liable to after-sickness, bronchitis, etc., and the

discomfort of smelling ether for many hours.

After a short administration of ether, these after effects are often absent, rarely marked.

2. Chloroform anæsthesia is quieter, and is on that account more convenient for the surgeon.
3. The danger of *inducing* anæsthesia with chloroform is avoided, the advantage of *maintaining* it with chloroform is preserved.
4. A more complete muscular relaxation is obtained, which is especially desirable for abdominal surgery.
5. Excessive secretion of saliva and mucus may make the change imperative.

The nature and duration of the operation will to a large extent affect the time at which the change is made. When dealing with intra-oral and similar operations the change will of course be made as soon as anæsthesia is complete.

As a general rule, ether should be replaced by chloroform after half an hour. In abdominal surgery, however, for the reasons stated above, and in cases where engorgement of vessels is a disadvantage, the change should be made earlier.

The anæsthetist should never wait until the secretion of mucus, etc., impels him to discontinue the ether; if he does so, the unpleasant after effects will not be avoided. He should exercise all possible care and observation to enable him to anticipate such events, and by so doing will the subsequent comfort and safety of his patients be increased.

When the change of anæsthetic is made the character of the respirations then in evidence materially influences the dosage of chloroform. As a rule, the patient will be breathing deeply and regularly and a strong vapour of chloroform must not be given for fear of over-dose. At first, therefore, the chloroform should be given in small quantity—about three drops—but if necessary this may be gradually increased, according to the patient's condition. By degrees what may be called ether breathing is replaced by the quiet respirations characteristic of chloroform anæsthesia; as this transition takes place it is only natural that the number of drops of chloroform must be increased in order to maintain the same degree of anæsthesia.

After chloroform has been inhaled for four or five

minutes the transition from ether to chloroform anæsthesia will be complete. The remainder of the administration differs in no particular from that described in Chapter IV, but the anæsthetist should endeavour to give the minimum chloroform dose from the outset. In accordance with "*the law of diminishing resistance*" the number of drops given will be gradually decreased as the operation proceeds.

Should there be much salivation, etc., at the time that the change is made, the mouth and throat should be swabbed out ; and if the quantity of mucus in the air passages be excessive it may be advisable to relax the depth of anæsthesia sufficiently to allow the patient to cough and so clear the trachea and larynx. In any case where much mucus and saliva are present the administration of chloroform must be conducted slowly and with caution, for it has already been pointed out that the dose which is correct under normal conditions becomes a "relative over-dose" when obstruction to respiration exists. The mucus and saliva will be much diminished in these cases after chloroform has been in action for ten or fifteen minutes.

Either A.C.E., C.E., or open ether may be used to take the place of chloroform in sequence to nitrous oxide and ether. The advantages which the mixtures have over pure chloroform still hold good, although in a less degree, since the induction by means of the latter drug has been avoided.

Enough has been said to indicate that the gas-ether-chloroform or gas-ether-chloroform-mixture sequence will be found invaluable in practice. The safest possible induction is performed, the most equable and easy anæsthesia is maintained. The after effects are usually insignificant when the patient has not been kept under the influence of ether for a long period : the return to consciousness is quiet and uneventful. When vomiting does occur it usually comes on just before consciousness is regained as after an ether administration, and causes little distress.

Ethyl Chloride-Ether-Chloroform Sequence.

This sequence is the natural outcome of the substitution of ethyl chloride for nitrous oxide as a precursor to ether. The reasons which make a

change to chloroform desirable are the same as those given with the description of the gas-ether-chloroform sequence; they are, however, still more urgent in this case, for a profuse secretion of saliva and mucus is the rule with ethyl chloride and ether, or at least more common than with nitrous oxide and ether. On this account the change to chloroform is made at an early stage, the ethyl chloride and ether being used for little more than the induction of anæsthesia. The precautions to be observed in administering chloroform in sequence to ether have been already enumerated: if they do not receive due attention an over-dose may be the result.

It is worthy of note that the comparatively large pupil associated with ethyl chloride and ether, does not become fully contracted until chloroform has been administered for several minutes. In the gas-ether-chloroform sequence this phenomenon is not nearly so marked, for not only is the pupil smaller when the change is made, but also it more quickly attains the characteristic dimensions of chloroform anæsthesia.

CHAPTER VII

THE SELECTION OF THE ANÆSTHETIC ¹

General Considerations.

THE practitioner's success as an anæsthetist depends in no small measure on the employment of the most suitable drug at his command for every case. The fact that there are such a number of different methods of anæsthetisation in existence points to the probability of no one method being perfect for every case, but to each one having its own sphere of utility.

In the consideration of the question of the selection of the anæsthetic to be used, it will be necessary to recapitulate some of the effects produced by the different drugs.

The most important factors which influence the decision of the administrator are :—

1. The safety of the patient.

¹ Spinal analgesia is considered separately in Chap. VIII.

2. The comfort of the patient both
 - (a) During induction and
 - (b) After consciousness has been regained.
3. The convenience of the surgeon.
4. The condition of the patient.
5. The nature of the operation.

1. Of all anæsthetics in use, nitrous oxide and oxygen is the safest. Next to it comes nitrous oxide alone, but, as we have seen, not quite on the same plane owing to the element of asphyxia it introduces (*vide* Chap. II). Neither of these anæsthetics, however, will always fulfil the other necessary requirements. The use of the latter is limited by the short duration of the anæsthesia, and the former is unsuitable for certain operations and individuals (Chap. II, p. 56). Moreover, complete muscular relaxation is not effected by them.

When ether is compared with chloroform we find that, according to statistics and the opinions of eminent authorities, fatalities are five times more frequent with the latter than with the former. These figures, though correct, include the results

of administrations conducted by inexperienced men ; there can be no doubt that while chloroform may be almost without danger in the hands of an expert anæsthetist, it cannot be so regarded when administered by a novice. For this reason, if for this alone, the practitioner who is not giving anæsthetics daily should avoid the use of chloroform as far as possible, and should perfect himself in the management of ether. It were better for him that his patients should suffer from bronchitis after ether than that they should die on the table from chloroform.

The mixtures A.C.E. and C.E. are less dangerous than pure chloroform, but cannot compare with ether in the matter of safety. The safety of ethyl chloride as an anæsthetic has probably been exaggerated. Although I have never seen death result from its use, a large number of fatalities have been reported. When the rapidity of its action and the liability to spasm are considered one would be inclined to rate its dangers as equal to those of chloroform.

2. (a) The method of inducing anæsthesia which

is most pleasant to the patient is nitrous oxide and oxygen. This, however, only applies to operations of short duration, and there is no advantage to be gained by using gas and oxygen instead of gas as a precursor to ether. The induction by gas and ether is almost as free from unpleasant effects as when gas and oxygen is used ; it should be adopted as the routine method on this account in addition to its safety.

(b) The after comfort of the patient will not be ensured if a prolonged etherisation be performed (Chap. III, p. 92). For this reason chloroform or a chloroform mixture should be substituted for ether at some time during a long administration (p. 94). My own routine practice is to induce anæsthesia with gas and ether, and change to chloroform or C.E. mixture after fifteen or twenty minutes.

It is not urged as a method to be adopted by one unfamiliar with the administration of chloroform, but it certainly reduces the unpleasant after effects of anæsthesia to the minimum.

3. The gas-ether-chloroform sequence is usually well adapted to the requirements of the surgeon.

The quiet and tranquil anæsthesia of chloroform permits the operator to perform his delicate manipulations without fear, distress or inconvenience.

Some surgeons, it is true, detest the very sight of a gas and ether apparatus and prefer their patients to be anæsthetised with chloroform from the outset. It is well to conform as far as possible with the surgeon's wishes, but it will rarely be found that a surgeon objects to the methods deemed by the anæsthetist the safest and most suitable for the patient.

4 and 5. The condition of the patient and the nature of the operation to be performed must now be considered in relation to the choice of the anæsthetic.

Special Cases.

For Dental Extractions and short operations such as the incision of an abscess, nitrous oxide or nitrous oxide and oxygen will be selected. Of the two the latter will always be given the preference if the anæsthetist is familiar with its administration.

It must be remembered that gas should not be given to patients with inflammatory or other swellings of the neck which may cause respiratory obstruction.

For Minor Surgical Operations in general gas and oxygen or gas and ether will be employed if more time is required by the surgeon than can be provided by gas alone.

Major Operations.—Enough has already been said in favour of the gas-ether-chloroform sequence as a routine method for a long operation.

Certain special cases, however, demand further consideration.

Phthisis.—Where acute or chronic phthisis exists ether should never be employed. The irritation of the vapour is likely to aggravate an acute pulmonary affection, and to convert a chronic one into an acute broncho-pneumonia.

Chloroform is the least harmful anæsthetic to employ, and due regard must be paid to the debilitated state of the patient and any abnormal respiratory phenomena.

Empyema.—The administration of an anæsthe-

tic to a patient suffering from a large empyema is one of the most difficult and dangerous that has to be undertaken. There is always some respiratory and frequently also cardiac embarrassment, the degree depending upon the size of the empyema, the amount of lung tissue available for respiration, and the displacement of the heart. Chloroform or C.E. mixture should be used, and it is sometimes advisable to give oxygen at the same time if shortness of breath and cyanosis are at all marked. The anæsthesia should be "light" throughout, and the administration discontinued as soon as the rib has been resected or the pleura incised.

The position of the patient on the table is of the greatest importance. He must not be turned so as to lie altogether on the sound side, lest the weight of the body impede still further the already hampered respiration. The patient should be placed in the dorsal position, so that the affected side projects beyond the edge of the table. This will enable the surgeon to perform his operation, although not so convenient for him as the lateral position. It must be remembered that the pus should be allowed to

escape slowly and gradually : a sudden evacuation may easily lead to fatal syncope.

In some cases the respiratory embarrassment is so great that orthopnœa results ; it will then be impossible to administer the anæsthetic to the patient in the recumbent posture. The patient might be propped up with pillows to obviate this difficulty, but we have already seen the dangers that accompany an administration of chloroform when a sitting position is permitted. Where orthopnœa is present, and indeed in every case where respiratory embarrassment is at all marked, the pleural cavity should be aspirated some hours before the anæsthetic is administered. There can be no serious objection to this procedure, and the subsequent administration of chloroform for the resection of a rib to provide adequate drainage, becomes a comparatively safe and simple task. The following brief report of a case illustrates some of the points to which the attention of the reader has been called.

J. M., aged forty-five, a butcher, was admitted to hospital suffering from a large empyema of the right pleural cavity. The patient had an anxious expres-

sion, dusky colour, orthopnœa, very rapid breathing with marked movements of the alae nasi, sweating and feeble pulse. The patient was propped up on the table into a sitting position and chloroform administered on lint. A very dilute vapour was given, but the patient's air-hunger continued and he suddenly stopped breathing before consciousness was lost. The operator promptly plunged a knife through an intercostal space and allowed pus to gush out. Breathing began again without any attempt at artificial respiration being made. The operation was completed, the remainder of the pus allowed to escape slowly, drainage tubes inserted, and the patient returned to bed without further difficulty. In this case the anæsthetic should not have been given until a considerable proportion of the purulent fluid had been withdrawn by means of an aspirator. Happily the result was not fatal, but it depended, not on the good judgment or skill of the anæsthetist, nor on the surgeon's promptness of action, but rather on the providence that sometimes protects the steps of fools in places where angels fear to tread.

Bronchitis and Emphysema.

Patients suffering from bronchitis and emphysema are bad subjects for an anæsthetic. Ether is evidently unsuitable in any form, and chloroform will prove less harmful but must be administered even more slowly than usual.

Cardiac Affections.

Valvular disease of the heart is no contra-indication to the administration of an anæsthetic provided that compensation for the lesion is established. It is, however, unwise to risk the destruction of compensation by throwing an increased strain on the already overworked heart. The same reasoning holds good when dealing with the hypertrophied heart of chronic interstitial nephritis.

Thus a prolonged nitrous oxide, or even nitrous oxide and ether, would be an injudicious administration, and C.E. mixture will be preferred.

Diabetes.

The onset of coma may be precipitated by the action of an anæsthetic upon a diabetic patient.

It is known that increased metabolism hastens

the onset, and that coma is due to acid intoxication. We have seen that chloroform has a tendency to cause a condition of acidæmia, although it produces a quieter anæsthesia than ether. It is therefore difficult to guess which of the two anæsthetics is the less dangerous. This is completely in accordance with the experience of practice, for one authority recommends chloroform, another ether, as the safest drug.

For my own part I prefer to use neither the one nor the other. The most common operations that are performed on these patients are the incision of abscesses and carbuncles, amputations for gangrene, etc. Nitrous oxide and oxygen will usually answer admirably for such procedures, and I know of no ill effects that have followed its administration.

Alcoholism.

Patients who have been addicted to the excessive use of alcohol or tobacco take anæsthetics badly.

The alcoholic subject requires a large dose to induce anæsthesia, but his tolerance of the drug is not proportionately increased, so that a narrower margin

is left between correct dose and over-dose. The difficulty as a rule is to induce anæsthesia at all ; the patients often struggle violently, and the stage of excitement is prolonged and marked. Gas and ether is the best anæsthetic for the purpose, and a liberal allowance of gas must be given as well as a full dose of ether, but the supply of air must not be curtailed.

Ethyl chloride and ether is frequently of great service in these cases, since the induction period is very short and struggling and excitement are avoided.

Heavy smokers, especially cigarette smokers, are very subject to laryngeal irritation from ether. A plentiful supply of nitrous oxide must therefore be given, and ether turned on very slowly.

Opium.

It is not uncommon to find that a patient about to be operated upon has been given a considerable quantity of opium. The cases most frequently so treated are perhaps those of strangulated hernia, and appendicitis. It is not within our province

to discuss the surgical aspect of this proceeding, but it affects the administration of the anæsthetic to no slight extent.

The pupils are rarely of any service as an index to the condition, for they are in a state of pin-point contraction from opium.

The anæsthetic must be given cautiously—a very small dose will suffice—and it should never be pushed so as to produce a deep degree of anæsthesia.

Some anæsthetists recommend the giving of opium as a routine before operations on the brain, cranium, jaws, and tongue: this matter may be left to the discussion of the specialist and need not concern the majority of practitioners.

Pregnancy.

During the early months of pregnancy there are no reasons for departing from the ordinary routine of gas-ether-chloroform sequence.

During the later months, however, prolonged gas or gas and ether should be avoided.

For confinements chloroform is by far the best

anæsthetic to use, and it is noticeable that the patient at this time is comparatively insusceptible to the dangers of the drug. She almost invariably takes chloroform very well, and may be kept in a state of unconsciousness for several hours without difficulty or danger.

From the obstetrician's point of view, it is rarely necessary and usually inadvisable to push the chloroform to the degree required to produce true anæsthesia.

Junker's inhaler is particularly useful in these cases. It can be suspended from the bed rail and the mask and bellows given to the patient.

A few words of instruction will suffice to enable the patient to maintain for herself a kind of analgesic condition, while there is no danger of an overdose being taken.

Ophthalmic Operations.

Operations on the eye which require a general anæsthetic, are best conducted under chloroform with the exception of excisions, and for these gas and ether should be employed if possible.

The reasons for choosing chloroform rather than ether, are :—

1. Quiet breathing is desirable so that the operator may not be inconvenienced by any movements.
2. Ether causes engorgement of the vessels and is therefore undesirable.
3. A chloroform lint will not be in the surgeon's way as would an ether inhaler.

The administrator must bear in mind that a full degree of anæsthesia is required for excisions, or else shock-syncope may occur when the optic nerve is divided.

Abdominal Operations.

When performing an abdominal operation, the surgeon desires absolute relaxation of muscles, and as little movement as possible of the abdominal walls. To attain these requirements chloroform must be employed, for the respirations are quieter and muscular relaxation more complete under this anæsthetic than under ether. The most perfect flaccidity of the abdominal muscles is obtained by

inducing as well as maintaining anæsthesia by means of chloroform. It is almost as satisfactory to the operator to induce anæsthesia with gas and ether, and change to chloroform after five minutes. The advantages of this sequence have been fully pointed out (Chap. III, p. 94), and this method should therefore be followed as a routine proceeding. Relaxation of the abdominal wall is by no means brought about by a large dose of chloroform, and the administrator is powerless to obtain perfect flaccidity by a sudden increase in the strength of the vapour. On the contrary, rigidity of the abdominal wall will follow a slight over-dose of chloroform owing to the strained respirations produced.

Rectal Operations.

Ether is the most suitable anæsthetic for most rectal surgery. Dilatation of the sphincter and causes a marked increase in the rapidity of the breathing and a peculiar crowing inspiration. This reflex action is noticeable during operations on the perineum when the finger is inserted into the rectum,

and also occasionally when the uterus is pulled upon as in vaginal hysterectomy. It is one of the last reflexes to be abolished ; in fact, it persists unless an undesirable depth of anæsthesia has been induced.

Tonsils and Adenoids.

The administration of an anæsthetic for the removal of tonsils and adenoids requires skill and practice. The most suitable anæsthetic has to be selected, the requisite depth of anæsthesia must be accurately gauged, the gag must be manipulated, the head steadied, and the surgeon assisted by pressing inwards the tonsils and swabbing out the throat.

The selection of the anæsthetic is in great measure influenced by the method of operation adopted by the surgeon. If the surgeon is a quick operator, gas and oxygen or ethyl chloride will give him ample time provided that the anæsthetist assists him properly by holding the head and manipulating the gag. For those surgeons who prefer a more deliberate operation, a longer anæsthesia is required.

In these cases A.C.E., C.E., or chloroform should be used for the induction and anæsthesia maintained if necessary by means of chloroform in a Junker's inhaler. It is scarcely necessary to remind the reader that this latter method is only applicable when the operation is to be completed with the patient in the recumbent position. Some anæsthetists prefer to give gas and ether instead of a chloroform mixture, and to get the patient deeply anæsthetised before the operation is begun, so that no further administration is necessary. This method has the advantage of permitting the sitting position to be adopted if the surgeon should desire it. Ether does not usually find favour with the operator since it causes engorgement of the blood vessels and increases the hæmorrhage.

It is important that the duration of the anæsthesia be accurately adapted to that of the operation : for although the patient is always turned on to the side as soon as the surgeon has finished, it is highly desirable that the cough reflex should by that time have returned, in order to prevent the entry of blood into the larynx.

Operation on the Tongue and Jaws.

The majority of surgeons are convinced of the advisability of performing preliminary laryngotomy in these cases. The usual method of procedure is

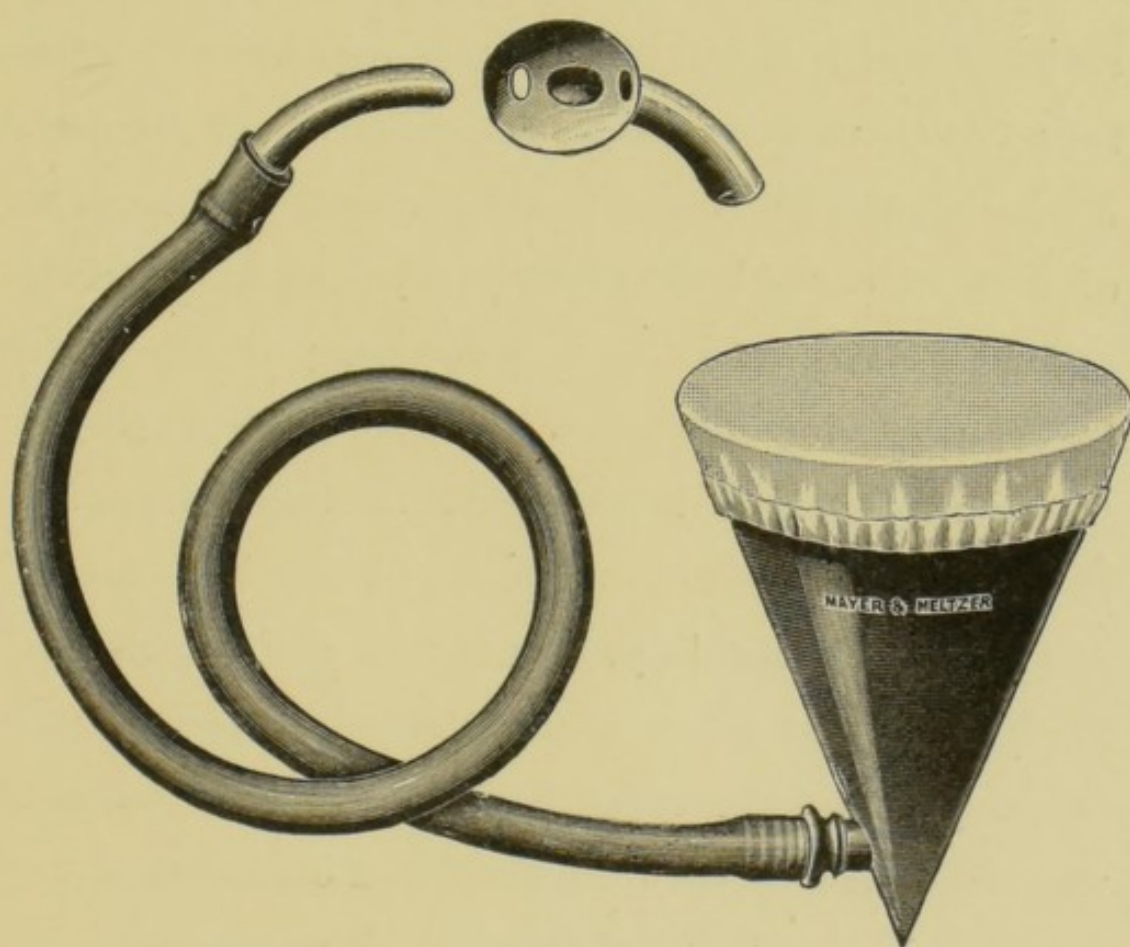


FIG. 14.—Author's Extension to the Laryngotomy Tube.

as follows. The patient is anæsthetised with gas and ether, and laryngotomy is performed. A dry

marine sponge with a tape attached is then inserted into the oro-pharynx, so as to completely shut off the superior aperture of the larynx. Anæsthesia is maintained by administering chloroform through the laryngotomy tube. For this purpose some use a Junker's inhaler, but as this is not always satisfactory, I have devised an extension to the laryngotomy tube (*vide* plate), which Messrs. Mayer & Meltzer have made for me. It consists of a short curved metal tube, one end of which accurately fits into the laryngotomy tube, whilst to the other is attached a piece of rubber tubing, which in its turn is attached to the cone of a Hahn's inhaler.

As soon as the laryngotomy is performed, and the patient has become accustomed to the change of respiration, the extension tube is inserted, and the anæsthetic is then administered on to the gauze covering the aperture of the Hahn's cone.

With this tube in place there is no fear of blood getting into the trachea, and the anæsthetist is removed from the area of the operation.

The rubber tube should not be longer than 12

inches, as the longer the tube the more difficult is it for the patient to breathe through it.

It is advisable to allow a few breaths of air to be taken through the laryngotomy tube before chloroform is administered; a few moments sometimes elapse before the respiratory machine accommodates itself to the altered conditions. A very small quantity of chloroform is required to maintain good anæsthesia; it is very easy to give an over-dose. The breathing, colour, and pulse must be closely observed.

Any bubbling noise in the tube or the onset of cyanosis will probably indicate that there is excessive mucus in the trachea, or that blood has trickled past the sponge. Such events are met by taking away the gauze and passing a feather down the tube to remove the blood or mucus. It is sometimes a good plan to suspend the administration for a few minutes in order that the depth of anæsthesia may be so far diminished as to allow the trachea to be cleared by coughing. The anæsthetist must then be ready with a sponge to remove the mucus and blood which is coughed up, otherwise

it will be drawn in again by the next inspiration.

Laryngeal Operations.

In some operations, such as thyrotomy, and excision of the larynx, tracheotomy is performed and a Hahn's tube introduced into the trachea.

Hahn's tube is a specially modified tracheotomy tube which is covered externally with a layer of dry sponge. When in position the sponge swells so that no blood can enter the trachea from above. In some patterns a small air cushion—Trendelenburg's tampon—takes the place of the sponge, and can be inflated after the tube has been inserted.

To the outer end of the tracheotomy tube a flexible pipe is attached connected with a vulcanite funnel. A piece of domette is stretched across the end of the funnel on to which the chloroform is dropped.

The administration with Hahn's tube differs in no essential particulars from that when laryngotomy has been performed.

The author's modification of Hahn's tube does away with the large projecting metal attachment, and substitutes a bent tube and rubber fitting; these can be sterilized by boiling, and as

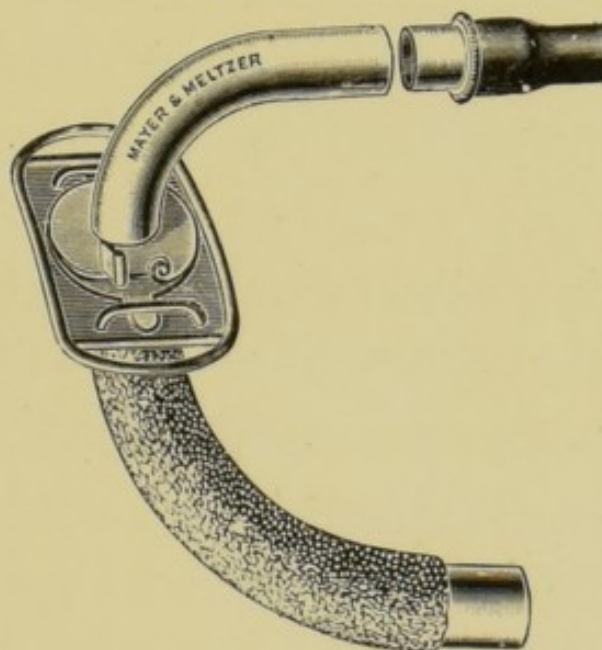


FIG. 15.—The Author's Modification of Hahn's Tube.

the tube now lies flat on the patient's chest, it is less in the way of the surgeon than with the original apparatus.

The apparatus enables the anæsthetist to remove himself entirely from the immediate vicinity of the

operation and so provides more room for the surgeon and his assistants.

Cleft Palate.

The operation for cleft palate is usually performed when the child is quite young. The best anæsthetic to employ for induction is C.E. mixture ; during the operation anæsthesia must be maintained with chloroform by means of Junker's inhaler.

The position of the patient for this operation is most important : the child should be placed on its side with a sandbag behind the shoulder to maintain this position.

This position has been adopted by me for some years now, for almost all throat cases. If the surgeon sits facing the patient and uses some form of head-lamp or mirror, he is enabled to get an exceptionally good view of the area of operation, whilst the blood collects in the dependent cheek and can easily be sponged away.

If, however, the surgeon prefers to stand to do the

operation, then perhaps it is better to have the head kept as far back as possible to allow of the blood collecting in the naso-pharynx. I think, however, that this position is by no means as safe as the lateral one.

Some operators like the anæsthetist to get the child fully under the influence of chloroform before the operation begins, and then to wait until signs of returning consciousness are observed before a further administration is made. The reason given for this method is that chloroform vapour blown on to the cut surfaces of the palate prevents union taking place. It is unlikely that this effect will be produced unless the vapour is continuously pumped on to the same spot for a long time, and this should never be done. The intermittent method of administration is contrary to all accepted principles: it entails the risks of shock and collapse both during and after the operation.

Vomiting of Obstruction.

It is often necessary to administer an anæs-

thetic to a patient suffering from intestinal obstruction. The patient is frequently vomiting at the time of the administration or has been doing so just before its commencement.

Now the act of vomiting in such a case is different from that due to other causes, inasmuch as it comes on without any warning. There are no preliminary swallowing movements, no noticeable pallor, no dilatation of the pupils, but a sudden effortless pouring out of the stomach contents. It is obvious, therefore, that special care is required to prevent vomited matter from entering the larynx and even suffocating the patient.

In dealing with such an administration, not only should the patient's head be turned to one side, but the head and shoulders should also be lowered. It is in addition advisable to place a prop between the jaws, or to insert a gag and open it directly the patient has lost consciousness. Sponges on forceps must of course be close at hand for swabbing out the mouth and throat when necessary. The head and shoulders are lowered with the object of allowing vomited material to run into the upper

part of the pharynx and to diminish the risk of its entering the larynx. A very close and careful watch must be kept lest the outpouring of stomach contents escape notice. It may occasionally be advisable to pass a soft rubber œsophageal tube and wash out the stomach with warm water, as soon as anæsthesia has been established. This measure will sometimes effect a marked improvement in the patient's general condition, but in others intestinal contents will be again ejected at a later period of the administration.

The abdominal distension which is almost always present in these cases acts as an impediment to respiration : moreover the patient is usually in a very feeble condition, so that the anæsthetic must be administered with caution. C.E. mixture is probably the best anæsthetic to use ; it may be given on lint with the same precautions and in the same manner as chloroform.

The Age of the Patient.

For the purpose of selecting the anæsthetic best suited to the age of the patient, only two classes need be considered.

1. Adults.
2. Children of ten years or less.

It is not necessary to place the very aged in a separate class, since their infirmities and general feebleness of body are not reckoned by their years alone.

Patients above the age of ten or twelve may be treated as adults : for them the ordinary routine described elsewhere may be adopted, provided that there are no special conditions present which call for modifications in the method of administration

Children bear anæsthetics well as a rule, but at the same time an over-dose affects them more readily than it does an adult ; that is to say the margin between correct dose and over-dose is comparatively small. C.E. mixture is by far the most useful anæsthetic for children below the age of ten or twelve years.

The practice of giving ether except by the open method to infants and young children has little to recommend it : the secretion of mucus and saliva is much more profuse than in adults and frequently leads to respiratory difficulty as well as to distress-

ing after effects. Even if this reason be ignored there is another factor which almost forbids the use of ether, at all events in private practice. Children are very easily frightened; the appearance of a stranger is often in itself sufficiently alarming, but a gas and ether apparatus is well calculated to inspire them with absolute terror. On the other hand, C.E. mixture or open ether can be satisfactorily given to children on lint or a handkerchief, which are not unknown objects to be regarded with suspicion. Moreover, a few tactful words from the administrator will often reassure the child, so that the anæsthetic is inhaled without struggle or demur.

It is advisable in the case of a child to depart from the rule given at p. 13, Chap. I, and to induce anæsthesia before transferring the patient to the operating-room.

For short operations, such as the extraction of teeth, etc., ethyl chloride is perhaps a better anæsthetic for children than nitrous oxide. Gas and oxygen is preferable to either, being safer than ethyl chloride and avoiding the early jactitation and twitchings that occur with gas alone.

CHAPTER VIII

SPINAL ANALGESIA.

THE production of analgesia of the lower half of the body by means of the injection of solutions into the spinal canal was first introduced by Bier some years ago. Cocaine was first used, but later other drugs of a less toxic nature have been employed, the chief of which are stovaine and novocaine.

Stovaine Sulphate.—The average dose for an adult is 5 centigrammes. To the solution of stovaine may be added glucose or mannitol to increase the specific gravity of the injection. Barker employs a 5 per cent solution of stovaine in distilled water to which is added 5 per cent of glucose: 1 c.c. of this solution contains the average adult dose; namely, 5 centigrammes of stovaine.

Jonnesco attaches great importance to the addition of strychnine to the solution of stovaine sul-

phate, and he recommends that the mixture should be freshly prepared before each operation.

Jonnesco's dosage is as follows :—

1. For high puncture—

Age 1 to 5 years :

1 c.g. stovaine sulphate with $\frac{1}{3}$ m.g. strychnine sulphate.

Age 5 to 15 years :

2 c.g. stovaine sulphate with $\frac{1}{2}$ m.g. strychnine sulphate.

Adults :

3 c.g. stovaine sulphate with $\frac{1}{2}$ m.g. strychnine sulphate.

2. For low puncture—

Age 1 to 5 years :

2 to 3 c.g. stovaine sulphate with 1 m.g. strychnine sulphate.

Age 5 to 15 years :

4 to 6 c.g. stovaine sulphate with 1 m.g. strychnine sulphate.

Age 15 to 20 :

6 to 8 c.g. stovaine sulphate with 1 m.g. strychnine sulphate.

Adults :

10 c.g. stovaine sulphate with 1 m.g. strychnine sulphate.

The mixture is prepared from the following :—

1. A solution of 10 c.g. of neutral strychnine sulphate in 100 grams of sterilized (not distilled) water.

Or 1a. A similar solution of half the above strength.

2. Crystals of stovaine sulphate : the required amount is carefully weighed, placed in a stoppered tube and sterilized in an autoclave.

The method of preparation is as follows :—

1 c.c. of the strychnine solution is drawn up into a Pravaz syringe and ejected on to the required weight of stovaine crystals. As soon as the crystals are dissolved the mixture is drawn up into the syringe and is ready for injection.

The weaker solution of strychnine is used for preparing the mixture for high puncture, 1 c.c. of this solution containing .5 m.g. of strychnine : the stronger solution is used for low puncture, 1 c.c. containing 1 m.g. of strychnine.

Novocaine.

The average dose for an adult is .1 to .15 gramme.

Solutions may be prepared as with stovaine or 2 to 3 c.c. of a 5 per cent solution employed.

Careful attention must be paid to the sterilization of the mixture, syringe and needle. No trace of soda must be admitted to the water in which syringe and needle are boiled, as any alkali renders the solution inert.

Glass ampoules containing stovaine and strychnine or novocaine, ready for injection, can now be obtained.

The Apparatus required consists of a Pravaz syringe and needle.

The needle is 4 inches long and has a specially

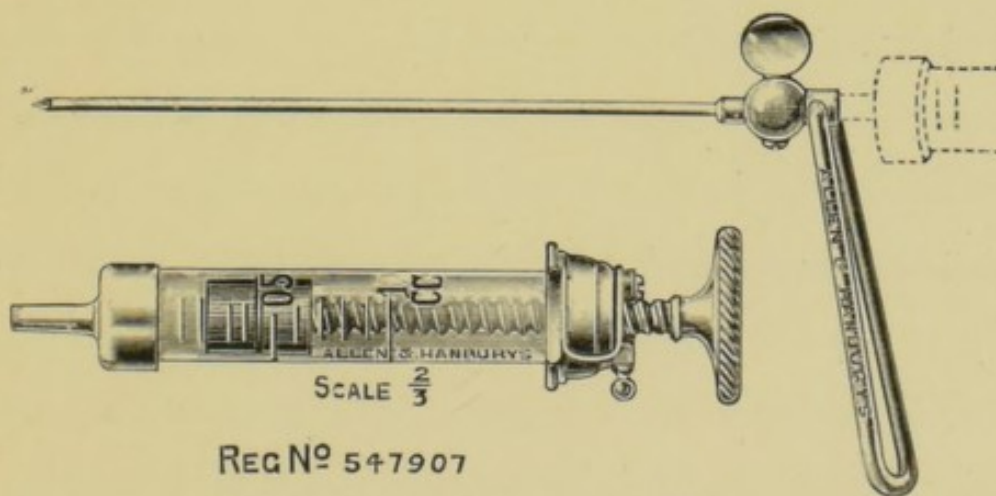


FIG. 16.—Needle and Syringe for Spinal Analgesia.

short bevel at the point, to minimise the chances of the lumen of the needle being partly within and partly without the arachnoid space. The point, however, should be sharp to avoid the possibility of pushing the dura mater before it without puncturing it. The needle is furnished with a tap near to the end which fits on to the syringe.

Methods of Puncture.

1. The Upper Dorsal Puncture is used for operations on the head, neck, upper limbs and thorax.

The patient is placed in a sitting posture with the head fully flexed so that the chin nearly touches the sternum. The skin having been prepared as for operation, the spinous processes of the vertebra prominens and the first and second dorsal vertebræ are then identified.

The needle is introduced in the middle line in the interspace between the first and second dorsal spines, and pushed onwards in a plane parallel to the upper border of the second dorsal spinous process. As

soon as the arachnoid has been punctured—and this can be felt by the distinctly lessened resistance to the needle—if fluid does not flow out, the patient is told to cough; this will probably cause cerebro-spinal fluid to escape from the needle.

The tap on the needle is then turned off, the syringe adjusted, the tap turned on again, and the solution injected slowly and carefully so as not to impinge on the cord. The needle is now withdrawn, and the site of puncture covered with gauze and collodion.

The patient is then made to lie down, and analgesia should be complete in about 5 minutes.

2. The Dorsi-Lumbar Puncture is used for operations on the abdomen and lower half of the body. The patient should be if possible in a sitting position with the legs hanging over the side of the table. The patient is told to bend forwards and arch his back in order to widen as far as possible the interspaces between the vertebræ, and this is further effected if an assistant presses upon the epigastrium at the same time. When the sitting posture is not possible, the patient should be placed in the lateral

position with the thighs flexed upon the abdomen and the back arched as much as possible.

The skin having been prepared in the usual way, the needle is introduced in the middle line in the space between the twelfth dorsal and first lumbar spines, and pushed directly onwards until the arachnoid is pierced. Here cerebro-spinal fluid will flow readily, but it is well not to allow more than a few drops to escape before injecting the solution in the manner described for the upper dorsal puncture. After the injection the patient is kept in a sitting position for 2 or 3 minutes, after which he is made to lie down with the head and shoulders slightly raised.

For perineal operations it is better to keep the patient sitting for a rather longer time—5 to 7 minutes. Analgesia should be complete in 8 to 10 minutes.

3. The Lumbar Puncture may be used instead of the Dorsi-Lumbar for operations on the lower limbs, perineum, and lower part of the abdomen. Since the needle is introduced into the canal below the level of the spinal cord the puncture is

effected somewhat more easily. The method employed is similar to that for Dorsi-Lumbar puncture, the site chosen in this case being the interspace between the third and fourth lumbar vertebræ, which is on a level with the highest point of the iliac crests.

The pain of introducing the needle is but slight and only troublesome if a lamina is impinged upon in transit. Local freezing with ethyl chloride or injection of novocaine may be used, but in practice is scarcely ever necessary.

The patient should be prepared beforehand as for a general anæsthetic with regard to food, aperients, etc.: attention to these points lessens the after sickness and headache that frequently follow; moreover, it should be remembered that it may be necessary in some cases to have recourse to a general anæsthetic.

After-Effects of Spinal Analgesia.

In many cases unpleasant after-effects are slight or absent: in some, however, vomiting is trouble-

some, and this may be associated with severe intractable headache lasting for several days. Many sequelæ have been reported, such as "retention of urine and paralysis of the sphincter ani, lasting for days and even months ; paralysis of ocular muscles, especially the external rectus ; meningitis ; gangrene of the feet ; paraplegia, ending eventually in death ; acute mania or cerebral softening" (Probyn Williams).

In comparing, therefore, the relative advantages and disadvantages of general anæsthesia and spinal analgesia, the latter seems at the present time to possess no merits over the former to warrant its use in ordinary practice. Spinal analgesia may, however, prove of great value under certain circumstances, as, for instance, when a surgeon is called upon to perform an operation without skilled assistance of any kind. In some thinly populated districts and at sea such an occasion may arise, though it is of rare occurrence in this country. In certain cases also spinal analgesia is preferable to general anæsthesia : such are, amputations for diabetic gangrene, operations for intestinal obstruction, especially in the aged and bronchitic, etc.—cases in which the admin-

istration of a general anæsthetic is attended with great danger. It has been urged by the advocates of spinal analgesia, that if this method is admittedly preferable to general anæsthesia in such desperate cases, it must logically be regarded as safer for all cases. This reasoning, however, is fallacious ; we choose spinal analgesia in a case of diabetic gangrene because we know that a general anæsthetic is likely to induce diabetic coma ; we choose spinal analgesia in a severe case of intestinal obstruction because we know that under a general anæsthetic the vomiting is a source of grave danger. In other words, of two evils we choose what we regard as the lesser, but it is illogical to assume that because a general anæsthetic is a danger to a diabetic, or to a patient with the vomiting of obstruction, that it is therefore unsafe for others. In many cases in which a general anæsthetic is contra-indicated, local infiltration anæsthesia will suffice and should be employed.

CHAPTER IX

POSITION

THE general principles regulating the position of the patient during an anæsthetic have been already referred to (Chap. I, p. 12).

Certain special positions which are required by the surgeon will now be briefly mentioned.

1. The sitting.
2. The dorsal recumbent.
3. The lateral.
4. The semi-prone.
5. The prone.
6. The lithotomy.
7. The Trendelenburg.

With the exception of the first two, these positions are adopted after anæsthesia has been induced in the dorsal recumbent position.

The arms must never be allowed to hang over the edge of the table lest pressure palsy result.

Before starting the administration, it is a good plan to tell the patient to interlock the fingers across the chest (*vide* Plate VI).

The arms can if necessary be subsequently drawn up out of the surgeon's way and secured by a strap or bandage loosely fastened around the wrists. They must not be pulled up too much, and should be so arranged that they can be instantly released in the event of artificial respiration being required.

1. The Sitting Position is suitable for dental extractions, removal of tonsils and adenoids, etc. Any anæsthetic except chloroform, or a chloroform mixture, may be administered to a patient in this position.

2. The Dorsal Recumbent Position is more used than any other for surgical procedures. The head should not be raised, but should always be turned to one side and if possible away from the site of the operation.

3. The Lateral Position is used especially for operations on the kidney, through a lumbar incision.

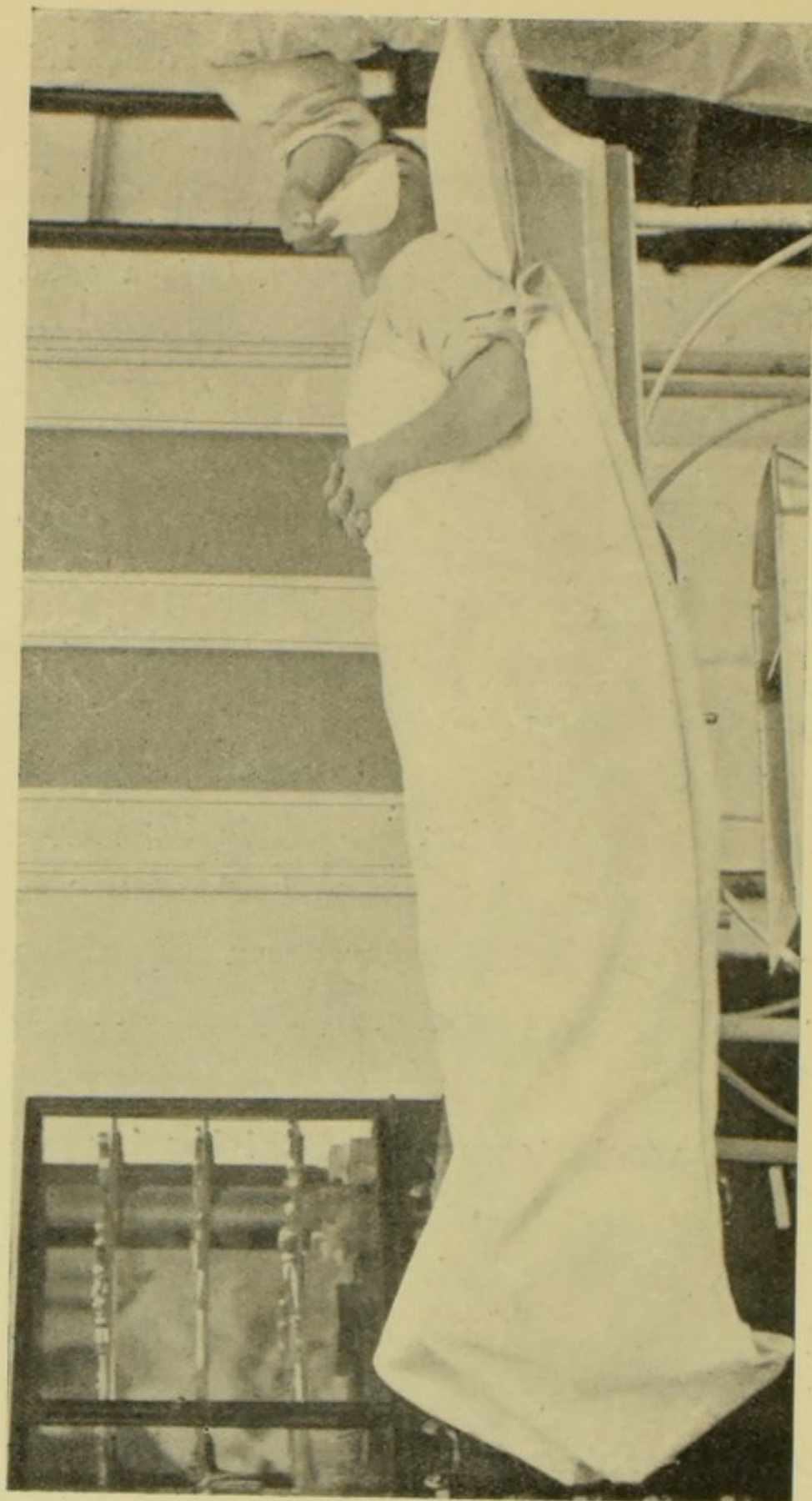


PLATE VI.

The Dorsal Position, showing the patient's head turned to one side and fingers interlocked across the chest.

The patient is turned on to the sound side, a sandbag placed under the loin, and the subjacent thigh flexed on the trunk.

In this position the breathing is slightly hampered because the weight of the body prevents full expansion of the underlying side of the chest.

It is especially important, therefore, to avoid any further interference with the respiration, and to remember that a smaller dose of the anæsthetic will be required to maintain anæsthesia, than when the breathing is normal.

4. The Semi-prone Position is employed for some rectal operations.

The patient is turned on to the side, and the subjacent arm is placed behind the back.

A sandbag should be used to prevent the upper shoulder falling down into the prone position, and one may also be placed under the loin if necessary.

5. The Prone Position is adopted for laminectomy, etc. A pillow should be placed under each of the patient's shoulders, and the head turned to one side. The administration will be facilitated if the head is close to the edge of the table.

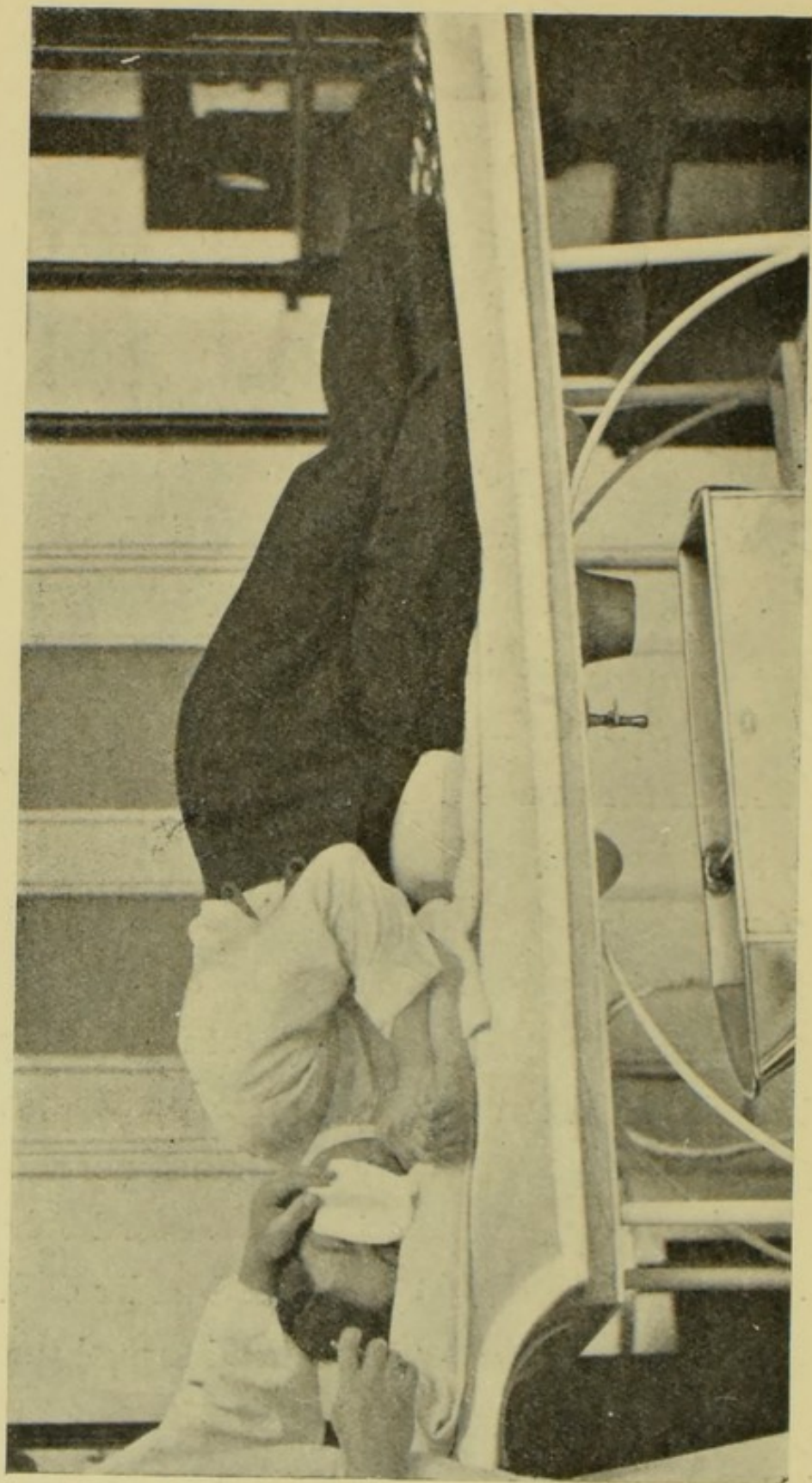


PLATE VII.
The Lateral Position, with sand-bag under the loin, for Lumbar Nephrotomy.

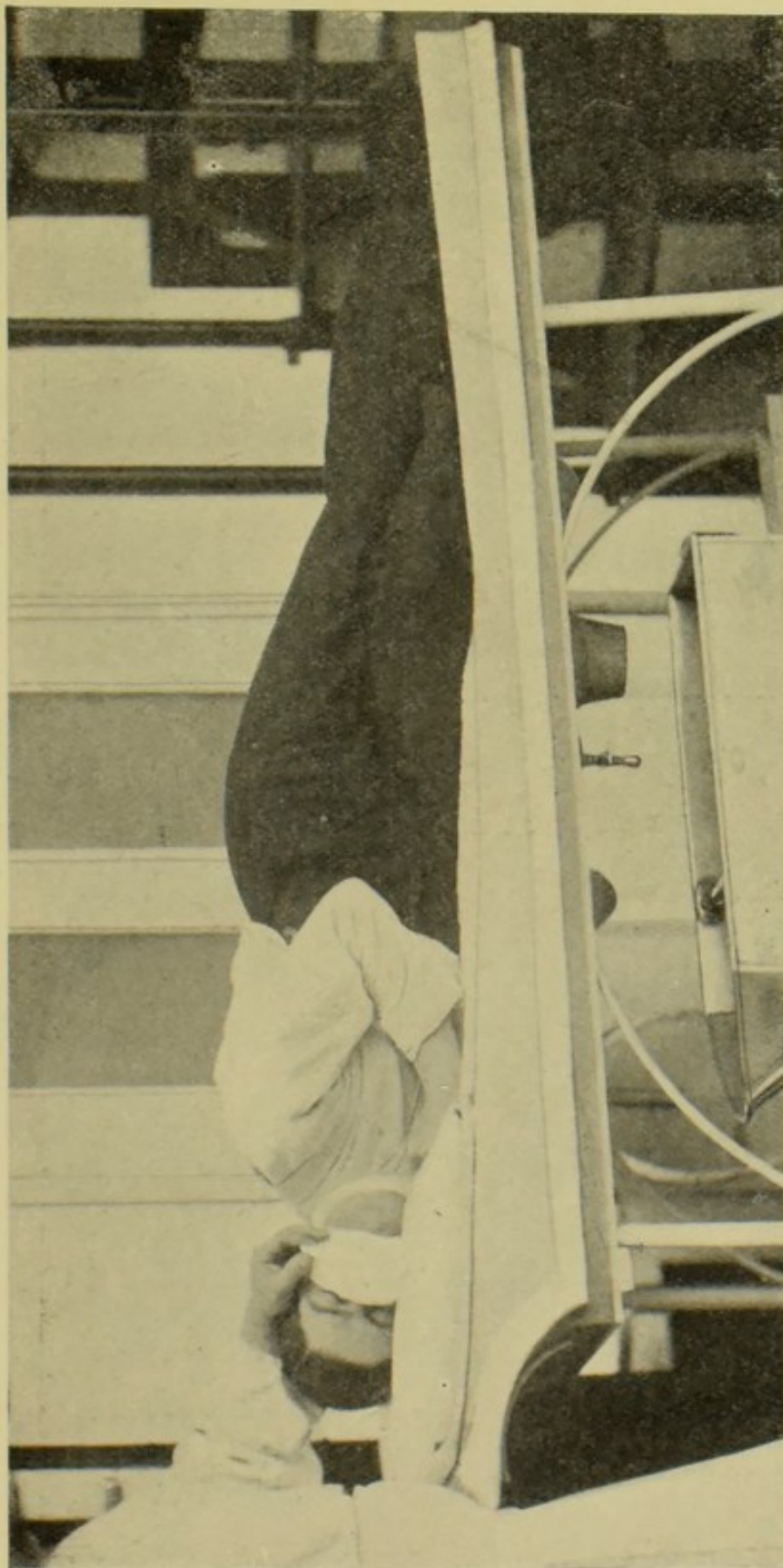


PLATE VIII.

The Latero-prone Position, i.e., lateral position with subjacent arm behind the back.

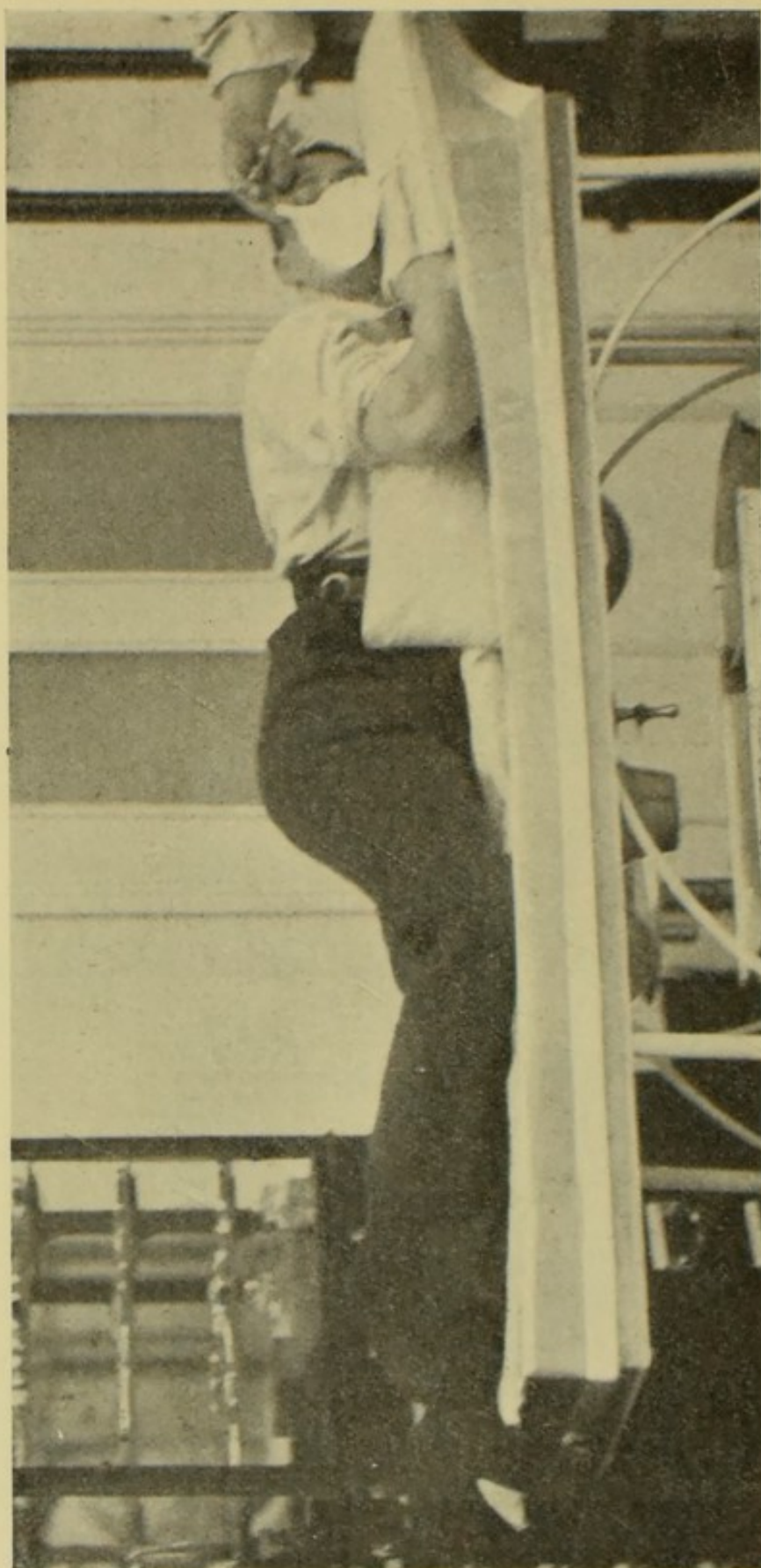


PLATE IX.
The Semi-prone Position.

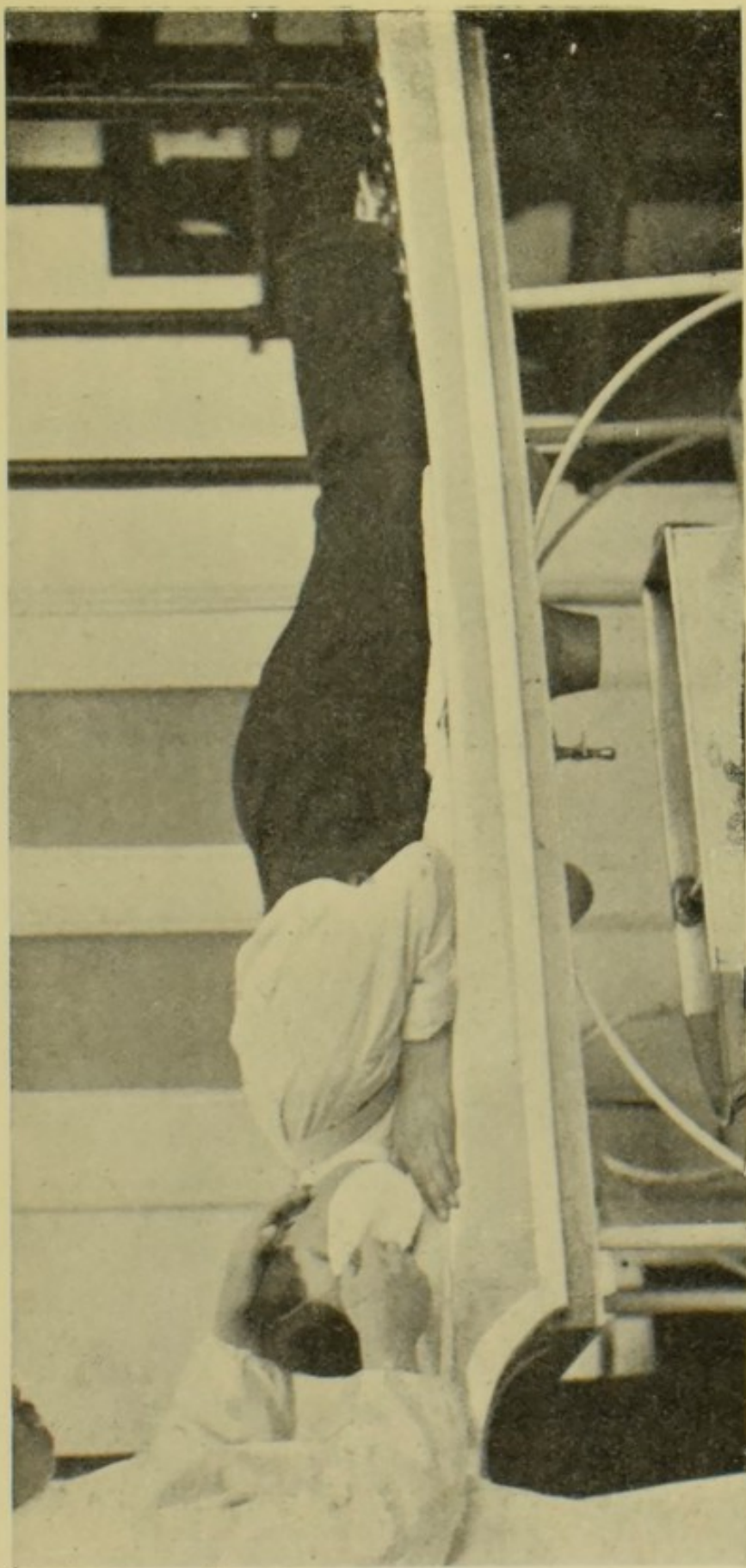


PLATE X.
The Prone Position.

The breathing is somewhat restricted by the weight of the body, more so than in the lateral position. The precautions enumerated above must therefore be observed.

6. The Lithotomy Position is used for some rectal, vaginal, urethral and perineal operations.

When a Clover's crutch is employed, the patient must be steadied by a nurse, or by means of knee straps fastened to the sides of the table.

The thighs must not be unduly flexed upon the abdomen, else respiration will be restricted and the patient may subsequently complain of pain from undue stretching of the muscles.

7. The Trendelenburg Position is employed for certain abdominal operations such as hysterectomy and ovariectomy. Apart from the assistance it affords to the operator, it is probably the safest position for the patient. When anæsthesia has been induced, the patient is pulled down the table so that the legs hang over the end and the knee joint is on a level with the edge. The end of the table is then raised to the required amount, so that the trunk is inclined at an angle to the horizontal.



PLATE XI.
The Trendelenburg Position.

The head must be lowered at the same time that the body is raised to prevent undue flexion of the neck. When the operation has been completed the patient is slowly lowered to the horizontal position, but the legs must not be allowed to remain hanging over the edge of the table.

From what has been said on collapse (Chap. I) and the dangers of chloroform (Chap. IV) it is evident that the Trendelenburg position is well suited for a severe abdominal operation.

It diminishes the danger of failure of the respiratory centre from toxic dilatation of the vascular musculature, and in actual practice post-operative shock is decreased.

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