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A PRACTICAL GUIDE TO THE ADMINISTRATION OF ANÆSTHETICS

R. J. PROBYN-WILLIAMS

ADMINISTRATION OF ANAESTHETICS

A Practical Guide

to the

Administration of Anaesthetics

By

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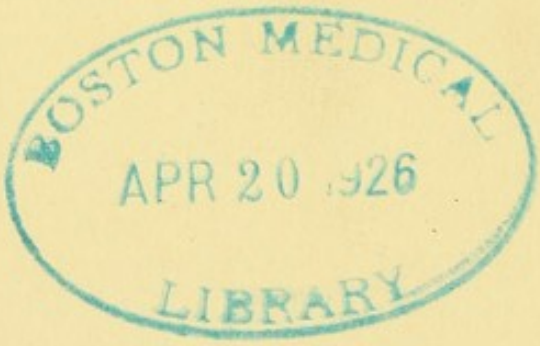

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PREFACE

WHILE teaching the practical administration of anaesthetics I have constantly been asked to recommend a small book on the subject; for at present the average student neglects the larger ones, and either reads nothing at all, or perhaps glances through the article on "Anaesthetics" in some text book on Surgery.

It is with the object of supplying all the essential points in as small a form as possible, and not with any idea of rivalling the larger manuals by Dr. Hewitt and Dr. Dudley Buxton, that I have written this little book, in the hope that it may meet the needs of students, and be read by them during the period in which they receive their practical instruction in this branch of medical practice.

My best thanks are due to Dr. Dakin and Mr. Arthur Durand for very kindly drawing the illustrations for me; to Dr. Silk, Dr. Dudley Buxton, Mr. Carter Braine, Mr. Paterson, and Messrs. Mayer & Meltzer, Barth & Co., and Montague, for the use of blocks illustrating apparatus, etc.; and to Mr. William Turner and Mr. Harvey Hilliard for help with the reading of proof sheets, etc.

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September, 1901.

CONTENTS

CHAPTER I.

GENERAL CONSIDERATION OF THE ADMINISTRATION OF AN ANAESTHETIC.

In the course of the following pages, whenever anaesthesia is mentioned it should be understood that reference is being made to a state of general anaesthesia produced by inhalation of one of the agents commonly employed. The subject of local anaesthesia, or to speak more correctly, analgesia, will be shortly described in the last chapter. The general arrangements which are common to all inductions of anaesthesia, such as the preparation of the patient, etc., will first be described; then the difficulties and dangers that may be met with in connection with this artificially produced sleep; then the various anaesthetic agents will be considered in turn, and the apparatus by which they should be administered will be described; afterwards the choice of the anaesthetic for the different classes of patient, and for special operations will be discussed; and the final chapter, as above mentioned, will be devoted to the subject of local anaesthesia.

Preparations of the Anaesthetist.

Beside the actual apparatus for the administration of the anaesthetic, to be described later, it is important that the anaesthetist should have at hand the necessary instruments

for the treatment of any accidental complications that may arise during the course of the operation. These are a gag, a wedge, mouth-props, tongue-forceps, and a case containing instruments for tracheotomy, with a hypodermic syringe, and solutions of strychnine, morphine, and possibly digitaline. A cylinder of oxygen, a tube for intubating the larynx, and some capsules of amyl nitrite, will also be useful.

The Gag.—The best form of gag is Mason's (Fig. 1), with ring and slide adjustment, and with a fair amount of separation

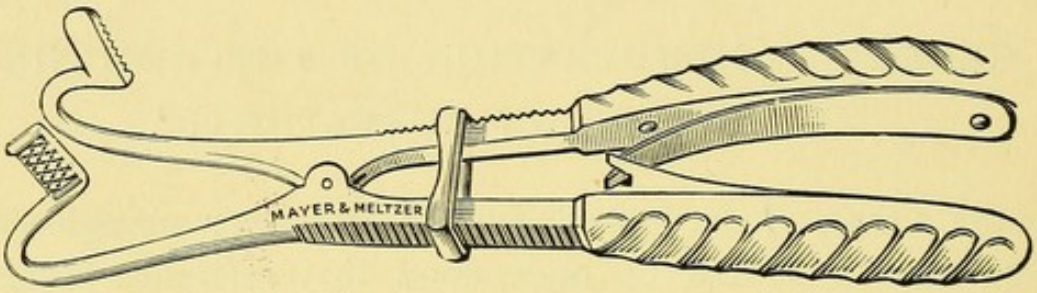


FIG. 1.—MASON'S GAG.

between the two arms when fully open. It is made entirely of metal, and the extremities of the arms should be protected with india-rubber tubing.

The Wedge.—When the jaws are tightly closed, a wedge is very useful in obtaining enough space between the teeth for the insertion of the gag. The wedge may consist of a tapering piece of smooth hard wood (Fig. 2), or may be made of metal, and hollowed to fit over a finger.

FIG. 2.—WOODEN WEDGE.

Mouth-props are generally only required in dental work, and are described on page 66. If, however, it is desirable that the mouth should be kept open for a long period during the course

of an operation, a mouth-prop may be found more convenient than a gag.

Tongue-forceps (Fig. 3) do not vary much in pattern, but there should be a sufficient number of slots on the ratchet to allow of varying pressure being exerted on the tongue, so that the forceps need not be closed more tightly than is necessary to prevent the tongue from slipping out when they are pulled forward.

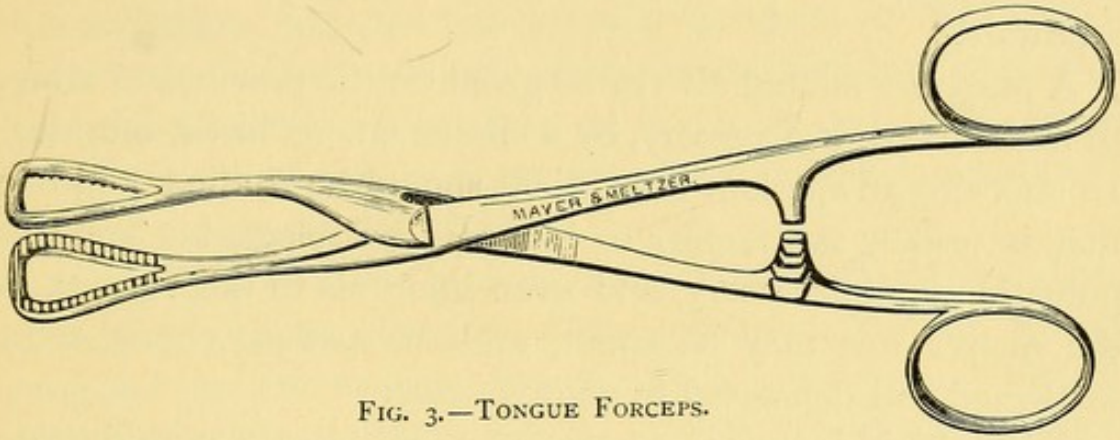


FIG. 3.—TONGUE FORCEPS.

Time of Day for Operation.

The best time for the performance of a serious operation is undoubtedly in the early morning about nine o'clock. The patient may be expected to have awaked after a more or less refreshing sleep, and to be in what has been called the state of "greatest vitality." Should the early morning for some reason be unsuitable, the next best time is the early afternoon, preferably about two o'clock. In the case of children the early morning is especially to be preferred, as they may then be kept in ignorance of any unusual occurrence till the actual time of the operation.

Preparation of the Patient.

When called to administer an anaesthetic, there is seldom time or opportunity for the anaesthetist to suggest any details for the preparation of the patient, but he should be prepared to give any advice when called upon.

In hospital practice it is noticeable that a patient who has been confined to bed for some days will, as a rule, take an anaesthetic much better than one admitted on the day of the operation, in other words, that the discipline and regulation of the diet which precede the operation are beneficial. For all serious operations at least it is important that the patient should be carefully prepared, and neglect of the proper precautions may give rise to trouble, either during the operation, or afterwards.

A *purgative* should always be given on the previous evening, to be followed, if necessary, by a simple enema in the morning. In choosing an aperient the patient should be studied, and one that is usually satisfactory to him may be selected. Too free purgation is unnecessary, and even injurious to the patient, as the night's rest may be spoilt, and the patient considerably weakened and depressed in consequence.

Diet.—This is very important, and exercises a considerable influence on the vomiting after an operation. If the time fixed is in the early morning, the last meal of solid food is best taken on the previous evening, at the time to which the patient is accustomed, probably between seven and eight o'clock. The food should be light and easily digestible, and moderation in the amount should be exercised. If the patient is fairly robust, and sleeps well through the night, nothing need be taken on the morning of the operation; but if he is wakeful, a little tea, or clear soup, or some meat extract with hot water, may be given between five and six o'clock; but in no case should food of any description be given within three hours of the operation. Milk given in the early morning is specially objectionable, as the nervous excitement produced by the dread of the operation will probably retard digestion, and the milk will be vomited in the form of curds.

When the operation is to take place in the afternoon an ordinary breakfast may be taken between eight and nine o'clock,

though caution should be exercised both in the quantity and quality of the food. After breakfast nothing more should be taken. If the time chosen is not in the early morning, or early afternoon, the last meal must be so arranged that there is at least three hours' interval between the taking of the last food and the administration of the anaesthetic.

If the patient is extremely feeble it may be well to administer a little stimulant even within half an hour of the beginning of the operation, but this should only be done in exceptional cases. One or two tablespoonfuls of good brandy diluted with an equal quantity of water may be taken by the mouth, but it is better given in a nutrient enema, with 2 ounces of good beef-tea, and an egg beaten up in it.

It is well to caution habitual smokers that they must deny themselves on the morning of the operation, and be strictly moderate on the evening before; as the pharyngeal catarrh which so generally exists will by recent indulgence be temporarily increased, and will often prove a cause of great annoyance to the patient and anaesthetist during the early stages of the administration.

In operations on the stomach that organ should be washed out just before the anaesthetic is given; and the same procedure may be followed with advantage in all patients suffering from frequent vomiting, as in cases of intestinal obstruction, etc.

For the administration of nitrous oxide much preparation of the patient is not necessary, but it is as well that food should not have been taken for two hours previously, so that for dental operations the later hours of the morning and afternoon are to be preferred. It is also important that no stimulant should be taken just before the administration, as if it is the anaesthesia will be shorter.

Examination of the Patient.

In examining a patient before the administration of an

anaesthetic, a general inspection is often more valuable than auscultation of the chest. The patient will almost certainly be somewhat nervous, the heart will beat rapidly in consequence, and abnormal murmurs will not be easily detected. Again, the mere intensity of a murmur is very little help as a guide to the way in which the heart is doing its work, and in cases which have proved fatal from cardiac failure, it is seldom that auscultation has given any indication of any grave cardiac trouble. In fact, should the stethoscope reveal a cardiac murmur, that alone is of comparatively small consequence, but the supremely important question to be answered is whether the lesion is fully compensated, and whether the heart is doing its work well; and this can be better determined by inspection, etc., than by auscultation.

The character of the pulse, the colour of the lips, and the presence or absence of breathlessness will give a very good indication of the circulatory system. Should these seem unfavourable, search must be made for signs of back-pressure, as oedema of ankles, and moist sounds in the lungs, and the heart should then be carefully auscultated.

The chest should be carefully examined for signs of bronchitis, and if the patient has been lying in bed for some time, attention must be given to the bases for signs of oedema. Emphysema must be specially noted, as when it is marked ether is not tolerated well. Whether trouble is suspected in the chest or not, it is a good plan to watch every patient take a full inspiration and expiration.

The arteries should be carefully examined for signs of degeneration, and if they exhibit marked atheroma ether should not be chosen as an anaesthetic. Cerebral haemorrhage has followed the use of ether in patients with marked degeneration of their arteries.

After the chest, the mouth should be examined to see that no artificial teeth have been left unremoved, and notice should

be taken of any loose teeth, as these may become dislodged if the patient closes his jaws very firmly.

All examinations of the patient should be conducted quietly and with tact, as otherwise he may be unduly frightened, and more harm than good will result.

Position of the Patient.

Whatever may be the position in which the surgeon may require him to be placed during the operation, anaesthesia should be induced in one that is comfortable to the patient. If he is in good general health the dorsal position with the head turned to the right is the one to be preferred, but if this is unpleasant, there is no reason why he should not be allowed to lie on one side. With the head turned to the right the inhaler is held most naturally in the right hand, and the tongue tends to fall into the right cheek instead of towards the pharynx, where it would obstruct the respiration. Most of the mucus and saliva that may be secreted will also collect in the right cheek, and will either run out of the corner of the mouth, or may be removed by the anaesthetist. If, however, the operation is to be performed on the right side of the head, neck, chest, or upper extremity, it is better that the head should then be turned to the left, so that the surgeon is not inconvenienced, and the seat of the operation is not contaminated by mucus or saliva.

By means of pillows, or by raising the upper end of the operating table, the head should be placed at such an elevation that the patient can breathe freely, and if it seem unduly high, the pillows can be removed when the patient is unconscious.

If the operation takes place while the patient is lying in bed, care must be taken as he becomes unconscious, that he does not slip down into the middle of the bed, and the breathing in this way become obstructed through the approximation of the chin to the sternum.

Gas, or gas and ether, may be given without fear of accident while the patient is sitting upright in a chair, but on no account should anaesthesia be induced in this position with chloroform or any of its mixtures, though for the purpose of the operation it may be afterwards necessary to raise the head.

If there be present any disease of the heart or lungs which renders breathing difficult, the anaesthetic should be administered in the position which the patient naturally assumes as the one of greatest comfort, and only when consciousness has been completely abolished should that position be changed. If there be a collection of fluid in one pleural sac the patient will generally lie with that side undermost, and this relative position must be strictly maintained throughout the whole course of the administration.

When an operation is to be performed on any part of the cranium the patient should be anaesthetised in the dorsal position, and when unconscious, the head should be raised very gradually to the required height. If the head is jerked up quickly breathing is liable to be interfered with, and vomiting may occur, and both these accidents will produce intra-cranial congestion, which is to be avoided.

During the administration of any anaesthetic it is important that there should be no constriction of the neck or chest. All corsets should be removed, collars and shirt-bands undone, and if there be any bandage securing a dressing round the neck, if it be at all tight, it will probably require cutting.

The patient, especially if he be an adult male, should be advised to clasp his hands. If this is done, he will be less likely to move them during the induction of the anaesthesia, and should he seem inclined to do so, they may be more easily controlled in this position.

Forcible restraint during the early stage of the administration will be more likely to excite the patient than to produce any

good result, and is in fact only necessary when he seems about to become too violent.

The position for a dental operation will be described on page 69.

Under certain circumstances it is advisable that the patient should be anaesthetised in bed, and removed to a table for the operation. If this is to be done the removal should be made when the patient is unconscious, but before the corneal reflex has been abolished. During the removal the anaesthetist should look after the head, and see that respiration is not interfered with.

STAGES OF ANAESTHESIA.

For the convenience of description the period of anaesthesia has been divided somewhat arbitrarily into four stages, and the phenomena generally met with in them will now be described.

First Stage.

From the commencement of the administration to the loss of consciousness.

The phenomena observed during this stage vary with the way in which the anaesthetic is administered, and the manner in which the patient breathes.

If the drug is gradually and carefully given, and the patient breathes regularly and satisfactorily, no induction of anaesthesia should be unpleasant; but if the administrator is careless or incompetent, the initial stages may be unpleasant, especially if the patient is nervous and excited, and holds his breath. On the whole, chloroform or one of its mixtures is generally more pleasant to take than ether, unless the latter is preceded by nitrous oxide, which is quite tasteless. If the anaesthetic be given in too concentrated a form from the beginning the patient will have a feeling of suffocation, and will probably cough; but if it is sufficiently diluted

at first, and the strength very gradually increased, the patient should pass into a state of unconsciousness without being aware of any unpleasant taste or smell, even when ether alone is the anaesthetic employed.

The feelings which the patient experiences during the first stage of any anaesthesia are much the same. There is a general feeling of a pleasant sleepiness accompanied by feelings of pricking, or tingling in the limbs, with a gradually increasing disinclination to make any muscular movement. As the circulation becomes more stimulated and vigorous, noises and buzzing sounds are heard, and occasionally flashes of light are noticed. During this period any sounds heard by the patient will often be intensified, and it is important that the room should be as quiet as possible. The ordinary conversation of bystanders is heard for some time longer than they think, and the patient will often be troubled by remarks which he was not intended to hear. During this stage all attempts at the arrangement of the clothes of the patient, or any surgical examination, should be discouraged, as they will probably be considered as the beginnings of the actual operation, and fear alone has produced a fatal result during the early periods of anaesthesia. The patient should not be held restrained in any way during the administration, but assistants should be prepared to prevent his doing any damage to himself or his surroundings.

During the first stage the pulse becomes quickened and the respirations deeper and faster, unless of course the patient voluntarily holds his breath. The pupils will generally be somewhat dilated, and react easily and quickly to light.

Some very nervous patients make themselves very uncomfortable by their repeated attempts to vomit and retch, and by constant swallowing and endeavouring to open the mouth widely. In these cases the anaesthetic should be pushed, and the patient rendered unconscious as soon as possible.

As soon as consciousness goes, which event often happens in a very short time if the patient breathes well from the start, there is a short period of analgesia, during which a short operation such as the extraction of a single tooth may be performed without the patient experiencing any pain. There may be some general impression of the removal of the tooth, but it may be absolutely painless. Practically, however, this period of analgesia is of little use to the operator, as at best it is very short, and the points of time at which it begins and ends are most obscure.

Second Stage.

From the loss of consciousness to the loss of the corneal reflex.

The line of demarcation between the first and second stage, namely, the loss of consciousness, is not easily recognised.

It is generally supposed that consciousness is lost as the breathing becomes freer and deeper, but there is no such definite line to divide the first two stages as there is between the second and third—the loss of the corneal reflex.

In this stage there is unconsciousness, that is, the patient will not remember what takes place during the time that elapses between his passing into this stage, and the gradual emergence through it, in his return to consciousness on recovery from the effect of the anaesthetic. Besides this loss of memory there is also loss of volition and intelligence, though there will still be some response to various stimuli. If questions are asked, a reply will often be given, but probably it will be quite unintelligible, or absurd. The patient may make the movements which he is ordered, but they soon become incoordinate.

This second stage is known as the "struggling" stage, for in it some patients, especially those who are alcoholic, struggle more or less violently. With the struggling there is often associated singing or shouting, which, though quite coherent

at first, gradually become more and more incoherent. This condition is generally more marked with chloroform than it is with ether, and it is during this period that fatal cardiac syncope may occur with the use of chloroform (see p. 49). This tendency to struggle is much more marked if the patient is forcibly held during the earlier periods of the administration. Besides the irregular movements of the struggling stage, a condition of tonic contraction of various muscles will often be noticed. The extremities are principally affected, and they are held stiff and rigid; the respiratory muscles being also affected, the breath is held, and this contraction is generally marked in the muscles of the jaw, which causes the mouth to be firmly shut.

A form of regular clonic contraction is occasionally met with, more frequently in the case of ether than other anaesthetics, and known as "ether tremor." It is described on page 129, and is generally confined to the lower extremities. It must not be confounded with irregular jerking movements of the shoulders and upper extremities, which are practically the "jactitations" seen in the administration of nitrous oxide gas when given without air or oxygen. These are asphyxial in origin, and may sometimes occur if the air supply is unduly limited during the administration of ether.

The **respiration** varies considerably during the second stage of anaesthesia. In successful cases it may show very little change in rhythm, but simply becomes deeper and freer till the third stage is reached; but it is more common for the breath to be "held" for a few seconds. This occurs as part of the muscular contraction of the "struggling" stage, and passes off as more of the anaesthetic is absorbed. If the breathing, instead of becoming deeper and deeper, becomes shallow, it is probable that too much air is being allowed to the patient, and the breathing will become more satisfactory when more of the anaesthetic is given.

The breathing under chloroform will be quieter than with ether, and the shallow breathing from too free an admixture of air, which produces sleep rather than anaesthesia, will be more common with the former anaesthetic; while with ether the breathing becomes more noisy from the congestion of the air passages and the increased secretion of mucus and saliva, which is not noticeable with chloroform.

Circulation.

With ether the pulse becomes fuller and fuller, but with chloroform the depressant quality of the drug is manifested, and the pulse does not improve in character. If the struggling is marked the pulse soon shows signs of deterioration, and becomes faster and smaller in volume. This is much more marked if at the same time the breath is persistently held. It is at this stage, when the breath has been held for some seconds, and when the first long inspiration has to be taken, that if the vapour is not sufficiently diluted with air, a fatal overdose of chloroform may be absorbed. If the air-way is kept clear, and there is little struggling or holding of the breath, the pulse under chloroform will not change much for the worse.

The **colour** of the patient under ether will be at first flushed, but will gradually become more or less dusky from the restriction of oxygen on account of the construction of the apparatus employed. There will often be marked **sweating**, together with the special rash known as the "ether rash" described on page 129.

With chloroform the face, if it change colour perceptibly, will become somewhat paler, and sweating to the extent observed in the case of ether is rare.

With ether there will be a greatly increased secretion of **mucus** and **saliva**, which will not occur with chloroform.

The **pupil** in this stage is large, perhaps more so in the case

of ether on account of the greater restriction of free oxygen in its administration; it readily reacts to light.

The breathing gradually becomes deeper and freer, the muscles relax, and with the loss of the corneal reflex the third stage is now reached.

Third Stage.

The third stage begins with the loss of the corneal reflex, and is the stage of surgical anaesthesia.

If the drug which is being administered is pushed too freely, and an overdose given, a fourth stage is reached, the stage of poisoning.

Respiration.

In a typical case the respiration during the third stage, or in other words during surgical anaesthesia, is deep and regular, and gradually becomes more abdominal in character. It is more noisy in the case of ether than with chloroform on account of the congestion of parts of the air-way, together with the increased secretion of mucus and saliva produced by that drug; and the stimulating effect of the ether makes the rate of respiration also quicker. The muscular spasm referred to above will be more marked with ether, and hence it will be found harder to keep the jaw in good position, though as the muscles become relaxed it becomes easier. With chloroform the breathing, though deep and regular in a satisfactory case, is very different from that with ether, as it is very quiet and sometimes almost inaudible; the rate, too, is slower.

Laryngeal spasm may be met with in this stage, and is described on p. 36. If the breathing is not deep and regular during this stage the cause for this must be sought and remedied, as described in the account of the "Difficulties and Dangers of Anaesthesia" on page 38.

Circulation.

The condition of the circulation shows a marked differ-

ence according to the drug which is being administered. With ether the pulse will be found full and bounding. It is generally quite regular, and the rate is increased to between 80 and 100 beats per minute. With this stimulated circulation there may be noticed flushing of the face, sweating, especially on the forehead, and the "ether rash." The pulse of chloroform anaesthesia is generally about the normal fulness of the individual patient, and of the usual rate, or perhaps somewhat slower.

Of course all these descriptions refer to a patient who may be described as "taking the anaesthetic well."

The **colour** of the face of a patient under the influence of ether will, if the air-way and breathing are perfectly satisfactory, be somewhat florid, while in the case of chloroform the face is generally paler than normal. If the air-way and breathing are not satisfactory, the face will soon become dusky, especially with ether, and this must not be allowed.

The **pupils** should not be widely dilated, but of a moderate size; the average diameter of the pupil of a patient under ether being about 4 mm., while that with the use of chloroform is about 2·5 mm.

The pupil should react to light, and with chloroform there may be seen the unusual phenomenon of the two globes moving independently, the "unassociated movement" first recorded by Dr. F. Warner.

The **rigidity of the muscles** which occurs during the second stage lasts much longer, and is more marked in the case of ether, though eventually they may be perfectly relaxed by this drug. With chloroform the rigidity soon passes off. This is especially noticeable in the greater ease with which the lower jaw may be kept well forward in the case of chloroform, as compared with that of ether.

The **secretion of mucus and saliva** which was noticed in the second stage, becomes more and more marked in the third

when ether is being given, while with chloroform any marked increase is unusual. The principal differences in the condition of a patient under ether as compared with that of one under chloroform are due to the fact that while ether is a powerful stimulant, chloroform is distinctly depressant in its action.

Fourth Stage.

The fourth stage of anaesthesia, or *the stage of overdose* of the drug which is being administered, is not separated from the third stage by any sharp line of demarcation. But still the general condition of a patient who is suffering from an overdose of an anaesthetic presents so much difference to that of a patient who is only just sufficiently anaesthetised, that the onset of the fourth stage should be easily recognised.

Respiration.

The breathing gradually becomes more and more shallow, and slower in frequency with chloroform, though with ether it is often very rapid and shallow. It will eventually stop altogether, but before this happens it sometimes becomes intermittent and jerky.

Circulation.

The pulse becomes smaller and faster, till the beats can hardly be counted at the wrist, and will then be imperceptible. The face of the patient is now pale and livid in the case of chloroform, but more dusky with ether. The nose is cold to the touch, and the forehead is covered with a cold, clammy sweat.

The eyelids are separated, and the globes are exposed, and are often found to be rotated upwards. The *pupils* are widely dilated, and do not react to light, and the corneal reflex is entirely absent.

A patient exhibiting all the above signs would be in a very serious condition, but there are many degrees of overdose which vary in their signs between those just enumerated and

those of the third stage. In the case of ether, when an overdose is given, it must be remembered that the circulation will be affected much later than it is with chloroform; and that though the patient may show distinct signs of a too free use of the anaesthetic, if the cause is recognised, the inhaler removed, and the proper measures taken, the patient will be recovered in almost every instance. With chloroform, unfortunately, irreparable damage may have been done before the serious state of the patient has been appreciated, and all the measures that may be taken will sometimes fail to restore the patient to life.

The foregoing paragraphs indicate sufficiently the resemblances and the differences between the effects of chloroform and ether in the various stages of anaesthesia.

When mixtures of ether and chloroform are given the signs generally resemble those of chloroform rather than ether, with the exception that the circulation of a patient who is inhaling a mixture containing some ether should be better than one inhaling pure chloroform.

When gas and oxygen, or gas and air are being given for a prolonged operation, the general signs to a great extent resemble those of ether, though as a rule there is no excessive secretion of mucus and saliva; but the period of induction of the anaesthesia is so short that it is not generally described in three stages (see page 76).

Though the anaesthetic state has thus been divided into different stages, the student must remember that this division is purely for convenience of description: and that the loss of the corneal reflex is really the only definite line of demarcation between any two stages that he will always be able to recognise.

REGULATION OF THE ANAESTHESIA.

When once the patient has reached the third stage of anaesthesia, the attention of the administrator must be concentrated in maintaining him in a condition of unconsciousness

sufficiently deep for the operation to be performed. To do this he must observe the following :

1. Respiration.
2. Pulse.
3. Colour of the face.
4. Size of the pupil.
5. The presence of the corneal reflex.
6. Muscular movements.

1. Respiration.

The character of the breathing is one of the most important guides in maintaining the condition of anaesthesia. When the patient has once passed into the third stage of anaesthesia, the breathing becomes deep and regular, and the anaesthetist must endeavour to keep up this rhythm without any intermission. He must listen carefully when the first incision is made, and if the breath is not held, he will know that the patient is sufficiently under the influence of the drug; but if it is held, more of the anaesthetic will probably be required, and some stimulation of the respiration, by rubbing the lips with a towel, may be necessary to re-start the rhythm which has been interrupted. For this purpose the inhalation of a few breaths of strong ammonia has been recommended.

The more perfect a watch the administrator keeps on the respiration, the sooner will he learn to detect, by changes in it so slight that they might escape an ordinary observer, that all is not going well, and valuable time may sometimes be saved and accidents prevented. The breathing with ether is so loud that there is no difficulty in hearing it, but with chloroform it sometimes becomes inaudible, and then it must be felt by a finger or two held close to the mouth of the patient. In order to make this quiet breathing of chloroform anaesthesia audible, some administrators allow the jaw to slip back till there is just sufficient sound made by the soft parts to allow of each respiration being heard. Care, of course, must be taken that the jaw is not allowed to slip too far back.

Some inhalers are now made as a modification of Junker's, in which a feather is moved with each expiration of the patient; but these are of less use than would appear at first sight, for the feather is so very light that it will be moved by a current of air which would be quite insufficient to maintain the life of a patient.

It is not enough that some movement of the chest and abdomen is observed, for there may be muscular action with very little air passing backwards and forwards; but for the condition of the patient to be considered satisfactory each expiration should be heard, or felt by the fingers. When the breathing, which has once been deep and regular, becomes quieter and more shallow, the cause is one of two, viz., that the anaesthesia has been allowed to become either too deep, or too light. If too much of the drug has been administered, the pupil will be found dilated, there will be no corneal reflex, and the pulse will have become worse than it was when the respiration was satisfactory. If, on the other hand, the anaesthesia is too light, the pupil may be found either dilated or very small, as will be explained below, and the corneal reflex will probably be present.

If the respiration during the course of an administration becomes very shallow the lips should be rubbed with a towel, and more of the drug given if the other signs of light anaesthesia are present, while more air must be allowed if it is already too deep. Breathing which becomes more and more shallow, with the corneal reflex present, and the pupil pin-point in size, is generally followed by attempts at vomiting. When ether is being administered it should be remembered that the breathing may become rapid through the stimulating effect of the anaesthetic.

2. Pulse.

Though the pulse undergoes many changes during the second stage of the administration, when the third stage is

reached it settles down into a regular rhythm, which with ether is accelerated, while with chloroform it is either normal or somewhat slower, as is frequently the case when the patient is elderly. It is unnecessary to keep a finger on the pulse during the whole length of an administration, but it is important to examine it sufficiently frequently to observe the state of the circulatory system, and to detect the onset of shock induced by the operation.

As the operation proceeds the pulse tends to become smaller and more frequent, especially with the use of chloroform, but this will also happen early in the course of the operation if too much of the drug is given. The signs will then approach in character those described above under the heading of the stage of overdose, and the remedy is obviously to give less of the anaesthetic and more air. The pulse may also become feebler when the operation itself is producing a condition of shock to the patient, when much blood has been lost, and also when the breath is being held in light anaesthesia before the onset of vomiting.

3. The Colour of the Face.

The colour of the face is the best indication of the amount of air that the patient is actually receiving.

When first anaesthetised with ether it is generally slightly more cyanosed than it should be, but after a few minutes of the third stage, when the patient has been allowed several breaths of air, this should be replaced by a healthy though flushed colour. If this desired end is not obtained, the cause must be sought and remedied. (See Obstruction to Respiration, page 34.)

During the administration of chloroform it is most important that no asphyxial element should be allowed to complicate the depressant influence of the drug, as the danger to the patient is thereby immensely increased. Hence it is of the

utmost importance that the respiration and the colour of the face should be most carefully watched while this drug is being given, and any sign of cyanosis or undue pallor must be at once traced to its cause and remedied.

If the anaesthesia is light, that is, if the corneal reflex is present, the other signs of approaching vomiting will be accompanied by cyanosis, or, if chloroform is being administered, by pallor.

4. Size of the Pupil.

When the third stage is first reached, and the corneal reflex disappears, the pupil will generally be found large, especially with the use of ether, on account of the greater limitation of oxygen which naturally accompanies the induction of anaesthesia by means of the apparatus generally used.

Normal Pupil.—After a few minutes, however, when air has been allowed, the pupil becomes smaller, and after about five minutes the average size is reached, namely, a diameter of 4 mm. for ether, and 2·5 mm. for chloroform.

Contracted Pupil.—The size of the pupil during the course of an operation is one of the most delicate indications of the depth of the anaesthesia. If the pupil contracts to what is known as "pin-point," and the corneal reflex is found to be present, unless more of the anaesthetic is given, vomiting will often follow. Of course a very small pupil does not necessarily of itself indicate that vomiting will certainly occur, but it should put the anaesthetist on his guard against allowing the anaesthesia to become too light.

Dilated Pupil.—When a pupil which has previously been about the normal size is found to be dilated, the cause is one of two. In the first instance, too much of the drug may have been given, and the pupil will have dilated from paralysis of the sphincter of the iris.

Should this occur, the administrator may be conscious that

he has been giving the drug rather freely, the corneal reflex will be quite abolished, and other signs of overdose, as mentioned on page 16, may be present. To remedy this more air must of course be given.

If the dilated pupil is accompanied by a brisk corneal reflex, the cause of the increase in size is the reflex irritation due to the operation which follows too light an anaesthesia. The pupil will soon contract when more of the drug is given. This reflex dilatation occurs more readily in the case of children and weakly and anaemic women than it does in men.

When vomiting actually takes place a pupil which may have been "pin-point" will often be seen to dilate to a large size.

5. Presence of the Corneal Reflex.

When the patient has once reached the third stage described above, it will be found necessary for the performance of many operations that he should be kept in this condition by the administrator, in other words, the corneal reflex must be kept away. Of course the mere presence of the corneal reflex is in itself immaterial to the operator, but when once it has reappeared, if more of the anaesthetic is not given, it may be followed by the other signs of the second stage, namely, swallowing, straining, vomiting, coughing, and muscular movements, and each or any of these may be sufficient to ruin an important operation.

There are, however, many slight operations where any of these would not absolutely spoil the work of the surgeon, such as operations on the extremities, where a slight movement might be controlled by assistants, etc., and in these the corneal reflex may be allowed to be present, though the other signs of light anaesthesia should, if possible, be kept away. For the performance of serious operations, especially those on the abdomen, it is safer, as a rule, to keep the corneal reflex just away; but in some emergency operations on the abdomen in

very feeble subjects, it is possible to allow the skin incision to be made with the corneal reflex absent, and then allow it to return, as the intestines are less sensitive, and reflex phenomena will often not be induced by their manipulation.

In some operations, such as tracheotomy, operations for the relief of empyema, removal of the thyroid gland, etc., the corneal reflex should never be lost.

6. Muscular Movements.

In the great majority of instances the ordinary third stage of anaesthesia is characterised by complete absence of any muscular movements, but occasionally, and especially in alcoholic patients, even when the corneal reflex is completely abolished, small movements may be observed. They will generally be met with most frequently as wrinkling of the brows, or irregular movements of the fingers. In themselves they are of no great moment, but act as a warning to the administrator not to let the anaesthesia become lighter. Besides these, the movements referred to on page 12 may be noted.

In cases where the anaesthesia is intentionally light, the amount of muscular movement may be taken as a rough guide as to the amount of anaesthetic to be given, in other words, the patient may simply be kept quiet, and the movements not allowed to become so extensive as to inconvenience the operator.

In maintaining a patient in a satisfactory condition throughout the course of a long operation, the above signs must always be taken as the guides of the administrator; and the amount of the drug given, and the air supplied to the patient, will depend not on one alone, but on the sum of all these balanced one against another. Some practice will be necessary before the administrator will be able to recognise at once when he is giving too much, and when too little of any anaesthetic; but the above-mentioned signs are the only ones that can guide him,

and the greater attention he pays to them in every case in which he administers an anaesthetic, the sooner will he become proficient in this branch of practice.

It is well for the inexperienced administrator to remember that his object is not to see how much of the anaesthetic the patient can take with safety, but what is the smallest quantity that will produce all the results that he requires. On this account, when administering an anaesthetic to an alcoholic patient, though much of the drug will be required, and though the amount seems enormous when compared with that required by an ordinary individual, yet he must give sufficient to thoroughly anaesthetise his patient, and then as little as will suffice to maintain that condition of anaesthesia which the operator requires.

RECOVERY FROM ANAESTHESIA.

After an administration of nitrous oxide the return to consciousness is rapid, as the anaesthesia is quickly obtained. The dilated pupils contract, the colour of the face soon becomes normal, or even flushed, and after two or three minutes most patients are perfectly conscious. After-effects of the anaesthesia are as a rule absent, or if any are present, they are very slight. Some headache or giddiness may be complained of, but a few breaths of fresh air will soon remove these. Vomiting is very rare, unless the patient has just eaten a very heavy meal, or swallows some of the water with which the mouth should be washed out. As a general rule, the patient can walk away feeling perfectly well after about five minutes' rest.

As the anaesthesia from ether and chloroform is more slowly obtained than with nitrous oxide, so the return to consciousness is more gradual and slow.

The corneal reflex, if abolished during the operation, can again be obtained, the pupils, if dilated with the amount of the anaesthetic, will gradually contract, but if small from the light

anaesthesia during the operation they may dilate. Should they become very small, or "pin-point," and the face at the same time grow paler, while the breathing is very quiet, or the patient become cyanosed through "holding" of the breath, it is probable that vomiting is about to take place.

The gradual diminution in the force and frequence of the respiration is one of the most noticeable of the symptoms of the recovery from ether.

To describe thoroughly the return to consciousness all the signs of the first and second stages of anaesthesia might be enumerated, as the patient must pass through these in the reverse order to that in which they occurred during the induction.

The care of the Patient after an Anaesthetic.

When the operation is finished, the dressings applied, and the patient's wet clothes are removed, he should be lifted into the bed, which should have been previously well warmed by means of hot-water bottles. In this moving, care should be taken that there is no jerking of the patient, but that he is gradually lifted from the table to the bed, while the body is maintained in a horizontal position, and laid, but not dropped, in the bed. During the transfer the anaesthetist should take charge of the head, and see that respiration continues satisfactorily. Undue shaking or jerking of the patient at this time will encourage vomiting, while if the head is suddenly elevated, syncope may occur. For this reason, when it is necessary for the patient to be carried upstairs on a stretcher, it is better that he should be taken with his feet first.

The temperature of the room in which the patient is placed after the operation should be kept at about 65°, and though ventilation should be free, he must on no account be exposed to a draught, especially after the administration of ether.

If the nature of the operation will permit of it, the best

position for the patient will be for him to lie almost on one side, with a pillow under the uppermost shoulder. If there is nothing in the operation to indicate to which side the patient should be turned, the head should always be turned to that side which is most convenient for the purposes of nursing. When lying on one side vomiting is less likely to occur, and if it does, it can be more satisfactorily treated; coughing also will be more easily performed.

The room should be darkened, and if the patient has come round sufficiently to understand what is said to him, he should be told to go to sleep. Talking with a patient in this stage is to be distinctly discouraged, as vomiting is more likely to occur if it is allowed, and absolute quiet in the room is desirable. No friends should be allowed into the room till after consciousness has completely returned, and even then strict quiet must be enjoined on them.

During the recovery from an anaesthetic all patients should be carefully watched. Vomiting is very liable to occur, and if the patient is neglected, some of the vomited matter may not be thoroughly removed from the mouth, but be sucked back into the larynx, and give rise to very serious symptoms.

The patient must be kept warm by means of hot-water bottles and blankets, and if in spite of these endeavours the nose and the extremities remain cold to the touch, more active measures must be taken. (See treatment of Shock, p. 29.) Great care must be taken that hot-water bottles are not allowed to come in contact with the patient, as extensive burns have been caused in this way.

The anaesthetist should not leave a patient till he is satisfied that after he has been placed in bed, the pulse and respiration are satisfactory, and improving in quality.

Should a patient be inclined to be excitable or noisy on recovering consciousness, little should be done to restrain him at first, but persuasion should be tried, and care taken that in

any violent movements to throw off the bed-clothes he does not become unduly exposed to cold. Should the condition become worse instead of better, a hypodermic injection of morphia should be given, and the patient restrained by assistants from doing violence to himself or his surroundings. On no account must a patient's action be controlled by tying him down to the bed, but he may be restrained by hand till the morphia has time to take effect.

Extreme excitement during the recovery from an anaesthetic is generally only observed in alcoholic patients.

Vomiting.

If ether has been the anaesthetic employed, vomiting as a rule takes place early in the stage of recovery, often so early that the patient is not conscious of it, and does not remember it afterwards. The vomit consists chiefly of saliva that has been swallowed during the early stages of the administration, with the mucus that has been hanging about the pharynx, and may be mixed with a little bile-stained fluid from the stomach. If the patient has been well prepared for the operation, no sign of food will be noticed in the vomited matter. After this removal of saliva and mucus the patient will as a rule breathe more freely, will become of a better colour, and will often have no further trouble from the ether save a little headache, and a more or less distinct sensation of the smell and taste of ether.

With chloroform for the anaesthetic vomiting occurs in fewer cases, but when it does, it is later in the stage of recovery, often when the patient is quite conscious. It is then very annoying, and will be distinctly remembered by the patient. When vomiting occurs after chloroform it is sometimes very severe, being both very frequent, and accompanied by severe straining, and in some patients by a marked tendency to syncope.

Treatment.—For the slight cases no treatment beyond abstinence from all food for three or four hours is necessary.

Small pieces of ice are frequently given to be sucked, but a teaspoonful of water as hot as the patient can take it, given at intervals of about a quarter of an hour, will probably be of more service in checking the vomiting. With this hot water a minim of the tincture of Nux Vomica may be given. If the water can be taken really hot, it is best given in a china spoon, as a metal one may burn the lips.

Should the vomiting not yield to these remedies, from 10 to 15 grains of bicarbonate of soda may be given in a cup of hot tea or coffee. Should these fail, the patient must be treated on the same lines as one suffering from persistent vomiting from some other disease. Ice-bags, and a mustard leaf to the epigastrium have been recommended, and occasionally the stomach has been washed out with a good result. It is stated that the inhalation of toilet vinegar sprinkled on a handkerchief, and held near the patient's face, has also proved of service in checking vomiting.

Thirst.

This symptom is best treated by teaspoonfuls of hot water given as above, or by copious enemata of hot water. The **taste** of ether, which annoys some patients on their recovery, may be lessened by sucking a small piece of lemon; while if **dryness of the tongue** is complained of, the mouth may be swabbed out with glycerine and borax, or some other demulcent.

Shock.

At the end of a long and serious operation the patient may be found pale and blanched, with the extremities and nose cold to the touch, and a cold clammy sweat on the forehead, the eyelids slightly apart, and the pupils fixed and dilated, the respiration shallow and perhaps sighing in character, and the pulse rapid, and small in volume.

Such a patient is said to be suffering from severe surgical shock. The anaesthetic may have been given somewhat too freely, but the loss of blood, and the shock to the nervous system, have done most to produce the result.

Treatment.—A patient in this condition requires very careful management and nursing to enable him to recover. He must be placed carefully in bed as soon as possible, and extra warmth supplied in the form of hot-water bottles. The legs of the bed at the lower end should be raised and supported, so that the head is somewhat dependent, and not more than one pillow should be used. The lips are then to be briskly rubbed with a towel, and brandy may be rubbed on them, and on the inside of the cheeks. Ordinary strong "smelling salts," or Liquor Ammoniae should be held near the nostril. All these manoeuvres help to encourage respiration.

Two or three drachms of brandy may be given hypodermically, or an ounce of brandy mixed with two ounces of warm water, or, if it is ready, the same quantity of hot coffee, should be given by the rectum. The best drug for the treatment of this condition is undoubtedly strychnine. It should be given hypodermically in a dose of one-thirtieth of a grain, to be repeated if necessary, if it seem to produce a good effect.

If the condition of the patient is probably caused by an excessive loss of blood, copious injections of hot water by the rectum should be tried, and if these fail recourse must be had to infusion of normal saline solution. Indeed, if the haemorrhage during the operation has been very severe, this holds out the best chance of helping to eventual recovery, and should be performed as soon as possible.

Bronchitis.

Bronchitis is supposed to be a frequent sequel to the administration of an anaesthetic, especially of ether, but this

frequency has been much exaggerated, and in private practice at least, it is not common. It is true that it occurs more frequently in hospital patients, and this suggests that it is not so much the ether that is to be blamed, as the exposure of the patient after the operation.

He is taken from a theatre which is often overheated, then wheeled out into a draughty corridor, then carried through several wards and passages, perhaps up and down in a lift, and finally reaches his bed. The temperature of the ward is probably much lower than that of the theatre which he has just left, and he may be placed near an open window which is providing the ventilation for the ward. The wonder is that this exposure does not produce more cases of bronchitis among hospital patients.

Of course if ether is given for some time to a patient already suffering from bronchitis, one must expect the symptoms to be increased by it; but if the lungs are healthy to start with, and there is no undue exposure to cold after the operation, bronchitis will be found to be a rare sequel to the administration of ether. The class of patients most likely to be troubled by this complication are those who suffer generally from a cough in the winter, or who have a strong family history of phthisis or some other lung affection.

The operations after which it is most likely to occur are (1) abdominal operations, and those for the cure of hernia, etc., when the patient must lie flat on his back after the operation, and the abdominal respiration is interfered with by the presence of the wound and the application of dressings, etc.; and (2) amputation of the breast, when during the operation the chest is much exposed, and afterwards on account of the tight bandaging it is very difficult for the patient to cough, and so get rid of any mucus that may accumulate in the bronchi.

For all these cases it is better that ether should not be given for too long, but if anaesthesia has been induced with it, and the operation is likely to be prolonged, a change should be made to the A.C.E. mixture or chloroform at the end of half an hour or so.

Treatment.—Should any cough be noticed after the patient has recovered consciousness, special care must be taken to keep him warm in bed, and out of any draught.

There is nothing in the bronchitis or broncho-pneumonia which may follow an anaesthetic which calls for treatment differing from the routine treatment of bronchitis, but care must be taken to see that the patient is placed in such a position that he is able to expectorate; that is to say, if from the nature of the operation it is undesirable that he should sit up, he must be at least turned on to one side, and supported there by pillows.

Food after an Anaesthetic.

The longer a patient can go without food after the recovery from an anaesthetic, the less likely he is to be sick when he does take it. The first food should be entirely liquid, and tea is probably the best of all. If the patient does not wish for tea, coffee or a little soup may be given instead, but none of these should be given for at least two or three hours after the operation. After an abdominal operation, or one after which it is important that the patient should be kept especially quiet and free from vomiting for some time, food may be withheld from the mouth for a much longer time, and the patient fed by the rectum.

If the patient take the liquid food without any nausea or vomiting following it, some more solid food may be given two hours afterwards. In the choice of this the patient may be consulted, and bread and milk, or even fish, may be allowed.

RARE SEQUELAE OF ANAESTHESIA.

Under this heading may be noted :

Insanity.

This, as a rule, only occurs in a patient who has previously been insane, and has recovered for a time. It may take the form of acute mania, or melancholia.

Patients who are insane can take anaesthetics well, and are not as a rule made worse by them, but if ever it comes to the knowledge of the anaesthetist that a patient to whom he has to administer an anaesthetic has at some time or other been actually insane, it is his duty to warn the friends that it is quite possible that though the administration may be perfectly successful, and the operation required may be satisfactorily performed, yet on the return of the patient to consciousness, some of the old symptoms of insanity may again be manifest.

Paralyses.

These may be described as (*a*) central, and (*b*) peripheral. The *central* paralyses are generally the result of a cerebral haemorrhage, and always occur in old people, or those with very degenerate arteries. They may be due to the struggling which takes place when a nervous patient is being anaesthetised, but it has happened on more than one occasion that a haemorrhage has occurred just before the administration has been commenced, and the anaesthetic in consequence has escaped the blame which otherwise would have laid at its door. In a very neurotic subject an anaesthetic may be the starting-point of some functional nervous disorder.

The *peripheral* forms are local paralyses, generally of the muscles of the arm and shoulder from some faulty position in which the arms are kept above the head during the operation, or from pressure of some part of the arm against the edge of

the table during a lengthy operation. Such paralyses are to be treated on general principles, and for further information on the subject an article on "Post-Anaesthetic Paralysis," by Dr. Turney, in the *Transactions of the Society of Anaesthetists*, Vol. 2, should be consulted.

Albuminuria in a patient previously free from any trace of albumen in the urine is said to be more common after chloroform than after ether, but if albuminuria already exists, it is more likely to be increased in severity after a prolonged administration of ether, than after one of chloroform.

Glycosuria is stated to have followed the inhalation of chloroform.

CHAPTER II.

DIFFICULTIES AND DANGERS OF ANAESTHESIA.

In connection with the administration of an anaesthetic, danger to the life of a patient may arise through one of the two great systems of the respiration and the circulation. Though one system may be affected primarily, the other soon becomes involved; and in many cases when the condition of a patient on the operating table becomes serious, it is hard to tell which was the first to fail.

However, for the sake of clearness they will now be described separately:

FAILURE OF RESPIRATION.

The causes of the failure of respiration may be divided under two heads. (1) The mechanical, or local, producing obstructed breathing, and (2) the central, or general causes of failure.

(1) Obstructed Breathing.

This may arise (*a*) in the *mouth.*—In the old and edentulous the lips may so fall together during inspiration that they will form a sort of valve, and prevent the free entry of air.

The tongue may cause obstruction from its large natural size, or because of its increased size from congestion, and if

the head is not kept in a suitable position, will fall back against the pharyngeal wall, and almost completely block up the air-way. Further back, large tonsils and collections of adenoid growths, inflammatory swelling from cellulitis of the neck, etc., or retro-pharyngeal abscess, will be the commonest causes of obstruction, together with foreign bodies, as plates of artificial teeth, food, vomited matter, or blood.

(*b*) In the *nose* the presence of polypi, spurs, malformations of the septum, swelling of the mucous membrane of the turbinate bones, and tumours, will block the nasal air channel; and if the mouth is kept tightly closed, the air-way will become completely obstructed. It must be remembered that many of the causes which beforehand only somewhat narrow the air-way, may, on account of the congestion produced by the anaesthetic, completely obstruct the breathing; and this will be noticed more frequently with the use of ether.

(*c*) In the *larynx, trachea, and bronchi.*—Here the obstruction to respiration is generally due to the presence of foreign bodies, such as plates of artificial teeth, food, blood, or other fluid, either from the mouth, or coughed up from the chest, or vomited from the stomach, and sucked back into the air-passages by an inspiration. Lister has pointed out that the aryteno-epiglottidean folds, which are normally well supplied with blood, may become so congested that when they fall together like a curtain and touch the base of the epiglottis, they will produce complete obstruction. Excessive secretion of mucus in the air-passages may produce some considerable obstruction, as will oedema of the lungs.

Under this heading must be specially mentioned **Spasm of the Glottis.** In this condition the air-way is more or less occluded by the closure of the superior aperture of the larynx through muscular action. It may occur with ether or chloroform, and during light or profound anaesthesia. It may be distinguished from the other causes of obstructed

respiration by the curious "crowing" inspirations which accompany it, and which often become higher and higher in pitch as the air-way becomes more and more occluded. The vibrations producing the sound may also be appreciated by fingers placed over the larynx.

The *causes* of spasm of the glottis may be divided into local and remote.

(1) *Local causes.*—The first of these is the irritating nature of the anaesthethic which is being inspired, and is generally the result of the drug being administered from the first in an insufficiently dilute form.

The next cause is the presence of a foreign body in the larynx. This need not be so large as to produce obstruction by its mechanical action as described in the first part under this heading; but a small foreign body will cause enough irritation to produce the muscular action which closes the glottis. The most usual forms of foreign body which find their way into the larynx are teeth, or fragments of teeth, which fall there during extraction, or having been left in the mouth are sucked in by the first vigorous inspiration, fragments of broken instruments, and vomited matter sucked back from the pharynx.

(2) *Remote causes.*—Under this heading the reflex muscular action which closes the glottis no longer receives its stimulus from the sensitive mucous membrane of the organ itself, but from some remote part of the body. This form of spasm will be met with most frequently in operations upon sensitive parts, especially the genital organs.

(*d*) Respiration may be mechanically obstructed by causes which hinder the proper working of the respiratory apparatus of the *chest*, as for instance by tight corsets which have not been unfastened before the administration, tight bandaging,

a faulty position of the patient on the operating table, assistants leaning on the chest, or by the distension of the pleural cavities with fluid.

(*e*) Causes which hinder the proper action of the diaphragm will also mechanically affect the respiration such as the presence of a large tumour, tympanites, or much free fluid in the *abdomen*.

Signs of Obstructed Breathing.

The onset of the symptoms will be sudden or gradual, as the cause is complete or partial. The respiration will become more noisy, and the stream of air passing backwards and forwards will become smaller. If the obstruction is severe the colour of the face will change to some shade of blue, or sometimes almost black. The pulse will not be altered at once, but if the obstruction is not removed it too will fail. Muscular movements of respiration may still be seen in the chest and abdomen, though very little air may be passing; and clonic movements of the arms, comparable to the jactitations seen in connection with nitrous oxide anaesthesia, may sometimes be noticed. If left unrelieved the respirations will become feebler and feebler, and then cease.

(2) Failure of Respiration from Central, or General, Causes.

The respiration may fail with the circulation as a part of the gradual death of a patient from shock, or loss of blood, or from an overdose of the anaesthetic, and this failure will be more gradual than that caused by obstruction. The breathing may also suddenly stop when an incision is made or the operation otherwise begun before the patient is well under the influence of the anaesthetic—this may be described as reflex failure of respiration during light anaesthesia.

In some operations on the deeper structures of the neck, when the large vessels and nerves are being manipulated, the

breathing may suddenly stop even before any change has been detected in the pulse. This has been described as being due to irritation of the vagus, others have considered that it may be due to some excitation of the sympathetic nerves in the neck, but the exact physiological explanation is not obvious.

By far the commonest form of temporary failure of the respiration is the holding of the breath which occurs in connection with the act of vomiting. This is an accompaniment of light anaesthesia, and when it occurs the corneal reflex will almost certainly be present.

An inclination to vomit may sometimes be noticed near the beginning of the administration, and then it is generally in a very nervous patient, or in one who has not been properly prepared. It may occur at any time during the course of an operation if the anaesthesia has not been kept sufficiently deep, but it is most commonly seen after the anaesthetic has been withdrawn and the patient is returning to consciousness.

Before the breath is actually held it may have been noticed that the respiration has become more shallow, the pupil being at the same time small, with the corneal reflex as a rule present. If the breath is held in this way for some time the ordinary signs of asphyxia will show themselves; the face will become cyanosed, the circulation affected, and the pulse smaller, and the pupils may then dilate.

The condition of the patient will generally become rapidly improved if the anaesthetic is pushed to a deeper degree, or after the act of vomiting.

Treatment of Respiratory Failure.

The first thing to be done is to see if any obstruction to the breathing can be found, and then removed. If the trouble is caused by the valve-like action of the lips, they may be kept separated by means of one finger inserted between them, or a dental prop may be placed between the teeth or gums.

If the teeth of the lower jaw are inclined to get locked behind those of the upper, and so prevent the lower jaw being pushed forward, the jaw should be depressed, and then pushed forward till the lower teeth are in front of the upper, and they should be maintained in this new position.

It is of course most important that the tongue should be prevented from blocking up the air-way by being allowed to fall back, and rest against the posterior wall of the pharynx. Unless the position would be unfavourable to the operator, the head should first be turned over well to the right side, for by this means the tongue will then tend to fall into the right cheek rather than backwards into the pharynx. Pressure should now be exerted by means of one of the fingers of the left hand of the anaesthetist placed behind the angle of the jaw, and pressing directly forwards, *i.e.* towards the mouth. It is a very common mistake for the beginner not to place his finger really behind the angle, but on some spot on the lower surface of the jaw; in this way pressure will have very much less effect on keeping the jaw well forward than if the finger were placed quite behind the angle. Much help can be given in keeping the jaw in this position by means of some of the fingers of the right hand placed under the chin. This can be done as shown in the figure 20, without in any way affecting the holding of the inhaler.

If the patient has a delicate skin, and if the pressure behind the jaw has to be kept up for some time, it is as well to have a fold of the towel between the finger and the skin, as there will then be less risk of bruising.

It will be found that when consciousness is first lost considerable force is sometimes required in the case of young adult males to keep the jaw in a favourable position, but fortunately as the operation proceeds less is required. It is important while keeping the jaw forward to make sure that the tongue is not caught between the teeth. This sometimes

happens during the administration of ether, when the patient has been struggling, and the inhaler has been kept on the face without being removed for some little time. If the jaw does not move forward easily when pressure is first exercised from behind the angle, it is always as well for the anaesthetist to look in the mouth to see if it is prevented from advancing by locking of the teeth, or by the tongue being caught between them.

Should a favourable position of the lower jaw not improve the respiration, the mouth must be opened and the tongue drawn forward. If the teeth are firmly clenched they will have to be separated before a gag can be inserted, and this should be done with the wooden wedge. Metal wedges are sometimes used, but require much care in their application, lest the teeth be injured. As soon as sufficient room has been made by the wedge, the gag should be inserted, the arms being covered with india-rubber tubing to prevent damage to the teeth, and care must be taken that the gag itself does not dislodge any teeth. The mouth can now be opened sufficiently wide, all mucus, etc., should be sponged out, and the tongue drawn forward by the tongue forceps. Lister insists that this drawing forward of the tongue acts in some reflex manner, especially in separating the soft parts above the glottis which may have fallen together, and is not simply a removal of the mechanical obstruction of the base of the tongue from the air-way. The forceps should be closed sufficiently to hold the tongue firmly, and no more. Through careless handling with forceps the tongue is often considerably bruised, and in consequence very sore for some days afterwards. They should never be closed more tightly than is necessary to obtain a firm hold on the tongue, and to draw it forward, and as soon as their aid can be dispensed with they should be removed. Instead of the special tongue-forceps a pair of artery forceps is occasionally used in an emergency; but it should be remembered that though they are very effective, they are more likely to

damage the tongue, as they exert much more pressure, and therefore they should be removed as soon as possible. If the tongue has to be kept forward artificially for some time, especially if part of it is being excised, it will be much less damaged and much less painful to the patient on recovery if, instead of using the forceps, a ligature is passed through it, and it is kept forward by means of this.

When both nostrils are more or less obstructed, and the mouth, as is usually the case, is kept almost closed, there is very little room for the necessary current of air to pass for the maintenance of respiration. This is specially noticeable in the case of operations on patients suffering from post-nasal growths and enlarged tonsils. In these patients it is as well, whenever an anaesthetic is to be given, to make sure that there is at least a sufficient air-way through the mouth by keeping it open with a dental prop placed between the teeth. This may be kept in position during the operation, and is more convenient than a gag, which is sometimes used, as it will not prevent the application of the inhaler, and the arrangement of the head in any particular position will not be interfered with by the arms of the gag getting caught in the pillow. The gag shown on page 184 possesses a great advantage in the fact that it can be kept in position while a face-piece is applied over it.

It must be remembered that a prop must not be used without being firmly secured to another prop, or some other object which will prevent its being swallowed by the patient, and thus further increasing the embarrassment of the respiration.

If the breath is being held without any obstruction that can be discovered, the lips should be rubbed briskly with a towel, and this simple measure will often start the breathing again, or ammonia may be held to the nostrils. The corneal reflex should be tried, and if present, the anaesthetic should be given more freely, but if it is absent, more air should be allowed.

This treatment must be tried in cases of **Spasm of the Glottis**, which is not caused by the presence of a foreign body in the larynx ; but the obstructed breathing from this cause is not easily overcome in all instances. It may remain unrelieved with a very light anaesthesia, or even when the anaesthetic is pushed to the limits of safety, and the pupils become dilated from the overdose. If ether is being given the spasm may disappear if a change is made to chloroform ; but the real cause of it is not well understood, and certainly in some cases is very difficult to remedy, especially when the operation is upon one of the very sensitive parts, as the genital organs.

If the spasm is due to the presence of a foreign body in the larynx, the body of the patient should be bent forwards in the chair, and the back should be slapped vigorously. Coughing is to be encouraged, as by this means the foreign body is generally removed. An attempt may be made to feel for the cause of irritation, and if found, to remove it with the finger or forceps. Inversion has been recommended, but this treatment should not be carried out till preparations have been made for laryngotomy, as if the foreign body has passed through into the trachea, it may again enter the larynx when the patient is inverted. When the breathing becomes seriously obstructed by the spasms, and the patient shows signs of cyanosis, laryngotomy should be performed immediately.

If the accident happen at a dentist's this operation will in all probability fall to the anaesthetist, and for this reason he should never administer any anaesthetic without having the necessary instruments at hand ; but if a surgeon is operating, he will perform the laryngotomy.

If the obstruction to the breathing seems to be due to the accumulation of mucus in the air passages, the mouth should be opened, and the pharynx cleared out as much as possible with a sponge on a holder, and the anaesthetic changed from ether to chloroform or A.C.E.

If there still seem to be some obstruction remaining from accumulated mucus which cannot be removed by a sponge, the patient may, with the consent of the operator, be allowed to come round a little, and some of the mucus will then be removed by the vomiting which will result, and then the pharynx should again be sponged out. The patient, if possible, should be turned on to his side till the breathing becomes relieved, and then the administration may be continued with chloroform or A.C.E. After any case of the excessive secretion of mucus the patient should be carefully watched for any sign of bronchitis, and treated accordingly.

Of course any pressure on the chest, whether from tight clothing or from assistants leaning on the patient, must be at once removed as soon as discovered. When the respiration is hampered by the presence of fluid in the pleura or abdomen, the anaesthesia should be as light as possible till the fluid or tumour is removed, and the breathing is free. When the breath is held as the first incision is made the anaesthesia is probably too light, and the respiration will soon become regular if the anaesthetic is given more freely.

If rubbing the lips does not start respiration, **rhythmic traction of the tongue** may be tried. To do this the tip of the tongue is seized with forceps, and the tongue gently pulled forward out of the mouth and then allowed to return. This movement may be repeated about twenty times or more a minute, and is frequently found to be useful in restoring the respiration: it may also be tried while artificial respiration is being performed. This treatment was suggested by Laborde, who would appear to agree with Lister as to the reflex action produced by pulling the tongue forward. If these means fail, or no obstruction can be found, artificial respiration must be performed. The anaesthetic must, of course, be first completely withheld, and it must be ascertained that there is a clear air-way, or otherwise any attempts at artificial respiration would be useless.

If the larynx is blocked and cannot be cleared, tracheotomy or laryngotomy must first be performed. Occasionally the obstruction is below the larynx, as in the case of a tumour or an enlarged thyroid gland pressing on the trachea, and in this case tracheotomy might become impossible or useless, and intubation would then give the only chance of making an air-way.

Artificial Respiration.

The simplest way of aiding the respiration artificially is to compress the thorax during expiration, and in some cases this

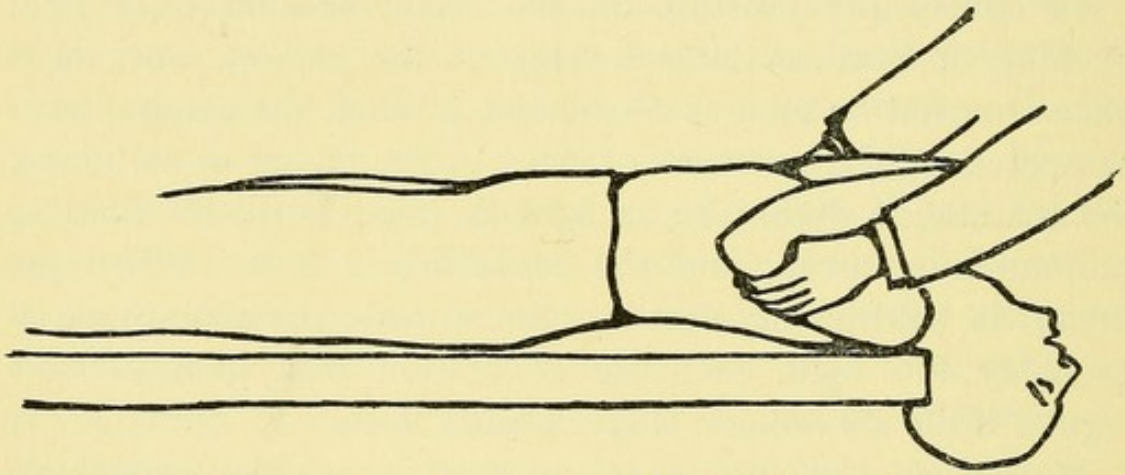


FIG. 4.—ARTIFICIAL RESPIRATION BY SYLVESTER'S METHOD. EXPIRATION.

is sufficient; but when the respiration is almost imperceptible, or has actually ceased, more vigorous methods must be adopted.

There are two principal methods of performing artificial respiration—namely, that of Sylvester, and Howard's method.

Sylvester's Method.—The patient should be lying flat on his back on the operating table or bed, with the tongue drawn forward by means of forceps, and the operator standing behind him. The patient's arms are now to be seized, one in each hand, about the elbow, and are then to be firmly compressed against the walls of the thorax (Fig. 4). If there is any sign of an attempt at natural respiration, however feeble it may be,

this compression of the thorax must be timed with expiration. If there is none, expiration should be performed before inspiration, so that any anaesthetic that may be present in the air-passages may be driven out, rather than that any fresh dose should be sucked in by a forced inspiration.

After the arms have been firmly compressed against the chest, they should be gradually lifted away in a direction upwards and outwards, making as wide a sweep as possible, till they meet above the patient's head (Fig. 5). After a short pause in this position they are again to be brought down and the chest firmly compressed as before. The movements should

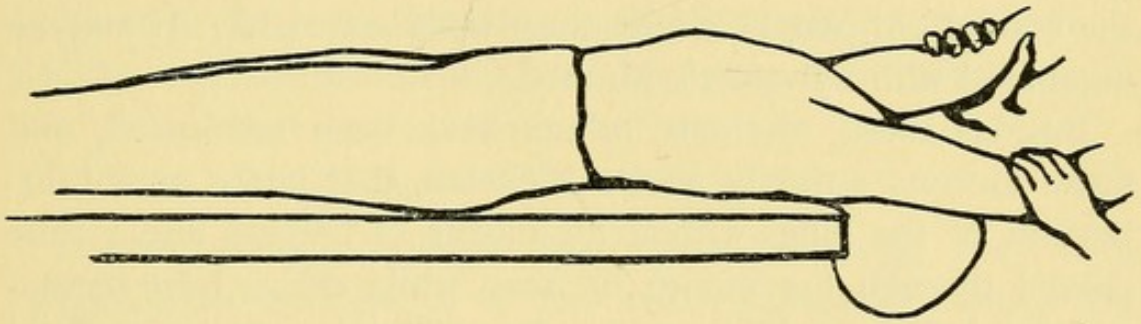


FIG. 5.—ARTIFICIAL RESPIRATION BY SYLVESTER'S METHOD. INSPIRATION.

be repeated about sixteen times a minute, and their efficacy depends much more on the care with which each is performed, than on the number of times it is repeated. The value of this artificial respiration will be much increased if, when the arms are being pressed against the chest-wall, an assistant should also compress the abdomen firmly, as though trying to drive the abdominal contents against the diaphragm. If enough assistants are available, rhythmic traction of the tongue may be employed at the same time. It is generally advised that the head should hang over the edge of the operating table, but the benefit of this is doubtful.

Care should be taken in the bringing of the arms above the head that they are not injured by pressure against the edge of the table: this is more likely to happen if the head is hanging over.

Howard's Method.—In this method the patient's arms are raised above the head, and tied together. The shoulders are raised on pillows, and the head is extended. The operator then kneels astride the patient, and places his thumbs on the xiphoid cartilage, and spreads his fingers along the lower costal margin. He then leans forward, and with his whole weight suddenly and firmly presses upwards and inwards against the diaphragm. This pressure is maintained for two or three seconds, and is relaxed by the operator suddenly raising himself. It should not be repeated more than sixteen times a minute.

This method of artificial respiration is particularly useful in the case of old people whose chest walls are rigid. It may be combined with Sylvester's Method.

Besides these methods others have been advocated, and some authors strongly advise **inflation,** that is the actual distension of the lungs with air by means of bellows and a tube passed through the mouth or nose, while others have recommended inflation with oxygen. In whichever way the artificial respiration is performed, it is most important that it should be carried out deliberately, and without hurry. Patience is also necessary, for natural respiration has been restored after being absent for more than an hour.

If respiration fails in infants or young children, they are best treated by **inversion**. Both feet should be seized in one hand, and the child held up by them, the head just resting on the operating table ; and one finger of the other hand should be placed in the child's mouth to keep the tongue well forward. While in this position an assistant should compress the chest rhythmically. As stated above, if there is any sign of an attempt at natural respiration, the chest should only be compressed during expiration.

In slight cases of respiratory failure much may be done by rhythmical pressure on the abdomen during expiration. It is

specially useful in children. Other means of restoring natural respiration have been suggested which, though they may help in minor cases of failure, are not likely to be of much service in the more serious ones. They are, flipping the chest with cloths alternately hot and cold, applying alternately hot and cold sponges to the perinaeum, holding strong ammonia to the nose, etc.

There is one drug that is of use in stimulating the respiration; that is **Strychnine**. It should be given hypodermically in doses of from 3 to 5 minims of the Liquor Strychninae Hydrochloratis, 3 minims containing about $\frac{1}{32}$ grain of the drug. This dose may be repeated as soon as seems necessary; but it must be considered as merely a stimulant to respiration, and the artificial movements must on no account be relaxed.

FAILURE OF THE CIRCULATION.

Failure of the circulation may occur suddenly, when it is spoken of as syncope, or it may come gradually, towards the end of a long and serious operation. These two varieties will be shortly considered separately.

Sudden Failure of the Circulation—Cardiac Syncope.

Syncope is the greatest danger which can threaten a patient who takes an anaesthetic. It occurs almost always in connection with the administration of chloroform or one of its mixtures, and is almost unknown in the use of ether or nitrous oxide. It is a cause of death not only in the weakly, but in the robust adult male, and unfortunately death has happened in this manner when an anaesthetic has been administered to a healthy individual for a trivial or almost unnecessary operation. Very many cases have followed the administration of chloroform to a patient sitting upright in a chair, for the extraction of one or two teeth; a practice which cannot be too strongly condemned.

Syncope may occur after the patient has been deeply anaesthetised, and is again emerging into a state of light anaesthesia; but is much more common in the very early stages of the administration. In fact, patients have died even before any of the anaesthetic had been poured on to the mask, and in these cases extreme fear is the only cause to which the syncope can be attributed. It may occur to a slight degree when an operation is begun in a patient imperfectly anaesthetised, the pulse not being felt for some seconds after the first incison is made. This form is explained as being due to reflex inhibition of the heart. Even when the patient is deeply anaesthetised, that is to say, when the corneal reflex is entirely absent, and all the muscles are relaxed, it may occur during the manipulation of the main vessels in the neck, or when the kidney is being examined for stone, or in fact when any of the more important abdominal organs are being handled.

Syncope may also occur when the patient is emerging from the condition of anaesthesia, generally when he is about to vomit, or on being raised up abruptly before consciousness has returned.

The commonest cause however, the most fatal, and the most difficult to treat, is the syncope which results from an overdose of chloroform. It may happen quite early in the course of the administration, but is more generally met with in the second stage when there is struggling.

Causation of Death from Chloroform.—More has been written on this point than on any other connected with the subject of anaesthesia, and the opinions of many writers are very widely divergent.

There are two distinct types of death from the effects of chloroform, the sudden death, or syncope, which occurs in the early stages, and the gradual death which occurs during the later stages of the administration. The explanation of these is

still the subject of contention, in fact the two Hyderabad Commissions have tried to prove that the primary syncope never occurs.

The best explanation of death from this cause is the one given by Dr. Leonard Hill, and may be shortly described as follows. During the early stages of the induction of anaesthesia, when a too concentrated vapour of chloroform is administered to a patient, the sensory fibres of the pneumo-gastric nerve are stimulated by it, and as a consequence the patient holds his breath and struggles. By these means, together with the closure of the glottis, the intra-thoracic pressure is very much raised. Through this, the venous system is congested, and less blood is pumped into the arteries; the arterial tension is lowered, and less blood is supplied to the coronary arteries. On account also of the holding of the breath, less oxygen is supplied to the blood in the lungs, and so the supply to the heart muscle is of poor quality, as well as deficient in quantity, and the nutrition of the heart suffers in consequence.

The breath cannot be held indefinitely, and two or three deep inspirations will now be taken, and if chloroform has been freely poured on to the mask during the temporary cessation of the breathing, a large dose of chloroform will be inspired into the lungs. Some of this is at once passed through the coronary arteries to the already enfeebled heart, which by this poisonous overdose is thrown into a state of paralytic dilatation, from which recovery is rare.

In some cases fear seems to have played a part in the production of syncope, and it may be remembered that when chloroform was to have been administered by Simpson for the first time for a public operation, and when, as he was late, the surgeon began his work before any chloroform was given, the patient suddenly died as the first incision was made. This element of fear, however, cannot be

considered as a factor in many cases, for it has been already pointed out that death occurs from syncope in many cases when the patient is a robust young adult fresh from his work, who is given chloroform for the performance of some slight operation, as the extraction of a tooth.

The causation of death in the gradual or late type is different from that of syncope. In this instance it is probably due to the effect of the drug on the medulla which has already been rendered anaemic by the gradual lowering of the arterial tension which is inseparable from an overdose of chloroform.

Signs of Cardiac Syncope.

In the severe forms of syncope the signs are unmistakable, and most startling in their onset. With no warning, the patient suddenly becomes blanched, the circulation and respiration fail, if not together, with no appreciable interval between them, the eyelids are separated, the pupils widely dilated, and corneal reflex absent,—in fact, the patient is, to all appearances at least, dead.

This is the form which generally happens in the early stages of the administration of chloroform, and from which it is so hard to recover the patient.

In the milder forms of syncope there is more often some warning. The patient becomes pale, the pulse gradually fails, and the pupils slowly dilate. The respiration is hardly affected at first, but gradually fails with the circulation. This form is generally met with in cases of syncope arising during light anaesthesia, which may be described as reflex; and also when vomiting is accompanied by syncope. From this form there is fortunately much more hope of recovering the patient.

Treatment of Cardiac Syncope.

The most important treatment of cardiac syncope is *preventive*; in fact, in the severe cases, no remedial treatment is usually of any avail.

The preparation of a patient who is suffering from known cardiac disease, or of one that has on some previous occasion exhibited alarming symptoms while under an anaesthetic, should be carried out with great care. The diet must be strict, though not too limited in quantity, and if the patient seems exhausted or very nervous just before the commencement of the administration, half an ounce of brandy diluted with an equal quantity of water, should be given by the mouth, or better still, unless the operation is on the rectum, an ounce of brandy mixed with two ounces of hot water or beef-tea, may be given in an enema. This may be done even up to the last few minutes before the administration.

The choice of the anaesthetic will be of great importance, and is considered on page 171. If possible ether should be given rather than chloroform, at any rate at first.

The patient must be kept as warm as possible by means of hot-water bottles, and the head should be kept low, but he should not be placed in an uncomfortable, or constrained, position. If obviously nervous, an attempt should be made to encourage him.

It is the duty of the anaesthetist to see that no unnecessary fear should be caused by the examination of the patient while partly anaesthetised, that the operation about to be performed is not discussed before him, and that the instruments should be hidden from him as much as possible. All the arranging of the coverings of the patient, mackintoshes, etc., should be done before any anaesthetic is given, or postponed till he is unconscious, for when in a half-anaesthetised condition a patient is very apt to think that any movement in his surroundings is the commencement of the operation.

For the same reason, no patient should be forcibly held when quite conscious, but assistants should be ready to prevent him doing damage to himself or his surroundings, and not till any danger is actually threatened should any constraint

be placed on his movements, and then no more than is necessary.

In the administration of the chloroform great care should be taken that it is given very gradually at first, and that a large dose is not poured on the mask, and then held close to the patient's mouth and nose.

The respiration must be most carefully watched. It is not enough to see that some movement is taking place in the chest or abdomen, but each inspiration and expiration should be heard or felt by the anaesthetist. If the breath is held, the lips should be briskly rubbed with a towel or cloth, and no fresh chloroform should be poured on the mask till the respiration starts again. When the breath is held for a prolonged period, as in the struggling stage, special care must be taken when the patient takes his first inspiration, which must of necessity be a deep one, that he has a free supply of air. This is the most dangerous time for the patient in the hands of an unskilled anaesthetist. While the breath is held, more and more chloroform may have been poured on to the mask, and when the patient does at last breathe, the dose of chloroform that he takes with his first inspiration will be a poisonous one, and the syncope which follows will often prove fatal.

Care must be taken that the air-way is perfectly clear, for any accompanying obstruction to respiration will make the prognosis of the circulatory trouble infinitely more grave.

Remedial Treatment.—The anaesthetic must, of course, be entirely withheld, at least until the patient is in a perfectly satisfactory condition.

In the severe form the head should be lowered and the feet raised. This is the position which is generally adopted as the best for the patient, but Dr. Leonard Hill, from theoretical grounds, and after very satisfactory experiments on the lower animals, argues that this position is more likely to do harm than good, by driving more blood into the already over-

distended heart. He recommends that the feet should be placed on a level distinctly lower than that of the head, so that the heart may in this way be relieved, rather than have more work thrown upon it.

Though this experiment has been tried repeatedly with complete success on the lower animals, I am not aware that it has yet proved efficacious in the human subject.

It is fortunate that all the measures which are likely to improve respiration when it fails, are also of service in restoring the failing circulation. In other words, artificial respiration is the most efficient means we possess for the recovery of a patient in a state of syncope, and this should be carried out in the way described on page 44. Strychnine, too, may be given hypodermically, and rhythmic traction of the tongue will also be of service.

Besides these measures, there are some others which are more specially directed to the circulatory system, and they should be tried. The heart may be helped to contract by actual compression with the hand. This should be tried during the artificial expiration, a hand being passed as far as possible under the left costal margin, and an attempt made to compress the heart with it.

Hot cloths may be applied to the praecordium, and the heart itself may be stimulated by means of an electric current, or even by acupuncture, that is the introduction of a needle into its cavity; but this is of very doubtful value, and electric stimulation may inhibit the heart rather than cause it to contract, and would thus be more harmful than beneficial.

Brandy in doses of three or four drachms may be given hypodermically, but if this is not available, and the patient is not already suffering from an overdose of the anaesthetic, 10 to 15 minims of ether may be given in the same way.

An enema of about a pint of hot water may also have a good effect, which will be increased by the addition of an ounce of brandy. Beef-tea has been advocated as a suitable fluid to be given as an enema, and if it is at hand it should certainly be tried. The inhalation of 3 or 4 minims of Nitrite of Amyl has been recommended, and a capsule may be broken and held to the patient's nose while artificial respiration is being carried on, or a few drops of the strong Liquor Ammonia may be used in the same way.

The hypodermic injection of a solution of supra-renal extract has been used abroad with success, but there is no record of any trial in this country.

Gradual Failure of the Circulation.

The **causes** of gradual failure of the circulation are :

(1) Shock, from a very long operation, or from one on important organs, such as the abdominal viscera, or the brain.

(2) Loss of blood during the operation.

(3) A gradual overdose of the anaesthetic.

Any of these three causes may be combined with some cause which prevents the proper oxygenation of the blood, as some obstruction to the breathing, and the symptoms will then be made proportionately more severe.

Signs of gradual Failure.—In this form of circulatory failure there will generally be sufficient warning. The patient's face gradually becomes pale and blanched, the eyelids remain apart, the pupils slowly dilate, the nose and forehead begin to feel cold to the touch, a moist clammy sweat forms on the forehead, the pulse becomes smaller, more frequent, perhaps "running" in character, and finally imperceptible at the wrist, and the respiration fails with the circulation.

Treatment.—When the pulse is found to be deteriorating in quality, and becoming faster and faster, treatment is called for.

Any difficulty in the breathing must be first noticed, and looked after; and if the anaesthesia seems to be too light, and there is a tendency to vomit, the anaesthetic should be given rather more freely. If, however, the anaesthesia is fairly profound, as shown by the absence of the corneal reflex, etc., the anaesthetic should be withheld for some seconds, and the patient allowed to breathe a freer supply of air. Rubbing the lips, by stimulating principally the respiration, will have an indirect influence in helping to improve the circulation. The condition of the pulse will probably be improved by this, and then the administration can be continued; but if the pulse again fail in spite of a freer supply of air and less of the anaesthetic, a more stimulating one should if possible be tried. For instance, if chloroform is being administered, and it is thought well to try a more stimulating anaesthetic, the A.C.E. mixture will often prove of great service. If the mixture were being given in the first instance, and more stimulation is required, some pure ether may be poured on the sponge.

Of course, before any change is made in the anaesthetic, the administrator must make sure that the patient is not suffering from an overdose of the one which is already being given, or from too little air being allowed at the same time. It is unwise to change too hastily from one anaesthetic to another till attempts have been made to place the patient in a more satisfactory position with the one already in use.

When all attempts to improve the character of the pulse by means of a more carefully regulated supply of the drug being administered, by a freer supply of air to the patient's lungs, or even by a change to a more stimulating anaesthetic, fail to produce the required result, the situation becomes more serious; and it is time that the surgeon should be warned that all is not going well. With his consent brandy may be given by the rectum or hypodermically, and a hypodermic injection of

Strychnine will often prove of great assistance. Should the condition of the patient not improve, any anaesthetic must be entirely discontinued, and the operation must be stopped, so that artificial respiration may be performed. This, as stated above, is one of the best cardiac stimulants that we possess. More brandy may be given in an enema of hot water, and if thought desirable, the hypodermic injection of Strychnine may be repeated. The foot of the operating table, or the bed on which the patient is lying, should be raised, and care must be taken that he is kept well warmed by means of hot-water bottles.

If much blood has been lost during the operation the limbs may be bandaged from their extremities, and more hot water injected into the rectum. Infusion of saline fluid will be of great use in all cases in which the patient has lost much blood.

CHAPTER III.

NITROUS OXIDE; NITROUS OXIDE AND OXYGEN.

NITROUS oxide (N_2O) is a colourless gas with very little odour, a faint sweet taste, and a specific gravity of 1·527. As an anaesthetic agent it is commonly spoken of as "gas."

At a temperature of 7° C. (44·6° F.) and at a pressure of 50 atmospheres the gas becomes a liquid; and it is generally supplied in this form, in strong iron or steel cylinders, containing 25, 50, or 100 gallons of the gas, 50 gallons weighing about 15 ounces. Nitrous oxide as a liquid is easily affected by heat, and the cylinders should not be exposed to it, as explosions have occurred. In these cylinders it may be kept for practically any length of time; but if it cannot be obtained in this form it must be made fresh. If this is done, care must be taken that none of the other oxides of nitrogen are present, as they are likely to produce a considerable amount of coughing when the gas is inhaled, and the administration will probably be followed by headache. Air is also liable to become mixed with any gas that is not kept in the liquid state, and though a small trace may produce no bad result, in large quantities its inhalation will be followed by considerable excitement, as in the old experiments with "laughing gas."

For a fuller account of the manufacture of nitrous oxide, the detection of its impurities, etc., the reader is referred to the text-books on chemistry.

As an anaesthetic agent nitrous oxide may be administered in one of three ways; as

(1) Nitrous oxide alone.

(2) Nitrous oxide mixed with air.

(3) Nitrous oxide with oxygen.

In whichever of the three ways it is administered, it is the safest anaesthetic agent that we at present possess. Very few deaths have occurred under the gas either pure or when mixed with air, and in those that have been reported the fatal result appears to have been due to the unnecessary deprivation of oxygen, rather than to the excessive amount of the gas supplied to the patient. Though very rare in a patient inhaling nitrous oxide, syncope is not unknown. No death has been reported which has been due to the inhalation of gas and oxygen.

Nitrous oxide also possesses great advantages as an anaesthetic agent both on account of the very few preparations which it is necessary that the patient should make before the administration, the absence of any unpleasant taste or smell in the gas, and the rapid recovery which follows the administration, with freedom from unpleasant symptoms.

It is well that the patient should not have a heavy meal within an hour or two of the administration, but the dieting which is so important before the inhalation of the other anaesthetics, is quite unnecessary. Nervous patients and children should have the bladder empty when taking the gas, as if it is full, its contents may be expelled when consciousness is lost.

The absence of any unpleasant taste or smell in the gas itself is of great advantage, and as a rule the patient is perfectly able to stand up and walk away within a very few minutes of the administration. Speaking in general terms, nitrous oxide may be given to any patient who is well enough to take an anaesthetic, but in the case of young children, old people, or patients enfeebled by disease, air or oxygen should always be added to the gas. The use of nitrous oxide in dentistry will

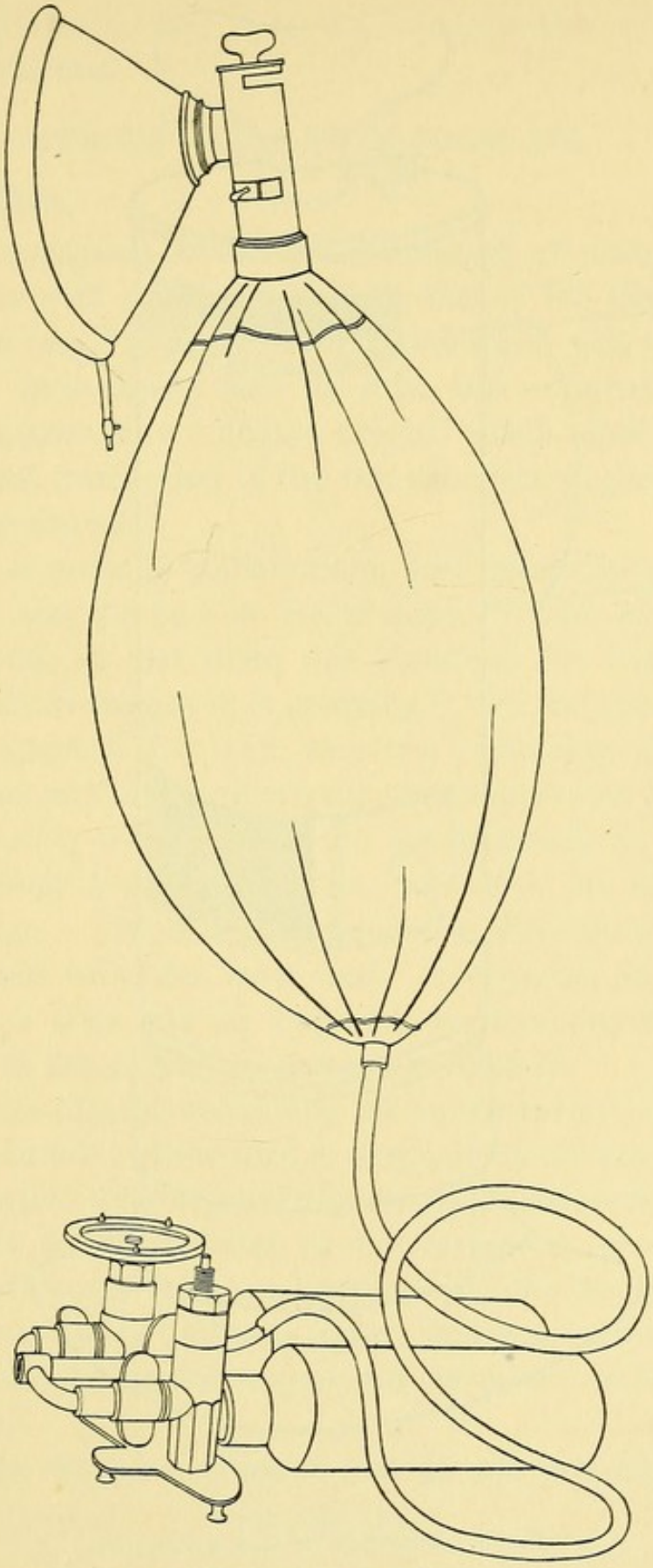


FIG. 6.—HEWITT'S GAS APPARATUS.

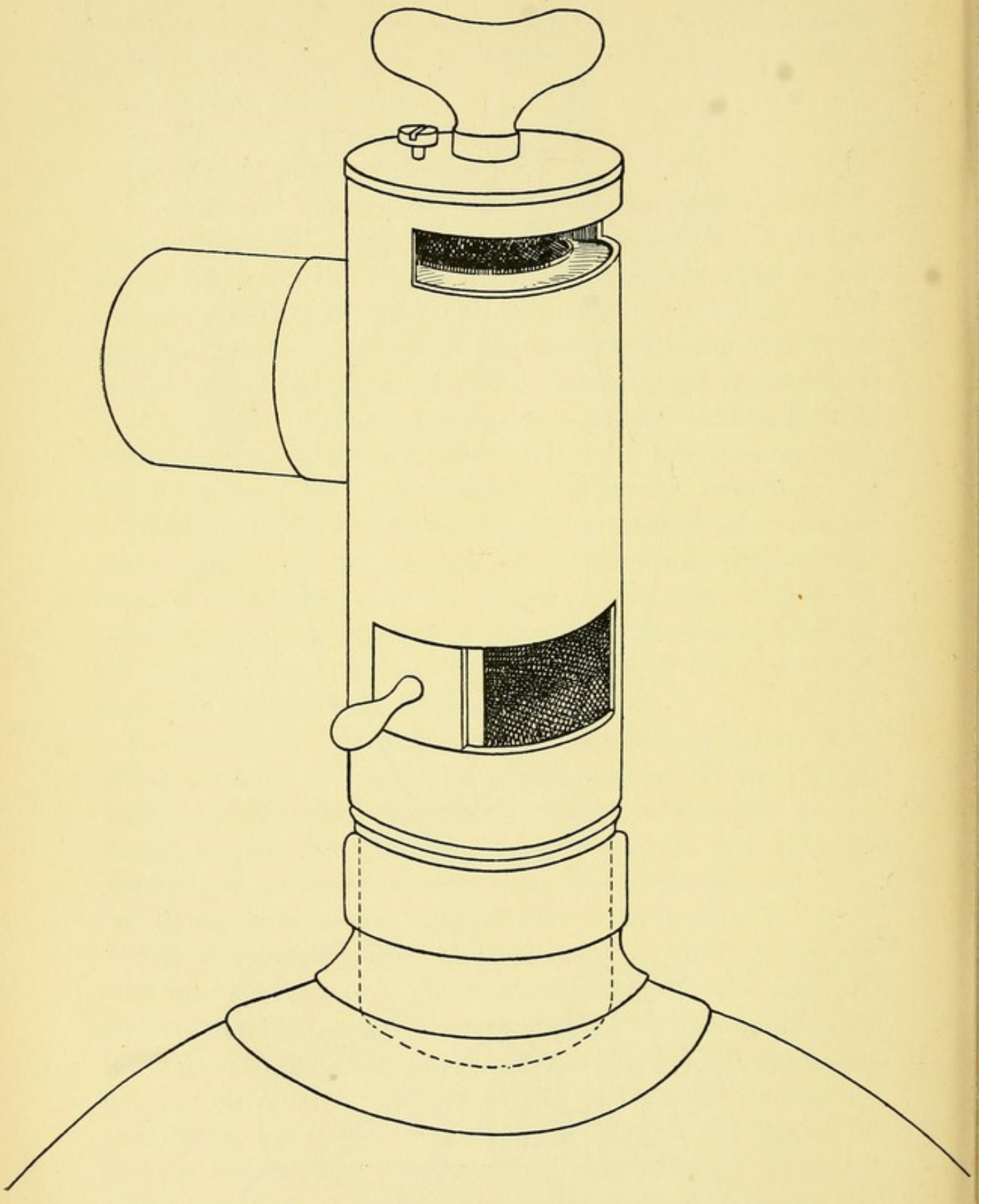


FIG. 7.—STOPCOCK OF GAS APPARATUS.

first be considered, and then its administration for minor surgical operations.

NITROUS OXIDE FREE FROM AIR.

The Apparatus.

The best apparatus for the administration of nitrous oxide, either pure or with air, is undoubtedly that of Dr. Hewitt.

It consists (see Fig. 6) of two *cylinders* filled with the liquid gas, placed horizontally side by side, and coupled together by what is known as a "double union," which allows the gas when liberated from either of the two cylinders, to pass through the tube into the bag.

The *bag* is made of india-rubber, and generally holds two gallons, but may be had in larger sizes. There is a tap at the lower end, so that when this is turned the bag may be removed without the gas in it escaping.[1] To the upper end of the bag is attached the large stopcock containing the valves, on the perfect working of which the whole apparatus depends.

The *face-piece* which fits on to the stopcock is made of leather covered with india-rubber, and with an air-cushion round its edge. This may be distended at will through a small tap connected with the lower end. Face-pieces of three or four different sizes will be required, as it is important that one should fit the patient's face fairly accurately.

The *stopcock* (Fig. 7) containing the valves is very ingeniously contrived, and will be described in detail, as its mechanism must be understood in some degree before it can be satisfactorily used.

There are four apertures in the stopcock, one opening directly into the gas-bag, one opening into the face-piece, and two slots, the lower and the upper, opening to the external air, which may be closed respectively by means of the handle and the tap.

Inside the stopcock (Figs. 8 and 9) are two india-rubber

[1] See page 139.

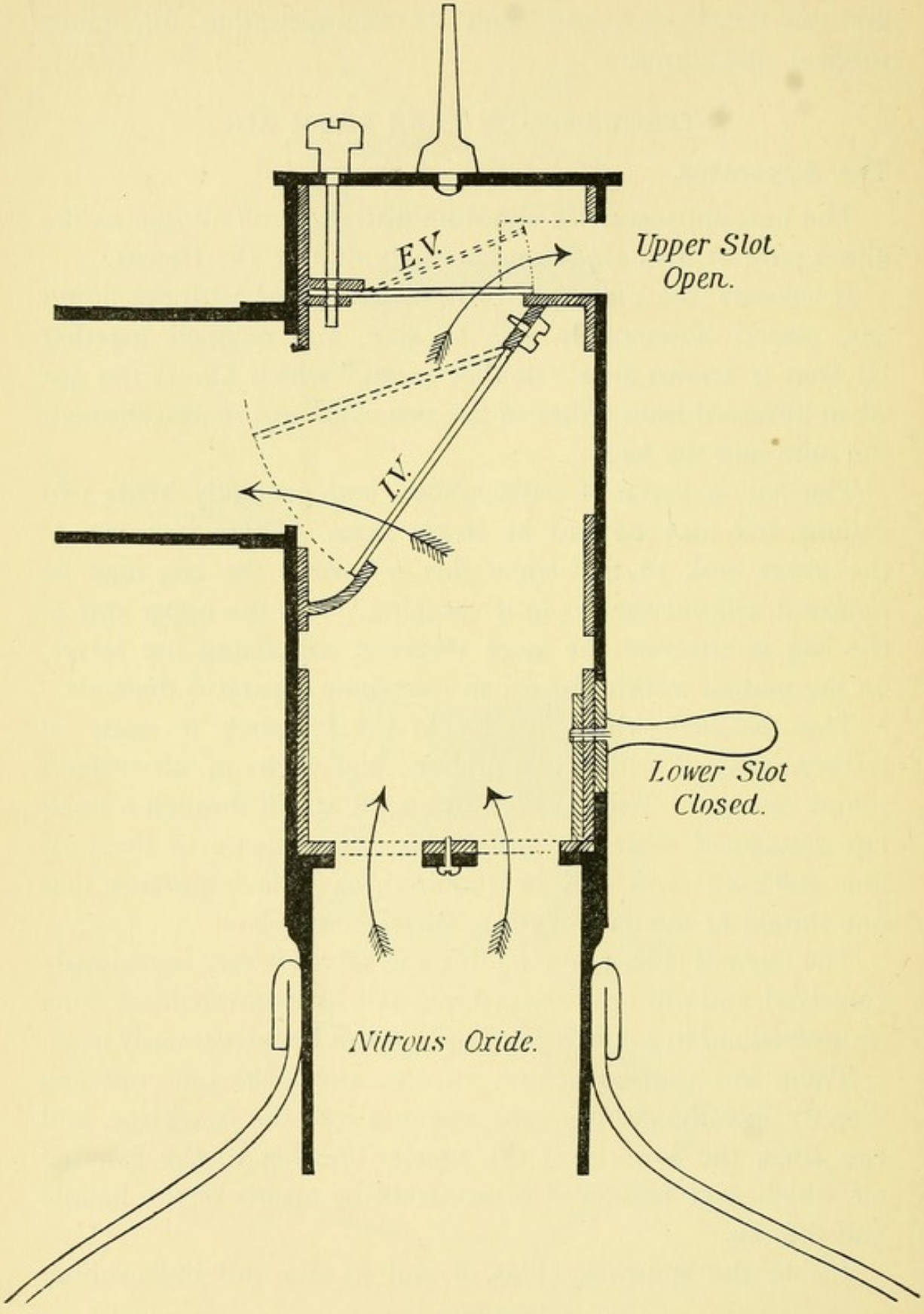


FIG. 8.—SECTION THROUGH STOPCOCK OF GAS APPARATUS. Showing the action of the valves.

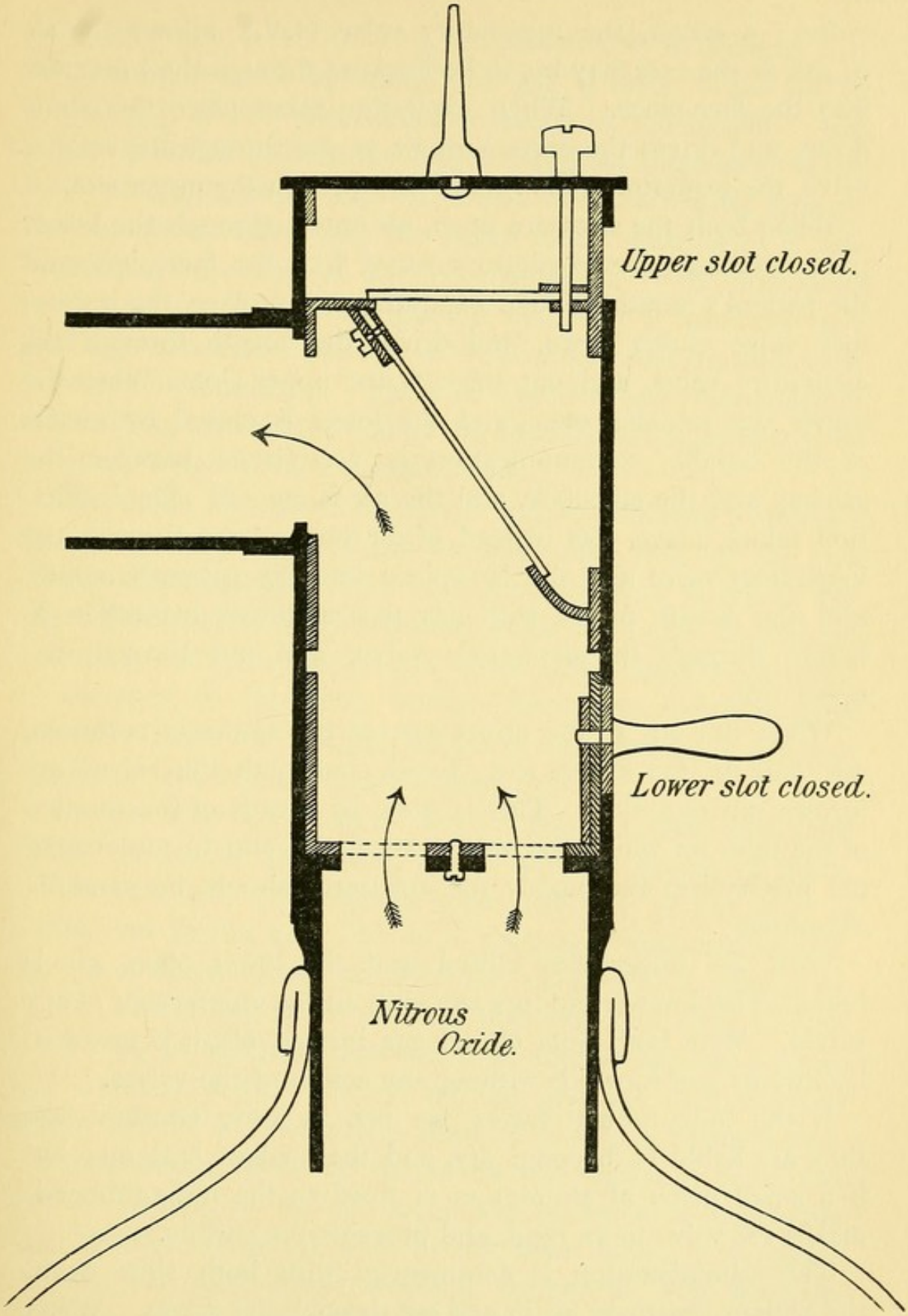


FIG. 9.—SECTION THROUGH STOPCOCK OF GAS APPARATUS. Showing the valves out of action, and rebreathing taking place.

valves; a larger, the inspiratory valve (I.V.), allows the air or gas, as the case may be, to be inspired through the lower slot into the face-piece. When expiration takes place this shuts down, and drives the current of air or gas through the smaller valve, the expiratory (E.V.), and out through the upper slot.

When both the slots are open, air enters through the lower, passes through the inspiratory valve, into the face-piece and the patient's mouth. Then expiration takes place, the inspiratory valve closes down, and drives the breath through the expiratory valve, and out through the upper slot. When the upper slot remains open, and the lower is closed by means of the handle, communication is established between the gas-bag and the stopcock, and the air is cut off. On inspiration taking place, gas instead of air now passes through the inspiratory valve and the face-piece into the patient's mouth, and the breath mixed with gas passes during expiration as before through the expiratory valve, and out through the upper slot.

When the tap at the upper part of the stopcock is turned, not only is the upper slot closed, but both the valves are thrown out of action. This is done by means of the rotation of the tube on which the valves are fixed, and to understand the mechanism thoroughly the apparatus should be carefully examined.

With the upper slot closed and the lower open, air is breathed backwards and forwards without the interference of any valves. With both slots closed gas instead of air is breathed backwards and forwards without any action of the valves.

If the india-rubber valves are not in fairly constant use they are liable to become dry, and their edges curl up; but if a small piece of aluminium is fixed to the india-rubber it makes the valve more rigid, and prevents the curling.

The administration is commenced with both slots open, the patient breathing air in and out through the valves. When

these are seen to be working satisfactorily, it is obvious that the face-piece must be fitting, and gas is then turned on by the closing of the lower slot by means of the handle. Gas is now breathed in from the bag, through the inspiratory valve, into the mouth, and is expired, mixed with the breath, through the expiratory valve and the upper slot. This is as a rule kept up to the end of the administration. The objections to the re-breathing of the gas are that after it headache and giddiness are more common, and secondly, that the bag soon becomes contaminated. There is, however, some advantage in re-breathing towards the end of the administration, as shown by a slightly longer period of anaesthesia.

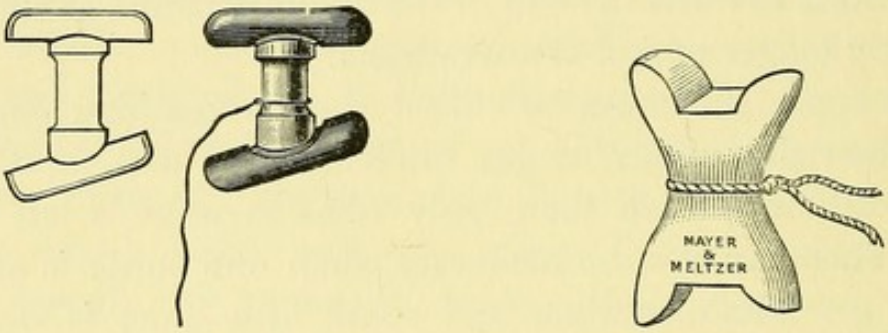
The upper slot must be closed and re-breathing employed first, when the supply of gas suddenly fails, and for the rest of the administration there only remains what is left in the bag. This may also be necessary when one bottle is emptied during an administration, and some little time is occupied in changing to the other bottle. Secondly, re-breathing is necessary when one bagful of gas is attached to a Clover's inhaler for use before ether, see page 138.

The gas is turned on by a "key." This is a metal disc from which are several projecting points, and by means of these, a firm hold can be obtained when the sole of the boot is pressed on to the key. If, as is generally most convenient, the gas is being turned on with the right foot, it should be placed on the key in an everted position, and then rotated in the way in which a screw-driver is used to remove a screw that is firmly fixed. To cut off the gas, the foot must of course turn as a screw-driver does in driving a screw home. The gas should never be turned on too suddenly, or in too large a stream, as by so doing the aperture of the bottle may become frozen up, and for the same reason it is better to keep the key always rotating backwards and forwards while the gas is being allowed to escape from the cylinder.

When the administration is finished, and the gas is being finally turned off, the key should be firmly turned, but not with a jerk, as this may lock it so that it will be difficult to move the key when the gas is next required.

Several means have been tried to diminish the noise made by the gas escaping from the bottle into the bag; but these are not necessary if care is exercised, and the bag is half distended before the patient comes into the room.

A full bottle may be distinguished from an empty one by the difference in weight, and to some extent by the quality of



a *b*

FIG. 10.—MOUTH PROPS. (*a*) Aluminium with india-rubber pads at each end —one shown with pads, and one without; (*b*) small prop of hard wood.

the sound which the bottle gives out when tapped with another piece of metal, such as the key.

Besides the apparatus just described, the anaesthetist must be provided with a good gag, tongue-forceps, a wooden wedge, and an emergency case for the treatment of any possible accident (see p. 2). He must also take with him some **mouth-props**, with which to keep the mouth open when the patient is anaesthetised.

These are made of many different materials, and in many shapes (Fig. 10), but those shown in Figure 10*a* are the best. They are made of aluminium, and can be easily cleaned, and if necessary boiled. Their extremities are covered with small pads of india-rubber, which can be easily detached and cleaned in a weak solution of carbolic acid. Others

are made of hard wood, and some are made of wood with pads of india-rubber at their extremities.

No prop should ever be placed in a patient's mouth without being attached to another by a piece of strong catgut. Children and very nervous patients are liable to displace the prop with their tongue, and if it is unattached it may be partially swallowed, and give rise to some difficulty of breathing, or an inclination to vomit.

A small prop of hard wood (Fig. 10*b*) or vulcanite, of a much smaller size than those mentioned above, is very useful in those cases of alveolar abscess, etc., where the patient cannot open the mouth sufficiently wide for the insertion of one

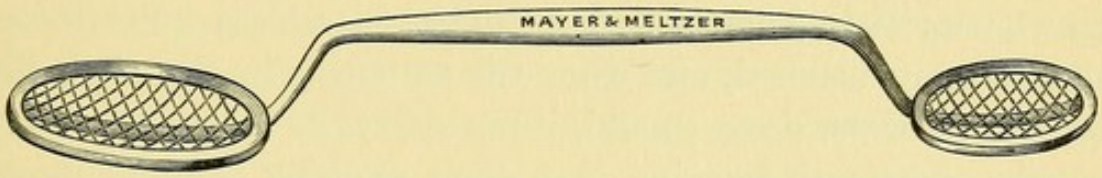


FIG. 11.—ORAL SPOON FOR CATCHING FRAGMENTS OF TEETH.

of the other props; and a wooden or vulcanite prop of a size even larger than the largest of the set of five mentioned above is occasionally very useful for persons who are almost edentulous.

In order to catch teeth, or portions of teeth, that fly back from the forceps, and are thus likely to enter the larynx, a **wire spoon** has been invented, as shown in Figure 11. This is held by the administrator behind the part of the mouth in which the dentist is operating, care being taken that it does not interfere with the operation. Experience teaches us that the bicuspids are the teeth most likely to give trouble in this way.

The above apparatus places the anaesthetist in a position to administer gas to any patient, and to treat any accident that may happen during the course of the anaesthesia.

The Preparation of the Patient.

As before stated, this is simple, but it is preferable that no solid food should be taken for one or two hours before the administration. It is, however, important that no alcohol should be taken just before, as the anaesthesia following the administration will then be very short, and there will probably be much reflex movement and excitement. Children should have their bladders empty.

The most important point is to make sure that the breathing of the patient is not hindered by any tight clothing. In the case of men the collar should be removed, and, if necessary, the shirt unfastened at the top. If the trousers are tight at the waist, the upper two or three buttons should be unfastened. In women, tight corsets and neck bands, unless quite loose, should be unfastened, and when the patient is in the chair the waistband of the dress should, if necessary, be undone. Some people are apt to imagine that their clothing is quite loose, while it is obviously so tight that it is certain to give trouble during the administration, and some persuasion may be necessary before a reasonable condition is obtained. The feeling of suffocation experienced by some patients in taking gas is generally due to the proper respiration being hampered by tight clothing.

Before the patient enters the room it is well to have the gas-bag half distended. This will prevent an empty bottle being used, and the patient will be spared the sound of the gas entering the bag when it is first turned on. The bag should not be so distended that when the gas is turned on a puff of it escapes at once into the patient's mouth. The anaesthetist should also breathe through the apparatus to see that the valves are in working order. The inspiratory valve will occasionally be found to have partly entered the aperture which it is to close, and must be replaced in position. Either or both of the valves may be found to have become dry and curled up

at the edges, and so the apertures will not be completely closed. The upper part of the stopcock must then be placed for a few seconds in warm water, till the valve at fault is immersed. This soon renders it supple again, and its aperture will then become perfectly closed. Both the above occurrences are less likely to happen if the valves are strengthened by a small piece of aluminium as suggested above.

The Position of the Patient.

The patient now takes his place in the chair, and the position he assumes is not unimportant. It should not be an uncomfortable one, and must meet the requirements of both the administrator of the gas and the operator. He should be instructed to sit as far back in the chair as possible, and not allowed to simply rest on the edge of the seat, and then lie back. The legs should not be crossed, and should not be too much flexed. The feet should be placed, if possible, on the rest provided for them, but if the patient is very tall it is better that the feet should rest on the floor, than that the legs should be too much flexed. The feet should not be fixed in any position, nor even pressed firmly against the foot-rest, for any constrained position is liable to be followed by opisthotonus when the patient becomes unconscious.

The position of the head is most important. The administrator should endeavour to keep the long axis of the head as much as possible in the continuation of the long axis of the body; that is to say, the head must not be unduly thrown back, nor, on the other hand, must the chin be allowed to be pressed down towards the sternum.

If the operator expresses a wish to have the head thrown far back while he is at work, a small air-cushion may be placed behind the head as suggested by Dr. Hewitt. This is distended at first, and enables the administrator to have the head fairly well forward while the patient is being anaesthetised, and

when he is ready for the dentist the air may be allowed to escape from the cushion, when the head will fall back into the position desired by the operator. If the air-cushion is not at hand, the position required by the dentist may be obtained by tilting back the chair when the patient is under the effect of the gas.

The patient should be advised to place his hands on the arms of the chair, and in this position will, if nervous, probably grasp them firmly as he becomes unconscious, rather than move them about to the inconvenience of both the administrator and operator. If this position is not satisfactory, he may be advised to clasp his hands.

Placing the Prop in Position.

Any loose teeth or plates must be removed, and the prop should now be placed in position. This will generally be on the side of the mouth opposite to that from which the first tooth is to be extracted; but if the tooth is situated in the front of the mouth, a small prop may occasionally be placed behind it on the same side, and so later on the use of a gag will not be necessary when teeth are also to be removed from the other side as well. Care must be taken that the prop rests on sound teeth, or firm gum, that it keeps the mouth sufficiently widely open, does not easily slip, and that it is not placed in such a position that it will be in the way of the operator.

If some teeth have recently been removed from the side on which the prop has to be placed, it should be kept from pressing on the gum, which will probably be sensitive. When teeth are to be removed from both sides of the mouth a central prop is sometimes placed between the incisor teeth, but this practice is open to the objection that as the patient becomes unconscious he may bite on the prop very firmly, and so injure the front teeth; and also when placed in this position the prop is more liable to become displaced by the semi-conscious

efforts of the patient. It is, however, useful from the fact that it does away with the necessity of changing from the prop to a gag during the operation. Before the face-piece is applied the dentist should always be consulted as to whether sufficient room has been obtained.

When a patient is suffering from an alveolar abscess the amount of opening of the mouth that can be obtained by any prop is often very small. In these cases a small prop should be placed between the teeth in front of the one to be removed on the same side of the mouth, or if a small enough prop is not at hand, a cork to which a string is attached may be employed. When the patient is anaesthetised a gag is placed on the opposite side, and the prop removed. Occasionally the jaws can be separated to such a limited extent that no prop can be inserted even between the front teeth, and then the patient must be anaesthetised without, and the mouth opened when he is unconscious. This will have to be done by means of the wooden wedge till an opening is made large enough to admit the arms of the gag, which must then be further opened to the extent required. A screw-gag if at hand may prove useful. If much trouble is experienced in opening the mouth by these methods the anaesthesia obtained from the gas may be insufficient, and recourse must be had to a prolonged gas anaesthesia by the nasal tube, or to gas and ether.

When the prop is once in a satisfactory position care must be taken that it is not displaced by movements of the tongue, or by the opening of the mouth. If when the prop is in position the patient is instructed to close the lips over it, it is less likely to be displaced by the voluntary movements.

The Face-Piece.

A face-piece must now be selected, and be attached to the gas apparatus, the air-cushion surrounding it having been fully distended. If afterwards it is found that the face-piece fits

better with the cushion less distended, it is very easy to let a little of the air out ; but if more distension is required, it will be necessary to remove the face-piece from the patient's face before this can be accomplished. A few drops of Eau de Cologne sprinkled on the inner surface of the face-piece will disguise the smell of the india-rubber, which some people find unpleasant.

Position of the Administrator.

The anaesthetist in administering gas usually stands on the left side of the patient, and is thus entirely out of the dentist's way when he wishes to operate from behind the chair. Some administrators, however, stand at the back of the chair, as if giving any other anaesthetic.

The right foot now rests firmly on the key by which the gas is turned on, and the bottles must be placed at a suitable distance, so that the administrator may have complete control over the apparatus. Before the face-piece is finally applied to the face, the patient should be instructed to breathe freely into the apparatus. Many, however, especially among the poorer class, such as are met with in hospital practice, are very inclined to hold the breath at first, but when told to "blow out" into the bag, will do so readily, and this deep expiration must be followed by a long inspiration, and a regular rhythm will soon be established.

Holding the Face-Piece.

With the administrator standing as above mentioned at the left of the patient, the face-piece will naturally be most conveniently held in the left hand. The best way of holding it is shown in the figure (Fig. 12), where it may be seen that the thumb is resting on the part of the face-piece which is above the connection with the stopcock, while all the fingers are below it.

As the face-piece is applied the upper part should be allowed to slide down the bridge of the nose to a slight extent to ensure its fitting in this part, which is one where the gas is most liable to escape through careless approximation. When

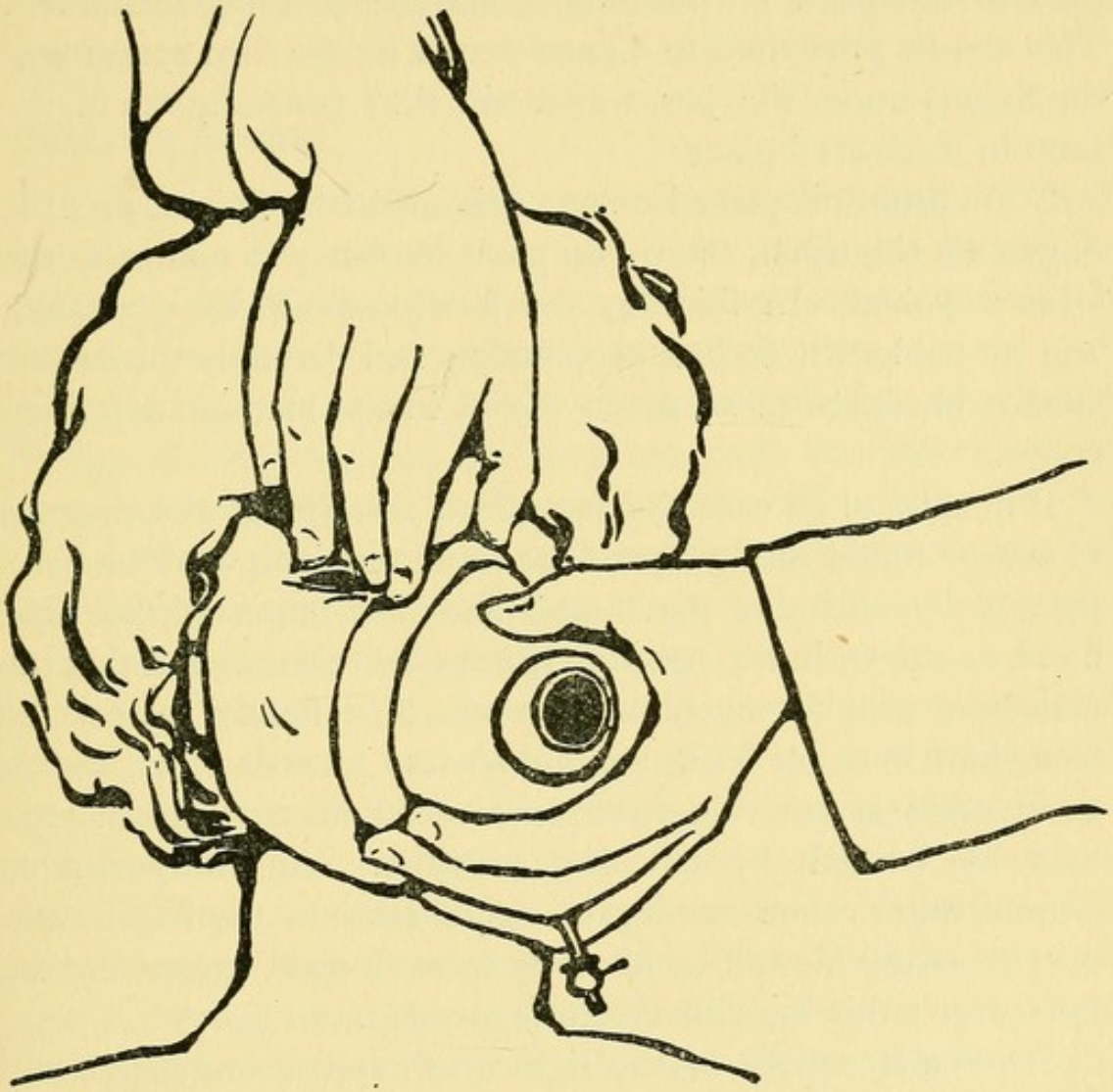


FIG. 12.—METHOD OF APPLYING FACE-PIECE FOR THE ADMINISTRATION OF NITROUS OXIDE.

the upper part has been placed in position the lower part must be carefully applied. For this purpose it will be found that accurate fitting of this part will be assisted by the placing under the chin of one, two, or even three fingers. These fingers will serve other useful purposes. With them the chin may be lifted forwards away from the sternum, and thus when

necessary the air-way may be to some small extent made freer. Some nervous patients, especially children, are often inclined to displace the prop which has been placed between their teeth, and even to force it out into the face-piece, or allow it to pass to the back of the mouth, and be partially swallowed. This can be prevented to a great extent by the firm pressure of the fingers under the jaw, which will thus generally retain the prop in its desired place.

If the thumb is placed on one side of the face-piece, and the fingers on the other, there is a great tendency to compress the sides together. In this way the face-piece will be elongated, and probably will fit less accurately ; and certainly the fingers cannot be made of so much use as in the method described above.

If in spite of all care the face-piece seem to be allowing gas to escape round the bridge of the nose, that part may be compressed by means of the thumb and first finger of the right hand, as shown in the figure. It must be remembered that the face-piece will fit much better when held lightly against the face than if much force is employed to press it there, and if the patient is suffering from an alveolar abscess, much pain may be caused by too firm pressure. An inexperienced administrator when turning on more gas into the bag is very apt to steady himself by allowing some weight to rest on the face-piece ; this must be carefully avoided.

When a face-piece of the right size has been adjusted, and both slots of the stopcock are open, the patient will be breathing air through the valves ; and if these are working satisfactorily, the expiratory valve will be seen to rise and fall rhythmically, and the regular sound produced by the action of the valves will be heard. The movements of the expiratory valve may be very slight if the respirations are feeble, or if the face-piece is not fitting accurately ; but the patient should not be allowed to inhale gas till the apparatus is working satisfactorily during

the inhalation of air. As soon as the valves are acting well the administrator should start the inhalation of the gas by turning the handle (Fig. 7) which closes the lower slot of the stopcock, and cuts off the supply of air at the same time that it establishes communication between the face-piece and the gas-bag.

Changing Bottles.

If, during the administration, the bottle which is being used is emptied, the tap at the top of the stopcock should be promptly turned, and the patient will then have sufficient gas to re-breathe till the other bottle is ready for use.

To change from one bottle to another the first one should be turned off firmly, the key then removed, and placed on the second bottle, and the gas from that allowed to flow into the bag. When the second bottle is working satisfactorily the tap of the stopcock may be turned back, and the patient again allowed to breathe through the valves.

It may happen sometimes that the second bottle is also found to be empty, and then the patient must re-breathe the gas which is in the bag till anaesthesia is complete. If the bag is full of gas when the first bottle is emptied, the upper slot need not be closed unless some trouble is experienced in obtaining gas from the second bottle ; but if there is not much gas in the bag when the supply from the first bottle runs short, it is better to be on the safe side, and allow some temporary re-breathing. Some anaesthetists prefer to allow re-breathing at the end of the administration as a matter of routine ; but as mentioned above, though the anaesthesia resulting from this method may be longer by a few seconds, yet after it headache, giddiness, and a tendency to vomit, are more common than when the gas is breathed through valves, and in this way the gas-bag is fouled by the patient's breath, instead of being used only for the passage of gas from the bottles to the stopcock.

When the patient is taking gas the room should be kept as quiet as possible, and remarks about the operation will often be heard and understood long after the patient is supposed to be unconscious. If the chair in which the patient is sitting is found to require raising or lowering for the convenience of the operator, this should be done either before the administration is commenced, or not till the patient is unconscious.

The breathing of patients inhaling gas, as with any other anaesthetic, is subject to many variations, both in rate and depth. Many will be met with who hold their breath as long as possible, while others wish to take enormously deep inspirations from the very start. If the patient seems to be breathing satisfactorily, and yet very little sound comes from the valves, it is probable that the face-piece requires more accurate adjusting.

For the majority of patients it will be sufficient to keep the bag about half full. For hysterical persons who are inclined to make a noise, or become violent in their movements, or strong men who seem inclined to struggle, the bag may be distended, or an extra amount of gas given for a few inspirations by compressing the bag with the hand.

Results of the Inhalation.

In the great majority of cases the inhalation of nitrous oxide is not unpleasant to the patient. The gas has no unpleasant smell, and the taste is faintly sweet.

An analysis of the sensations felt during the administration is naturally imperfect; but the general experience after a few inspirations is that of passing into a very pleasant sleep. A feeling of slight numbness or tingling is sometimes felt, beginning in the feet and travelling upwards, and though efforts may be made from time to time to do some voluntary action, as the lifting up of a hand, this will soon cease from a feeling of laziness. As the inspirations become deeper and the pulse

fuller, more pronounced sensations are noticed. Noises are heard, and are described as those heard when a train is rushing into a tunnel, or at other times as music. It is curious that though at the time the dream seems extraordinarily real to the patient, yet on recovering consciousness after comparatively few seconds, he is quite unable to recall it. Erotic dreams may occasionally be experienced.

If the operation has been completed before any return to consciousness, the first sound that will affect the patient will probably be the request for him to expectorate the blood which he finds in his mouth. If the operation has been allowed to go on too long the patient may experience a bad dream, which will have had some connection with the pulling out of a tooth, or he may even have been sensible of the last extraction. Too much reliance, however, must not be placed on the statements of a patient recovering from the effects of nitrous oxide as to the account of the operation that he has felt. A very nervous patient who knows beforehand which teeth are to be extracted, may declare that he has felt all the teeth being removed. It may sometimes be proved that he has not by asking which came out last, and a tooth on one side of the mouth may be indicated, while in reality the last tooth extracted was situated on the opposite side. If the prop is left in position for some seconds after the extraction of the last tooth, its removal may be noticed by the patient and described as the extraction of a tooth.

Phenomena observed by the Administrator.

The induction of anaesthesia by nitrous oxide is so rapid that it is unnecessary to divide it into stages, though this might be done as with other anaesthetics, with the exception that in this case the corneal reflex is not invariably lost when the patient is ready for operation. The first effect of the inhalation which becomes apparent to the anaesthetist is

generally the duskiness of the skin, noticed in the face, and increasing till in the end it results in a state of *cyanosis* or extreme lividity. The breathing after a time becomes deeper and deeper, and a loud sound described as *stertor* will be heard.

The term "stertor" is used somewhat vaguely for the sound produced by some obstruction to breathing in the upper part of the air-way, but when used in connection with the administration of nitrous oxide, as one of the signs of anaesthesia by that gas, one distinct form of obstructed breathing is always indicated. It differs from the other forms in being spasmodic and irregular, and is most probably produced by muscular contractions which elevate the larynx, and thus partly close its superior aperture by bringing it into contact with the epiglottis and the base of the tongue. Whatever its exact mechanical explanation, it is clinically due to the deprivation of oxygen from which the patient is suffering, and when this "stertor" is well established, no more gas should be administered. When nitrous oxide is not pushed to such a degree as to produce this form of stertor, especially when air or oxygen is administered with it, instead of this irregular and spasmodic sound there will generally be heard a deep regular snoring, which may be produced by the vibration of the soft palate, or by that of the arytaeno-epiglottidean folds.

The third special sign of the result of the inhalation of nitrous oxide is the presence of irregular muscular contractions, known as "*jactitations.*" These movements may be ushered in by slight twitchings of the orbicularis palpebrarum, but the arms soon become affected. The movements may be clonic in character, and to these the term "jactitation" is more properly applied; but tonic contractions are also common, and in some cases there is marked opisthotonus, which in some patients is extremely inconvenient, as the back becomes so arched that the head is forced out of the rest, and is thrown

so far back that the extraction becomes very difficult, if not impossible. Opisthotonus is very common in children, and it is among this class of patient that the bladder and even the rectum are emptied during anaesthesia.

As the inhalation proceeds the pulse is quickened, and becomes fuller in volume. The pupils generally dilate, and there may be an interval between the lids, and the globes are often rotated upwards. The conjunctival reflex is not always lost by the time the patient is ready for the operation, and so is not very valuable as a sign of anaesthesia with this particular agent; but this is of small importance, as the preceding signs are so obvious as to be unmistakable.

When to Remove the Face-Piece.

If the operation to be performed is only a very short one, such as the extraction of a single tooth that is already loose, sufficient time may be obtained if the face-piece is removed as soon as the patient begins to show much cyanosis, with the first advent of twitching round the eyes, or the first sound of stertor. If, however, the operator requires as much time as he can get, the administration must be continued till the muscular movements begin to become excessive, so as to cause possible inconvenience to the operator, when the face-piece must be at once removed. In the second of these cases the conjunctival reflex will probably have disappeared by the time that the inhalation is discontinued; but in the former case a very good anaesthesia can generally be obtained for a short operation without the reflex being lost, and it is best to work by the other signs as mentioned above.

Length of the Administration.

The time required to produce anaesthesia varies within wide limits. Very few inspirations of gas will suffice to anaesthetise a child, especially if weakly and anaemic, while a strong

alcoholic man will obviously require a very much larger quantity before he is reduced to a condition of unconsciousness.

Besides the general condition of the patient, the duration of the induction of the anaesthesia is affected by the rate and depth of the breathing, the fitting of the face-piece, etc., and the amount of distension of the gas-bag. The time given by various writers as the average of a considerable number of administrations, varies from 50 to 70 seconds.

Quantity of Gas Inspired.

The average amount of gas inhaled to produce anaesthesia is given as six gallons; but a child is sometimes completely unconscious after six or seven breaths, while an adult who is addicted to alcohol, or is in the habit of taking large quantities of such drugs as morphia, will require much more than six gallons.

Some patients present themselves for the administration of gas who have taken a dose of alcohol within a few minutes of entering the room. In these large quantities of gas may be given without a very satisfactory anaesthesia being obtained; it will probably be of quite short duration, and accompanied by a considerable amount of movement and phonation.

Duration of the Anaesthesia.

This will also vary within the same wide limits as the time occupied by the induction. A child will soon show signs of returning consciousness, while in adults the period during which the operation may be continued will, of course, be much longer. As a general rule, we may say that the longer induction, the longer is the resulting anaesthesia.

The average duration of the anaesthesia resulting from the administration of nitrous oxide without any air is given by different writers as varying between 25 to 40 seconds. If

children and very anaemic girls were excluded, the average would probably be about 35 seconds.

The length of the anaesthesia depends, in some degree, on the seat of the operation. For instance, if all the teeth to be extracted are situated in the lower jaw, the operator in his manipulations will often so depress the jaw and keep the tongue blocking the air-way, that the length of time available for his work will thus be unintentionally increased; for by this means the nitrous oxide already in the lungs of the patient is prevented from escaping at once, and the supply of oxygen is cut off for some seconds. It is the duty of the anaesthetist to see that this artificial asphyxia is not carried too far, and if the patient does not soon resume his natural breathing, the lower jaw must be kept forward by a finger placed behind the angle, and the air-way thus cleared, and, if necessary, the tongue must be pulled forward.

Signs of an Overdose of Nitrous Oxide.

These are practically the exaggeration of those which are taken as the signs of anaesthesia, that is to say, increasing cyanosis, stertor very loud for a time and then stopping, and finally cessation of respiration. The way in which death might be produced by determined pushing of nitrous oxide would be by primary respiratory failure, followed by failure of the circulation. This respiratory failure would be caused in two ways: (1) by an exaggeration of the obstruction of the air-way, which by its evidence as stertor is taken as one of the signs of anaesthesia, and (2) by an obstruction to respiration through spasm of the respiratory muscles, such as occurs in the muscles of the extremities.

Whether caused by one or both of these factors, it is certain that we may expect the circulation not to fail till after the respiration has first stopped, and so we have an opportunity to prevent death by restoring the respiration

before the circulation becomes affected to any serious extent. For the treatment of respiratory failure, and to prevent repetition, the reader is referred to page 38.

Though very uncommon, and probably only in patients with cardiac disease, it is possible for syncope to occur while nitrous oxide is being administered, as indeed it may occur without the administration of any anaesthetic ; for treatment see page 50.

The Operation.

When the administrator is satisfied that the patient is nearly ready for operation, before removing the face-piece, he should warn the dentist, so that the first and deepest part of the anaesthesia is not wasted. In the removal of the face-piece the anaesthetist should be careful to keep it well out of the way of the operator.

As soon as the operation is commenced the administrator should do all in his power to help the operator. In the first place, the head should be kept steady in the required position. If the upper jaw is the seat of operation, a hand should be firmly placed on the uppermost part of the head, and when the forceps are being driven up into the socket of the tooth, a certain amount of counter pressure should be exerted against this force. If the teeth are being removed from the lower jaw, no attempt must be made to regulate the extent to which the mouth is opened, as the dentist will have control of this movement, and must not be interfered with, but the opposite articulation may be steadied by pressure with two or three fingers, and in this way a lower jaw, which is sometimes easily dislocated, may be kept in its place.

By the depression of the lower jaw the nitrous oxide inhaled by the patient is not so easily eliminated, and so the period of anaesthesia is somewhat lengthened; but the anaesthetist must see that respiration is not thus hampered unduly, and when necessary the jaw must be pushed forward, or the tongue drawn out.

If during the operation the patient slips down in the chair so that the chin is forced towards the sternum, there will be very little room for the operator to exert traction in a downward direction, and the head should be slightly turned to one side, so that the operator may have more room in which to work.

When all the teeth have been extracted from the side opposite to that on which the prop has been placed, room is made on the other side by inserting a gag on that from which the teeth have just been extracted, and then removing the prop. For instance, supposing that some teeth are to be extracted from the right side, and then, if time permits, some are to be removed from the left, before the patient is anaesthetised a prop is placed on the left side, and when all the teeth on the right side have been extracted, a gag must be inserted on that side, and the prop which is on the left side removed, so that it does not interfere with the operation.

Before the operation is begun it is usual for the dentist to show the administrator what teeth he wishes to extract, so that some idea can be formed as to the time to change the prop for the gag, but it is not always possible for the anaesthetist to know whether all the teeth have been removed, and it is much better for him to wait till the operator gives the word. When this is done the change must be made as expeditiously as possible, and care must be taken that the gums which are already lacerated from the removal of the teeth, are not unnecessarily injured by the pressure of the gag. Of course, if a central prop has been inserted in the first instance, and has not been moved, a gag will not be required. Sometimes a prop which has been arranged so as just to give the requisite amount of space for the operation will, on the removal of the face-piece, be found to have been slightly shifted, so that there will now not be quite room enough.

Under these circumstances it is best for the operator not to waste time in trying to work in a space that is too small, but the gag should at once be placed in a suitable position, and the prop removed. If the prop has only moved a very little, it may occasionally be pushed back into its place by one finger, and kept there by the anaesthetist.

When the gag is in position, it must not be opened more than the operator requires, and it must not stretch the cheek too tightly, as extraction is then rendered much more difficult.

The entrance of foreign bodies into the larynx may be prevented by means of the spoon shown in Fig. 11, or if this is not at hand, the corner of a napkin may be placed in the mouth behind the seat of the operation.

The anaesthetist can render great assistance to the dentist in many ways, as for instance the steadying of the head in the best position, sponging the blood away when the lower teeth are being removed, and preventing any portions of teeth from being left on the tongue, and thus exposing the patient to the risk of having them carried into the larynx by the first vigorous inhalation. The more a dentist works with one administrator, the greater will be his ease and confidence, and the more will he be able to do during the same period of anaesthesia.

Signs of Returning Consciousness.

As the effects of the gas pass off, the colour of the patient will gradually improve, the cyanosis growing less, and the normal red colour again appearing in the lips, in fact a flush is not uncommon for the first few seconds. The dilated pupils slowly contract, the general appearance of the face becomes natural, the respirations become quieter, and the pulse slower.

If the operation is continued after consciousness has returned, the patient will generally show that pain is being felt

by phonating, or screaming loudly, and by movements of the hands and feet. But screaming, and movements of the hands and feet do not certainly show that the patient is actually feeling pain. They may be purely reflex, and after a piercing scream or violent movements of the hands, the patient, when asked on fully returning to consciousness, will often deny that he has felt anything of the operation. Some patients, especially nervous women, will be noisy from the commencement of the administration, but in this class of case the sounds generally become shriller when any pain is being felt, and a little practice will enable the administrator to recognise this difference. In hospital practice it will often be noticed that after one female patient has been very noisy the others following her will in their turn give way to screaming, and so, if possible, those who are waiting for the administration of gas should be prevented from having their naturally existing nervousness increased by hearing the screams of the patient whose turn comes before theirs.

The dentist is as a rule perfectly ready to stop when the administrator tells him that the patient is feeling pain, and it is most important that a patient who has to undergo several administrations should not be allowed to feel any pain with the first; and if any doubt is felt by the anaesthetist as to whether consciousness is present or not, it is much better to be on the safe side, and to stop the dentist too soon, rather than let the patient suffer pain. Even if the actual wrench of the extraction is not distinctly felt, a confused nightmare of a painful character is experienced, which may be much more unpleasant than ordinary pain.

The Recovery from Nitrous Oxide Anaesthesia.

When the operation has been concluded the prop should be removed from the patient's mouth, and the head bent forward so that the blood may run into a bowl, and not be swallowed.

Some warm water will now be given with which to wash out the mouth, and he must be warned not to swallow any of it. It is the swallowing of blood or water which is likely to cause nausea afterwards.

As a rule the patient will by this time feel recovered from the effect of the anaesthetic; if, however, he feels faint, he should not be disturbed too soon, but allowed to rest in the chair for a few minutes, while the windows are opened, so that he may breathe fresher air. If there is any marked tendency to syncope, or even a feeling of faintness, some smelling salts or ammonia may be held to the nose. Some patients at this stage become noisy, while others are very lethargic and slow to recover their normal vivacity, but it is very rarely that a patient has not perfectly recovered in ten minutes after the conclusion of the operation. He should not be encouraged to talk much soon after the administration of gas, but should be advised to go home, and if not feeling well to lie down for an hour or so. Though feeling perfectly well directly after the recovery, it is not unusual for a patient to complain of not feeling quite well on the next day.

Ordinary food may be taken as usual, but it is better to allow an interval of an hour before solid food.

NITROUS OXIDE MIXED WITH OXYGEN OR AIR.

In the old experiments with "laughing gas" there is no doubt that the nitrous oxide contained a considerable quantity of air mixed with it. Later on, when pure nitrous oxide was administered, and anaesthesia resulted, it was established that to produce unconsciousness the gas must be given without any air, and that should any mixture be allowed, no anaesthesia, but only excitement would result.

This opinion can now no longer be held, as by the addition to the nitrous oxide of a suitable quantity of oxygen, either in

the pure form, or as atmospheric air, a good anaesthesia may be obtained without the usual signs of anaesthesia by pure nitrous oxide as enumerated above, viz., lividity, stertor, and jactitations, which are due not to any specific action of the gas, but simply to the want of free oxygen, which is cut off during the inhalation.

Nitrous Oxide mixed with Oxygen.

The mixture of these two gases was first employed as an anaesthetic agent in Vienna, but it is due to the perseverance of Dr. Hewitt that we are now able to administer gas and oxygen in any desired proportion, and by means of an apparatus that is portable.

The apparatus (Fig. 13) is necessarily more complicated than that for the administration of nitrous oxide alone. Two large india-rubber bags, joined together down the middle, receive respectively the nitrous oxide and the oxygen from the cylinders. Of these cylinders there are usually three—two of nitrous oxide and one of oxygen. The tube conveying the gases to the bags, though apparently single, is in reality double, and consists of a smaller tube for the oxygen, surrounded by a larger one for the conveyance of the nitrous oxide. These two tubes are in some older forms of the apparatus kept separate during the whole of their course. With the one tube surrounding the smaller, considerable trouble may be experienced if the oxygen tube becomes detached from its cylinder without the knowledge of the anaesthetist, and the gas thus unintentionally mixes with the nitrous oxide in the passage to the bag. As a result of this, the inductions do not proceed in a normal manner, and until the outer tube is removed for examination the administrator may for some time be unaware of the cause.

The gases are thus kept quite apart till they leave the bags at their upper ends. Here they enter a complicated metal

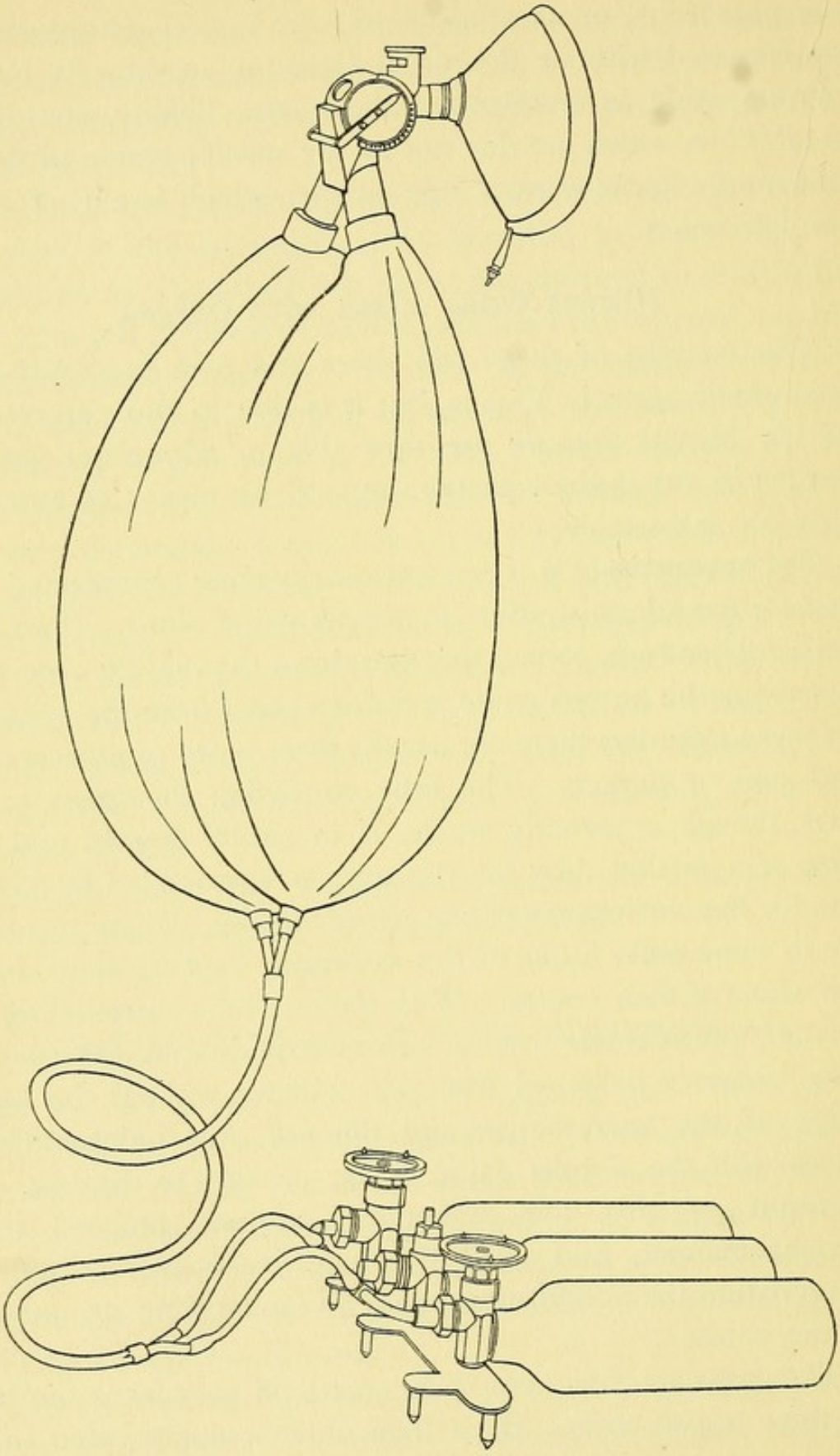


FIG. 13.—HEWITT'S GAS AND OXYGEN APPARATUS.

stopcock (Figs. 14 and 15), the nitrous oxide passing straight into the "mixing chamber," while the oxygen is conveyed into the "oxygen chamber." The return of the gases to their

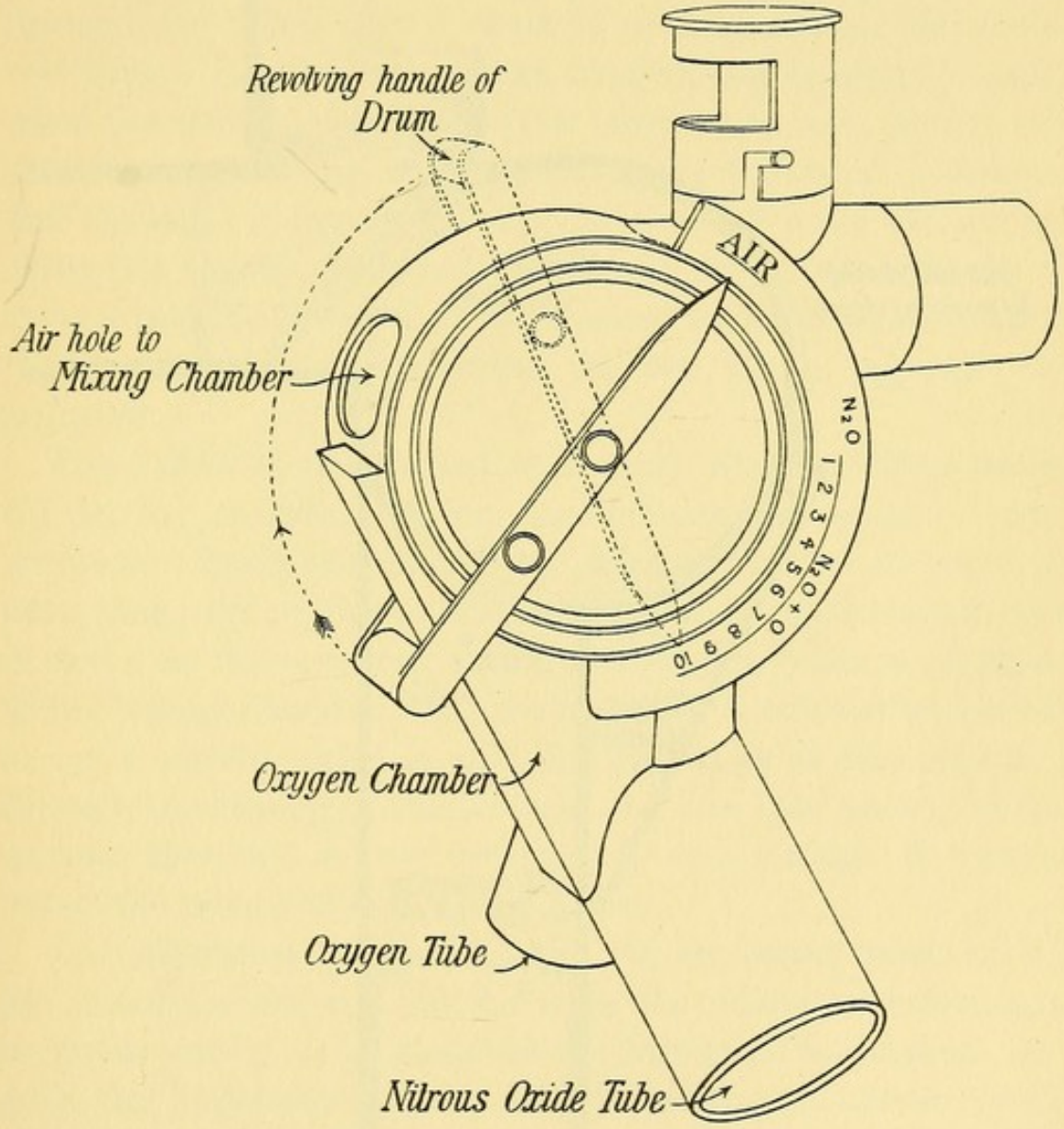


FIG. 14.—STOPCOCK OF GAS AND OXYGEN APPARATUS.

respective bags is prevented by two valves in the lower part of the stopcock. The oxygen is shut off from all communication with the mixing chamber while the indicator points to "air" or N_2O, but if this be rotated till it is opposite the figures 1, 2, 3, etc., the corresponding number of apertures leading from the

"oxygen chamber" to the "mixing chamber" are opened, and a mixture of the two gases results.

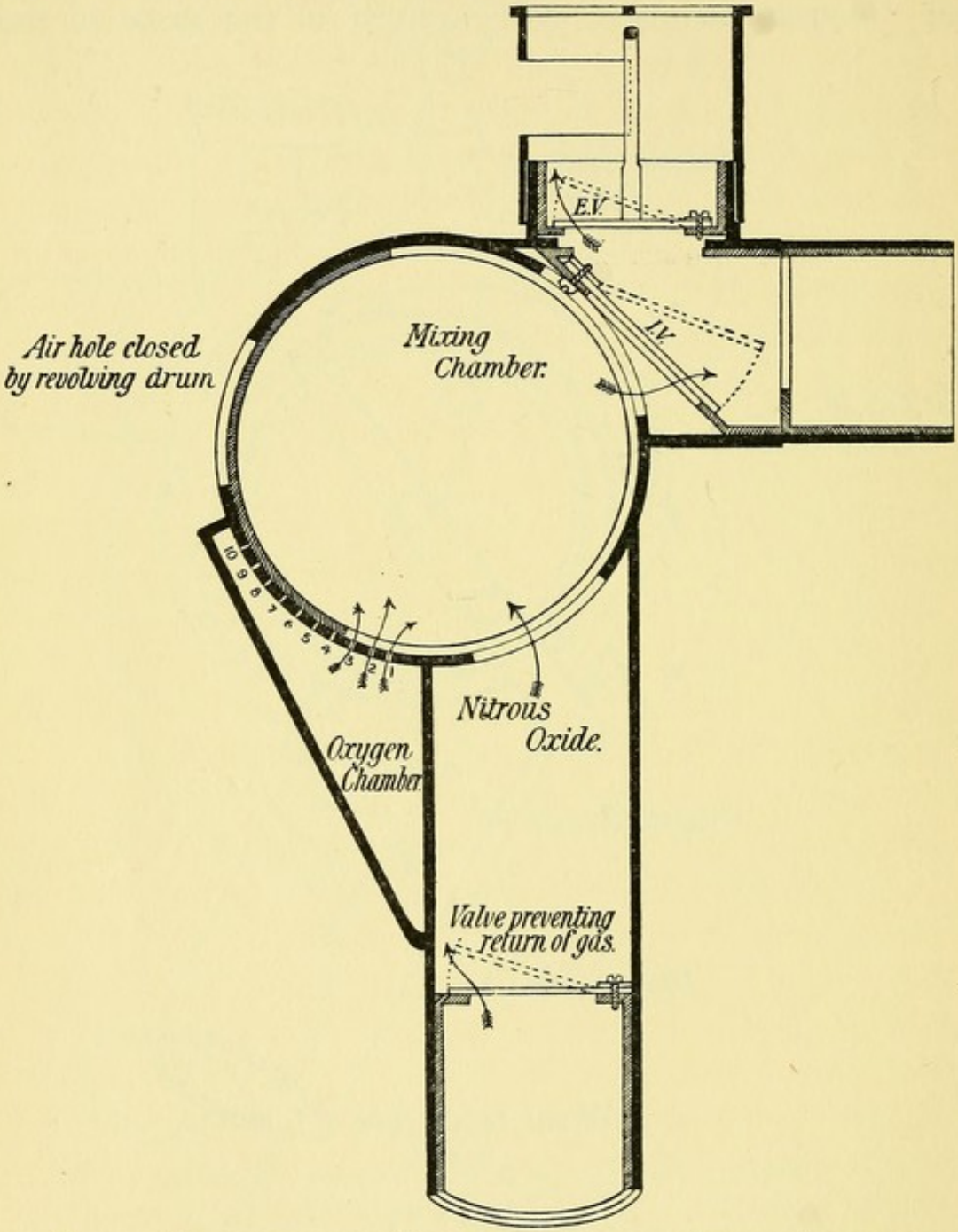


FIG. 15.—SECTION THROUGH STOPCOCK OF GAS AND OXYGEN APPARATUS. The patient is breathing Nitrous Oxide, while Oxygen also is being admitted from the Oxygen Chamber through 3 holes.

The numbers indicated do not represent the exact percentage of the oxygen in the mixture of the two gases, but the number of the holes through which the oxygen is allowed to

enter the mixing chamber. The proportion of the oxygen depends somewhat on the size of these holes, which vary slightly in different apparatus. As a rule, each hole that is opened allows about 1 or 1½ per cent. of oxygen to pass through, but this is only if there is an equal distension of the two bags. For instance, if the oxygen bag is almost empty while the nitrous oxide bag is distended, very little oxygen will pass into the mixing chamber when the indicator is turned; and *vice versa* if the oxygen bag is fairly full while the nitrous oxide bag has been allowed to become empty, the amount of oxygen that is allowed into the mixing chamber will be much higher than that represented by the figure opposite the indicator.

The indicator is attached to a drum which revolves inside the mixing chamber. When the indicator is opposite "air," air alone is being admitted to the mixing chamber through the open hole; but as the indicator is turned to N_2O the air hole is closed by the revolving drum, and nitrous oxide is admitted to the mixing chamber. As the indicator is still further moved on to 1 nitrous oxide is still flowing in, air is still excluded through the closing of the air hole, and one hole leading to the oxygen chamber is now uncovered, and through it oxygen enters the mixing chamber, and so on.

The inspiratory valve (I.V.) and the expiratory valve (E.V.) are situated at the end farthest from the mixing chamber, and to the extremity of the stopcock the face-piece is attached. As with the apparatus for the administration of nitrous oxide alone, the action of the expiratory valve is the best guide to the efficient working of the apparatus, and the approximation of the face-piece to the face of the patient.

As above stated, the bags should be kept equally distended throughout the administration, and they need never be more than two-thirds full. The nitrous oxide bag, which is usually arranged to be the one next to the anaesthetist as he stands at

the left of the patient, requires constant replenishing, while the oxygen bag, when filled to about two-thirds of its capacity, will last for four or five ordinary dental administrations. On the constant equal distension of the bags a good deal of the success of the administration depends, while another most important factor is the accuracy with which the face-piece is made to fit the patient's face. If it is only carelessly approximated to the face so much air will enter round its margins, that when combined with the oxygen given in the mixture of the two gases, the total amount of oxygen inhaled by the patient will be out of due proportion to the amount of nitrous oxide. As a result, the patient will either remain a long time without showing any signs of anaesthesia, or will pass into a condition of sleep, from which he will probably be aroused by the first application of the dental forceps.

The Administration.

All that has been said under the heading of the administration of pure nitrous oxide as to the preparation of the patient, the position in the chair, the introduction of the prop, etc., and all the remarks as to the conduction of the operation and after-treatment, etc., apply with equal force to the administration of nitrous oxide mixed with oxygen.

The two bags being equally distended, and a well-fitting face-piece having been applied, the patient is first allowed to take a few breaths through the apparatus with the indicator placed at "air." He is now simply breathing air in through the hole at the uppermost part of the stopcock, through the inspiratory valve and the face-piece into his mouth, and out again through the expiratory valve. When it is seen by the movement of the valves that the apparatus is working well, the indicator is turned to 2. As explained above, this means that the patient is now inhaling nitrous oxide gas mixed with from about 2 to 3 per cent. of oxygen. After four or five breaths

the indicator is turned to 4, when the proportion of oxygen may be reckoned at about 6 per cent. After five or six more breaths the indicator is turned to 6, and may be kept there till anaesthesia is complete, or further advanced to 7, 8, or even 10, according to the requirements of the case. The exact amount of oxygen to be allowed for each patient can only be learned by experience; but it may be stated roughly that children and anaemic girls require most, while strong men seldom require the indicator to be turned past 6.

If too much oxygen is given the patient becomes of a florid colour, and is inclined to phonate or struggle. If signs of excitement are noticed the amount of the oxygen should be temporarily diminished, or at any rate the indicator should be kept fixed, and not turned further on till the excitement seems to be abating. A small amount of phonation is more likely to accompany anaesthesia by this mixture than when gas is given alone. It may persist throughout the anaesthesia, and has occasionally been noticed to cease when the forceps have been applied to the first tooth to be extracted.

If, on the other hand, the patient shows any sign of lividity, the amount of oxygen should be increased, as if it were allowed to become more marked it might be accompanied by the other asphyxial signs of anaesthesia by pure nitrous oxide, namely, stertor and jactitations, and it is for the prevention of these that the use of oxygen was first suggested.

Signs of Anaesthesia.

With this mixture the signs of anaesthesia are quite distinct from the signs of nitrous oxide administered alone.

As the patient becomes unconscious the breathing becomes quieter and more regular, and at the same time deeper than before. The loud stertor will not be heard, but in its place there will generally be noticed a faint snoring sound produced by the soft palate, which is one of the best signs of

unconsciousness. If after the patient has been inhaling gas and oxygen for some little time, and the breathing is deep and regular, but at the same time this snoring sound cannot be heard, it may often be obtained by turning the indicator back about four holes, and with this diminution in the amount of the oxygen inhaled, the faint snoring sound will generally now be heard.

If the anaesthetist is not certain from these signs that the patient is ready for operation, he may also be guided by the following:

(1) In most cases, though not in all, the conjunctival reflex is absent when the patient is unconscious.

(2) The muscular system as a whole will be found relaxed, and if one of the patient's arms be lifted, and then let go, it will drop to the side. This is not always the case however, and instead of this flaccidity of muscles there may be rigidity, which is more often noticed in alcoholic patients.

Advantages of the Addition of Oxygen to Nitrous Oxide.

This mixture possesses advantages over pure nitrous oxide in the fact that the anaesthesia obtained with it is *longer*, and *quieter*. Speaking roughly, it is about half as long again. Dr. Hewitt, as a result of timing many cases with a metronome, found that the average time available for operation with gas and oxygen was 44 seconds, as compared with 30 seconds with pure nitrous oxide. The anaesthesia is *quieter*, for, as stated above, if oxygen has been admitted to the mixing chamber in suitable proportions there will be no stertor, but, what is of more practical importance to the operator, instead of the jactitations, which are often a source of great inconvenience, there will be an absolutely tranquil sleep, generally with marked flaccidity of the muscles, and practically never accompanied with opisthotonus.

Of course, there may be many unfavourable symptoms when this mixture is given by an inexperienced anaesthetist; in fact, it requires considerable practice before it can be given with a uniformly good result.

The addition of the oxygen renders the mixture a more suitable anaesthetic for young children, and old, or delicate people, as by its use the asphyxial element, which might prove harmful in many cases, is eliminated. When compared with its advantages, the *disadvantages* of the addition of oxygen to nitrous oxide are very small. With the use of the mixture the return to consciousness is not always so rapid, and it is more often accompanied by headache, giddiness, nausea, and even vomiting, than is nitrous oxide when administered alone. The apparatus, too, is more complicated, and requires more practice before it can be used with success.

The time required to produce anaesthesia with this mixture is longer than with gas alone. Dr. Hewitt, in his cases timed by a metronome, found that the average time taken with gas and oxygen was about 110 seconds, as compared with about 51 seconds with gas alone.

Of course, by this method more nitrous oxide is used for each administration, than when it is given without oxygen or air.

Nitrous Oxide mixed with Air.

For the administration of nitrous oxide mixed with air the apparatus described above for the administration of pure nitrous oxide is the best. All the details of the preparation of the patient, etc., apply to this method, and with the following exception the administration should be carried out as if no air were being given.

After the patient has taken about six good breaths of nitrous oxide the lower slot should be opened by turning the handle, and one inspiration of air should be allowed. Then, after five or six more inspirations of gas, one more of air should be again

given, and so on. It is impossible to give the definite proportions of air that should be given for any patient, but practice will soon show the anaesthetist what a valuable addition he has within easy reach. The amount of air required varies with the general condition of the patient, and the length of time required for the operation.

As regards the general condition, it may simply be stated that young children and anaemic girls require most air, and that strong alcoholic men should be given very little.

If the operation is to be very short it is not necessary to give much air, as the anaesthesia resulting from the inhalation of nitrous oxide without air might be enough; but in the writer's opinion it is well to give some air with every case of the administration of nitrous oxide, for the sake of the quieter anaesthesia which will result.

Signs of Anaesthesia.

If only one or two breaths of air are given the gas may be pushed till the signs of anaesthesia described under pure nitrous oxide begin to make their appearance—that is, slight stertor, lividity, and twitchings; and even then the resulting period of anaesthesia will be longer and quieter than if no air had been given.

If, however, more air has been given—in fact, enough to do away with all the asphyxial results of the gas—the usual signs will not be manifest; in other words, the patient will not become livid, but will remain of a fairly good colour, and no stertor or jactitations will be noticed. Instead of the noisy breathing, the patient will now breathe with long, deep, regular inspirations as if asleep, and instead of the loud stertor there may be generally heard a faint snoring as in a typical case of anaesthesia by gas and oxygen, and this may even be quite absent.

After a little practice the anaesthetist will recognise this

quiet, unconscious breathing, and when it is once present he may remove the face-piece and allow the operation to be begun. If, however, he is not sufficiently accustomed to the method to rely on the sound of the breathing alone, the administration may be continued till the conjunctival reflex is abolished.

By the allowance of a sufficient number of breaths of air an anaesthesia quite comparable with that of gas and oxygen may be obtained. It is as quiet, and lasts as long, and possesses the advantage of being obtained with a less complicated apparatus, and by the fact that after its use the return to consciousness is not accompanied by nausea or vomiting, as it is occasionally after the use of gas and oxygen. By thus regulating the amount of air which he allows, the anaesthetist can obtain an anaesthesia resembling that by nitrous oxide alone, though quieter, or a longer and still quieter one like that resulting from nitrous oxide and oxygen.

Some anaesthetists allow a constant supply of air to the patient by leaving the lower slot of the gas stopcock a little open; but of this method the writer has no experience.

Continuous Administration of Nitrous Oxide.

For the performance of some dental operations an anaesthesia longer than can be obtained with any of the methods described above is necessary. If the operation cannot be done in two parts, so that an interval of a day or so may elapse between the two administrations, a second administration of gas, or gas and oxygen, may be given as soon as the patient has recovered from the effects of the first, and the mouth is clear of blood. If the attempt to remove a tooth fails entirely, and no blood be left in the patient's mouth, the face-piece may be reapplied before the patient has recovered from the first administration. Any second administration of gas given in either of these ways is liable to be followed by a bad recovery,

with headache, giddiness, nausea, or even vomiting, and is unlikely to bring any credit to the anaesthetist, and should only be resorted to in very exceptional circumstances.

When an anaesthesia of two minutes is required, it can only be obtained by what may be described as the prolonged administration of gas, or by the addition of ether.

Gas may be given continuously for a dental operation either by the mouth or the nose. It is given by some anaesthetists by means of a tube leading from the gas-bag into the patient's mouth, and this is generally only employed after the patient has been anaesthetised in the usual way. It requires careful manipulation, and is liable to get in the way of the operator, and to blow the blood about in the mouth.

A better way of giving gas continuously was suggested by Mr. Harvey Hilliard. By this method the patient is first anaesthetised in the usual way, and the anaesthesia is maintained by means of a soft gum elastic naso-pharyngeal tube, which is connected with the gas-cylinders by means of a special stopcock, and then passed down one nostril. Anaesthesia has been satisfactorily maintained in this way for some minutes.

A way of giving gas from the commencement principally through the nose was suggested by Mr. Coleman, and a convenient **apparatus** has now been devised by Mr. Paterson.

It consists (Fig. 16) of two gas bottles coupled together as for the use of Hewitt's apparatus, but the *gas-bag* (C) used in this method is of smaller size, as a positive pressure of gas is sometimes required, and this is more easily obtained with a small bag, and less gas is wasted. The *stopcock* (B), which is attached to the gas-bag, is known as a two-way stopcock, for by turning it the gas is either retained in the bag, or allowed to pass on through the two tubes (E and E′) to the nose-piece (D). The *nose-piece* is made of aluminium, so as to be as light as possible, and is of such a shape as to fit over the end of the

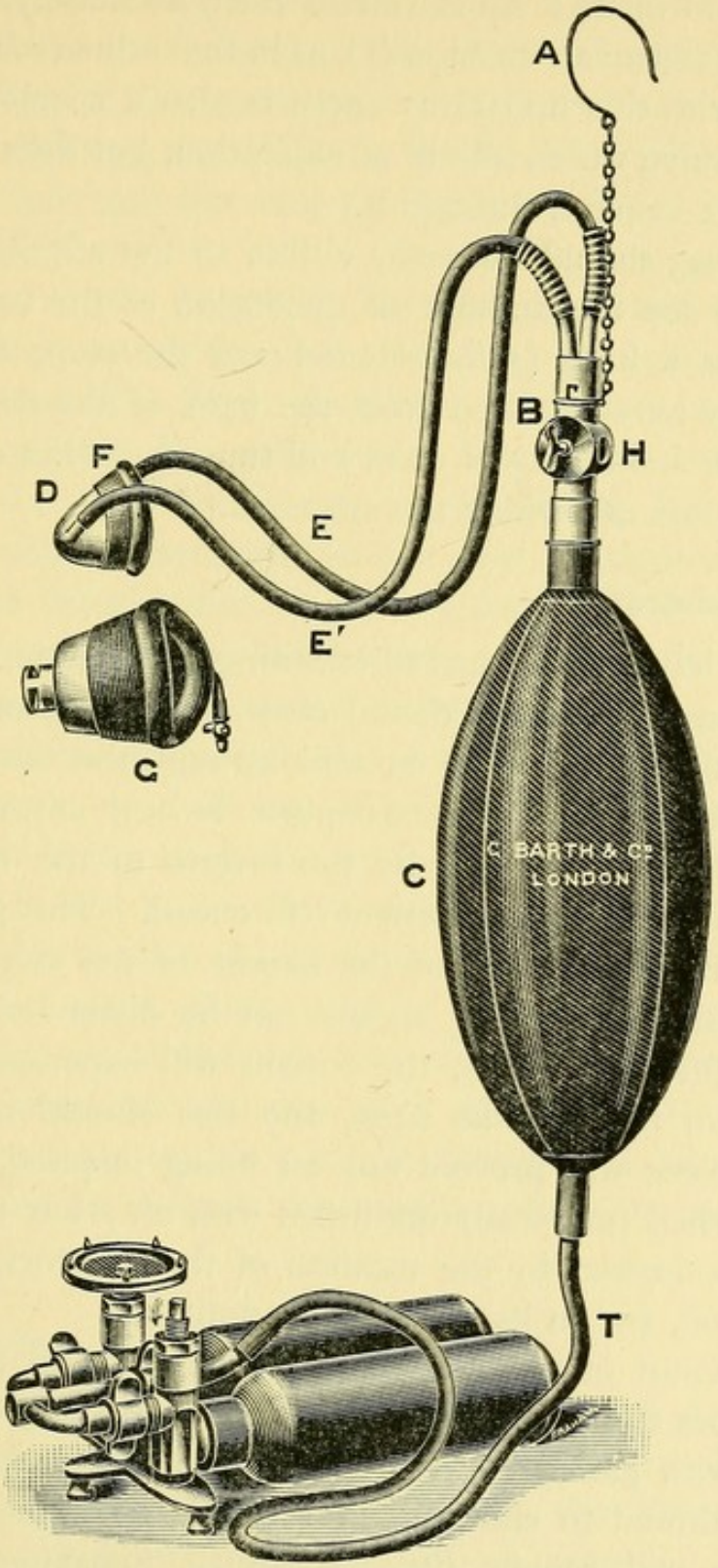


FIG. 16.—PATERSON'S APPARATUS FOR THE ADMINISTRATION OF NITROUS OXIDE BY THE NOSE.

nose, while to make it approximate more accurately, round its edge is attached an air-cushion (F), as in the ordinary face-pieces.

For use with this apparatus there is also a special *face-piece* (G), with a valve which allows of expiration, but does not allow any air to be inspired through it.

The gas-bag should be easily visible to the administrator so that he may see the amount of distension of the bag, and for this purpose a hook (A) is fastened near the stopcock, so that the bag may be suspended from the back of the dental chair, or from the anaesthetist's coat, and thus be within easy reach for the purpose of turning the stopcock.

The Administration.

The bag having been just filled with gas, the patient is seated as before described in the dental chair, and the prop inserted. He is instructed to breathe in well through the nose, and out through the mouth. The nose-piece is now adjusted to the nose and held in position by the fingers of the right hand, which rests lightly on the patient's forehead. The gas is now turned on by the rotation of the handle of the stopcock. As above mentioned, the bag should not be distended to its full extent at first, as if it is, the patient will experience the gas being blown through the nose, and this should be avoided. The face-piece will prevent any air being inspired, so the gas will be inhaled practically undiluted with air; but this can be supplied as desired by the rotation of the stopcock, when the gas is cut off, and in its place air is admitted.

The amount of air allowed to each individual patient will vary, as does the amount of oxygen given with gas, or when air is given with gas in Hewitt's apparatus; that is to say, more must be allowed to children and anaemic girls than to strong men, who will require little, if any. Speaking generally, phonation and movements indicate that more gas is required, while cyanosis and slight jactitations call for more air.

When air is to be given to the patient during the administration it is best done by means of the stopcock, and not by tilting up the edge of the nose-piece. It is true that air may be admitted this way, but in doing so the gas is allowed to blow on to the face, and the nose-piece may not fit so well when it is replaced.

As soon as the breathing becomes deep and regular, and snoring is observed, the face-piece may be removed, and the operator allowed to begin his work. This may often be done after the patient has only taken five or six breaths. For children the bag should not be distended, but a positive pressure may be necessary in the case of vigorous men. If the patient breathe well, and fairly deeply from the start, the face-piece may be dispensed with, and gas will be inspired through the nose and expired through the mouth without any air being taken in through the mouth. When the patient is at all nervous, or does not inspire well through the nose as directed, or if the breath is held, or the respirations are very shallow, it is best to use the face-piece.

The administration of nitrous oxide in this way is remarkable for the short time which need be allowed to elapse between the turning on of the gas and the commencement of the operation, and also the ease with which patients will inspire through the nose, and then expire through the mouth, without taking in any air through the mouth, even when no face-piece is used.

The Operation.

With this method the available anaesthesia is not to be counted by seconds, but the administration may be kept up for some minutes. Up to the present, the longest time for which it has been employed has been 15 minutes.

During the operation the fingers of the right hand must keep the nose-piece in position, while the patient's head may

be steadied by the pressure of the right wrist on his forehead. With the left hand the stopcock may be turned to admit air when necessary; but when both hands are occupied, and air is required, the stopcock cannot be used, and air must be admitted by tilting the edge of the nose-piece with the right hand. When during the course of the operation the prop requires moving from the right side, the gag may be used with the left hand; and when the gag has to be used on the right side of the mouth, the nose-piece must be retained in position by the fingers of the left hand. This is not always easy, and a better plan is for the dentist to remove the prop when he has finished operating on the one side, and then place it in position for the operation on the other. There will be plenty of time to allow him to do this, and it makes the work of the anaesthetist much easier. It is this question of the changing from side to side that constitutes one of the drawbacks to the administration of gas by this method for a long operation on teeth situated in different parts of the mouth. If an assistant is available, the question of the changing of the prop for the gag, and the sponging out of the blood, which in the course of a long operation must collect in the mouth, may be left to him, and the heavy burden of the anaesthetist will thus be much lightened.

The most suitable operations for the use of this method are those where no change from side to side of the mouth is required, and where there is not much blood to be sponged away—as, for instance, the breaking up of the pulp of several teeth, or the extraction of nerves.

If the anaesthesia obtained by the administration of gas, or gas and oxygen, by any of the above methods is not considered sufficient for the operation in question, recourse must be had to gas followed by ether, which will be described on page 138.

Gas in some form is, of course, preferable, both on account

of the unpleasant smell of ether, and the more severe after-effects which follow its inhalation.

NITROUS OXIDE IN MINOR SURGERY.

Unless the operation to be performed requires a very short period of anaesthesia—that is, up to half a minute—nitrous oxide alone is unsuitable on account of the inconvenience caused by the jactitations which occur when the gas is pushed; but even with the short anaesthesia obtained, as for the extraction of a tooth, by giving the gas till slight jactitation appears, and then withdrawing it, a superficial abscess may be opened, and other trifling operations performed.

But for those operations which require a few minutes for their performance nitrous oxide mixed with air or oxygen, a described above for dental operations, will be quite satisfactory. The apparatus will be the same as that already described, but the patient may now lie down, or sit up in a chair, according to the wishes of the surgeon.

If the operation is to be quite short, no more preparation of the patient will be necessary than that before the extraction of a tooth, but the longer the operation to be performed—that is, the longer the anaesthesia required—the more closely must the preparation of the patient resemble that of one who is to take an ordinary anaesthetic, such as chloroform or ether. (See page 3.)

The chief **advantages** of the use of nitrous oxide for minor surgical cases lie in the fact that it is quite pleasant to inhale, anaesthesia is soon obtained, and as a rule the recovery is rapid, and unaccompanied by unpleasant symptoms. Though in the majority of cases its action is so satisfactory, it must be remembered that the longer the operation lasts, the more likely is the recovery to be attended by headache, dizziness, vomiting, and collapse; and these may be sometimes so severe, that these

after-effects are as serious as those which follow the inhalation of one of the other general anaesthetics. A rapid return to consciousness is not always an unmixed blessing, for instead of remaining in a more or less dazed condition as after ether or chloroform, when sensation is not very acute, the patient may recover consciousness so rapidly that much more of the after-pain of the operation is felt, and to counteract this morphia may be necessary, which is often undesirable. With nitrous oxide mixed with air or oxygen it is not always possible to obtain such a tranquil sleep as the surgeon may desire, and in some cases it is hard even to obtain a thorough relaxation of muscles.

Cases suitable for Nitrous Oxide with Air or Oxygen.

This anaesthetic should as a rule be reserved for operations that do not last more than about twenty minutes, for those in which very complete relaxation of muscles is not required, and where the operation is not so delicate that a very slight movement on the part of the patient would ruin it.

Very many operations, too numerous to mention here, may be included in this category, such as opening and draining abscesses, scraping sinuses, moving stiff joints, removing ingrowing toe-nails, the first painful dressing after an operation, etc. Much more may of course be done if the surgeon makes all his preparations beforehand, and simply does that part of the operation which is painful while the patient is under the influence of the gas. For instance, for the performance of internal urethrotomy the guide may be passed before the patient is anaesthetised, and the gas only given for the painful part, that is, the cutting of the stricture.

When a patient has to return home after a short operation, such as is performed in the consulting-room, or the out-patient department of a hospital, there is on the whole no anaesthetic so suitable as nitrous oxide, mixed with air or oxygen.

The Administration.

The apparatus used is the same as that described above in the administration for dental cases.

If the gas is being given with air, the lower slot must be opened as often as necessary to keep the patient a good colour.

With gas and oxygen the indicator must sometimes be turned to 10 to obtain the required amount of oxygen, and even this is sometimes insufficient, and the face-piece must be removed to allow of some air as well. To remedy this, an addition to the apparatus has been designed in which, by turning a screw, a quantity of oxygen equal to that obtained from 10 or 20 of the ordinary holes will at once be admitted to the mixing chamber, so that the proportion of oxygen may rise above 30 per cent.

As stated above, the patient may be in almost any position that the surgeon desires, but the gas-bag should if possible hang freely, so that the amount of its distension may be easily seen. This is specially important if gas and oxygen is being administered, when, as described above, the two bags must be kept equally distended.

To keep a patient in the exact condition which the surgeon desires for a quarter to half an hour often entails a very heavy burden on the anaesthetist. It is very easy to allow the patient too much, or too little, of the air or oxygen that is being admitted with the nitrous oxide; and the mere mechanical labour of the changing of the bottles, and the turning on of the gas is not inconsiderable. The amount of the gas used may be reckoned as about 100 gallons of nitrous oxide, and 15 gallons of oxygen, for an operation lasting half an hour, and the cost of this would be about nine shillings. This has sometimes to be considered, as well as the difficulty of carriage of many heavy gas cylinders.

Whenever nitrous oxide is being given for a surgical operation, it is advisable that the apparatus for the administration of

one or the other general anaesthetics should be at hand, in case a change becomes necessary in the course of the operation from a failure in the supply of the nitrous oxide, or because the surgeon requires a more tranquil sleep.

If possible, the change should be made to ether, on account of its greater safety. Chloroform is more dangerous from the fact that the patient will probably be breathing deeply; and if the anaesthetist, in his anxiety to prevent an interval of consciousness, is too liberal in the supply of the drug, the patient will very probably receive an overdose.

The only case of death reported after the use of gas and oxygen is one of this sort, when it was found necessary to continue the anaesthesia which had been commenced with nitrous oxide and oxygen. Chloroform was employed, and the patient suddenly died.

Nitrous Oxide as a Preliminary to Ether.

On account of the rapidity of its action, and its pleasant qualities, gas is frequently employed for the commencement of the administration of ether, and this will be fully described on page 138.

It is unsuitable as a preliminary to chloroform, as with our present methods of administration of that drug the effects of the gas would have passed off before the chloroform could produce anaesthesia, and thus there would be an interval of more or less complete consciousness between the effects of the two drugs. In the administration of gas followed by ether there is no such gap, but the two gases are mixed together, and the anaesthesia obtained is continuous; but this "closed" method of inhalation is far too dangerous in the case of chloroform. Chloroform, too, if given from the first in a sufficiently diluted form, is generally so pleasant that gas is not required to disguise it.

CHAPTER IV.

ETHER: GAS AND ETHER.

ETHER, ethylic ether, or more correctly di-ethyl oxide $(C_2H_5)_2O$, was formerly known as sulphuric ether, and must not be confounded with a substance called "compound anaesthetic ether," which is intended for the production of local anaesthesia by cold, and is quite unsuitable for inhalation. The ether which is commonly administered is generally one of two varieties: (1) Aether purus, or purificatus; (B.P.) of a specific gravity between ·720 and ·722, prepared from absolute ethylic alcohol. (2) Rectified ether; of specific gravity ·720, prepared from methylated spirit.

These two varieties cannot be easily distinguished, but as that prepared from methylated spirit is about one-third the price of the aether purus prepared from absolute alcohol, this difference is well worth consideration, at any rate in hospital practice, where the drug is used in such large quantities.

At one time most administrators strongly advised the aether purus for anaesthetic purposes, as being less likely to contain impurities, and so to be attended with less secretion of mucus during its administration, and to be followed by a better recovery, with less nausea and vomiting. The methylated ether as procured from reliable chemists is, however, now so

well prepared, that in their results there is practically no difference between the two.

Ether is a colourless, limpid, highly volatile liquid, with a characteristic taste and smell. It does not mix freely with water, but does so with alcohol, chloroform, etc. Its vapour has a density of 2·58, is highly inflammable, and when mixed with air, it is explosive. Ether should never be poured from a bottle near any naked flame, as accidents have happened from this cause.

Its extreme volatility is one reason for the fact that ether is not often used in tropical climates; but it may be given there quite well in a suitable inhaler. The india-rubber, however, of which so many parts of the apparatus is made, perishes so easily in the heat, that it is rather from this cause that ether is so little used in hot climates.

Ether exposed to the air and light decomposes readily, and hence it should be stored in small bottles in a cool, dark cupboard. It has been stated that ether which has been exposed to light and air, and therefore presumably containing impurities, may be purified by some metallic mercury being poured into the bottle, which is then shaken up, and allowed to stand. The impurities are said to become deposited as a grey sediment, and the pure ether may then be decanted off. If a small quantity of the ether dropped on to blotting paper evaporates without leaving a greasy stain, and if no unpleasant and irritating smell is given off, it may be supposed that the drug is fairly pure; but for all the tests that a good ether should stand the reader is referred to the British Pharmacopœia.

The cases for which ether is suitable as an anaesthetic are discussed on page 176.

Ether may be administered by one of two methods, which are respectively described as the "open," and the "closed."

By the **open** method the ether is given in an inhaler

which admits of dilution with a large volume of air. It is not often employed in this country, for reasons which will be stated below, but if it has to be given in this way, the Rendle's mask figured on page 161 may be used for adults, while for children it is best given from a small felt cone (page 134). In America a special inhaler known as Allis' is employed, but it will not be described, as it is so seldom used over here.

The *advantages* of this method are that, with it, it is very difficult to give an overdose of the anaesthetic, and so it is to some extent safer for the patient at the time.

But it presents several *disadvantages*. The volatility of the ether is so extreme that very large quantities of the drug must be poured on to the inhaler before anaesthesia is produced. The ether is blown into the surrounding air, and becomes a source of annoyance to the administrator and the surgeon. The time required to produce unconsciousness will be much longer than with the closed method, and there will often be severe struggling; in fact, it is very difficult, if not impossible, to anaesthetise alcoholic men in this way.

Coughing at the time may be very troublesome, but, what is even more important, the evaporation of the large amount of ether will produce such a diminution in the body-temperature, that this, combined with the irritating nature of the ether on the air-passages, will not infrequently result in bronchitis following the inhalation.

For children it is more satisfactory. There is no complicated apparatus to frighten them; and if it is decided that ether is the best anaesthetic for any individual case, and the patient is quite young—say, up to four or five years—the drug is best given in a felt cone as suggested by Mr. Woodhouse Braine. These are made in various sizes, with a small piece of sponge pushed up to the apex, and on to this the ether is poured.

The essential feature in the **closed** method of administration is that the patient, instead of being supplied with a free

supply of air, breathes backwards and forwards into an india-rubber bag, to which is attached a receptacle containing the ether. In this way the evaporation of large quantities of ether into the surrounding air is prevented, and there will be less struggling and coughing. Unconsciousness will be produced in a much shorter time, and the risk of the inhalation being followed by bronchitis will be much diminished. In this re-breathing it is obvious that there is an element of asphyxiation, but as soon as the patient is once unconscious, so much air is allowed that if the administration is properly conducted, the patient will suffer no harm from this cause. The risk of bronchitis is further lessened by the fact that the mixture which the patient inspires from the bag will be at a higher temperature than the air which so freely dilutes the ether vapour when the "open" method is employed.

THE ADMINISTRATION OF ETHER IN A CLOVER'S INHALER.

The inhaler now to be described is more strictly known as Clover's small, or portable, inhaler, to distinguish it from the larger and more cumbrous form.

In writing this book my object has been not to multiply the descriptions of different apparatus, but to try to make the student acquainted with the use of those forms which are most frequently employed, and for this reason the large form of Clover's inhaler will not be described; but if the student wishes to understand its use, he will find the best account of it in Dr. Dudley Buxton's book on *Anaesthetics*, page 117. When Clover's inhaler is mentioned in this book, the small or portable form is always the one referred to.

The Apparatus.

The dome-shaped metal *inhaler* (Fig. 17) consists of a spherical chamber into which the ether is poured, and through

which the breath circulates on its way to and from the mouth to the bag. To the lower part of this sphere is attached a circular, flattened chamber containing water, which is added to produce a more equable evaporation of the ether.

The central part of the sphere is pierced by a shaft in which rotates a column, to which are attached both the face-piece, the bag of the inhaler, and the indicator. About the middle

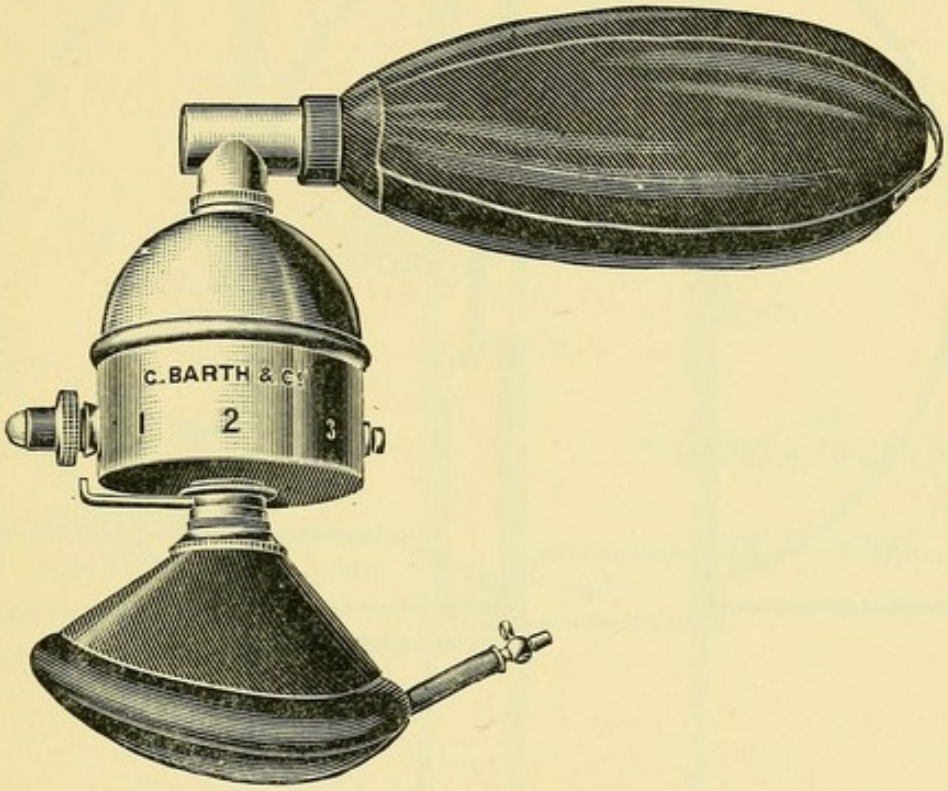


FIG. 17.—CLOVER'S INHALER.

of this shaft there are openings into the ether chamber, and on the corresponding part of the column are also openings through which the breath may pass from the face-piece, through the column to the interior of the ether chamber, and out again through the upper part of the column to the india-rubber *bag* at its extremity (see Figs. 18 and 19).

By means of the rotation of the ether inhaler on the central column more or less of the breath passes into the ether chamber in its passage from the face-piece to the bag, and back

again. The proportion of the breath that thus passes into the ether chamber is regulated by the approximation of the holes in the central column with those into the chamber, and can be best understood by the actual examination of the apparatus, though the above diagrams may help to make things clearer.

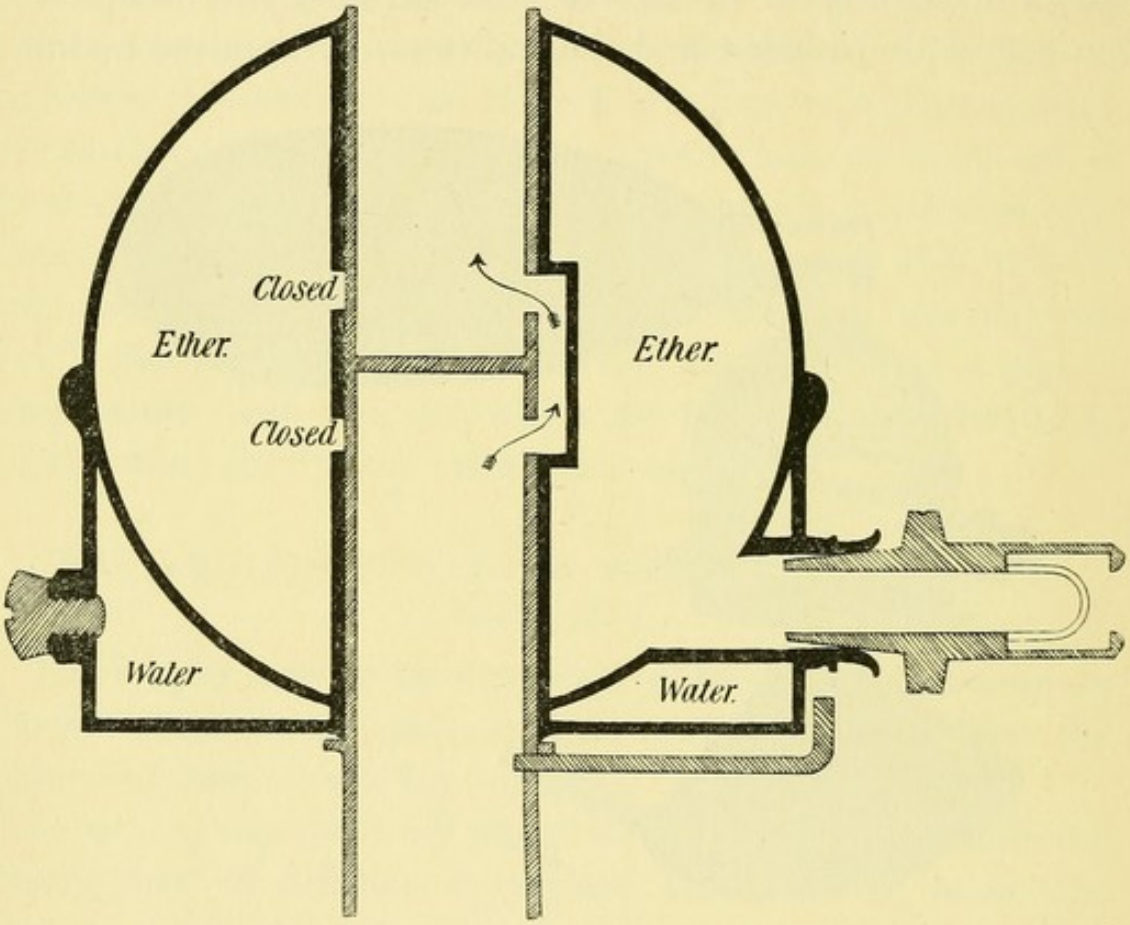


FIG. 18.—SECTION THROUGH CLOVER'S INHALER WITH INDICATOR AT O. All the breath is passing through the column, from the face-piece to the bag and back, without any entering the ether chamber.

The breath that does not enter into the ether chamber simply passes from the face-piece through the column to the bag, and back again. The proportion of the air respired that is passing into the ether chamber is indicated by the figures which are placed round the inhaler. Thus, when the indicator points to O, it signifies that none of the breath which is passing backwards and forwards from the patient's mouth to the bag is being allowed to traverse the interior of the ether chamber on

its way. With the indicator at 1, one part of every four is circulating over the ether, while the other three parts are simply passing backwards and forwards as before. With the indicator at 2, two-fourths or one-half is entering the chamber; at 3, three-fourths; and at F, or "Full," all the breath is

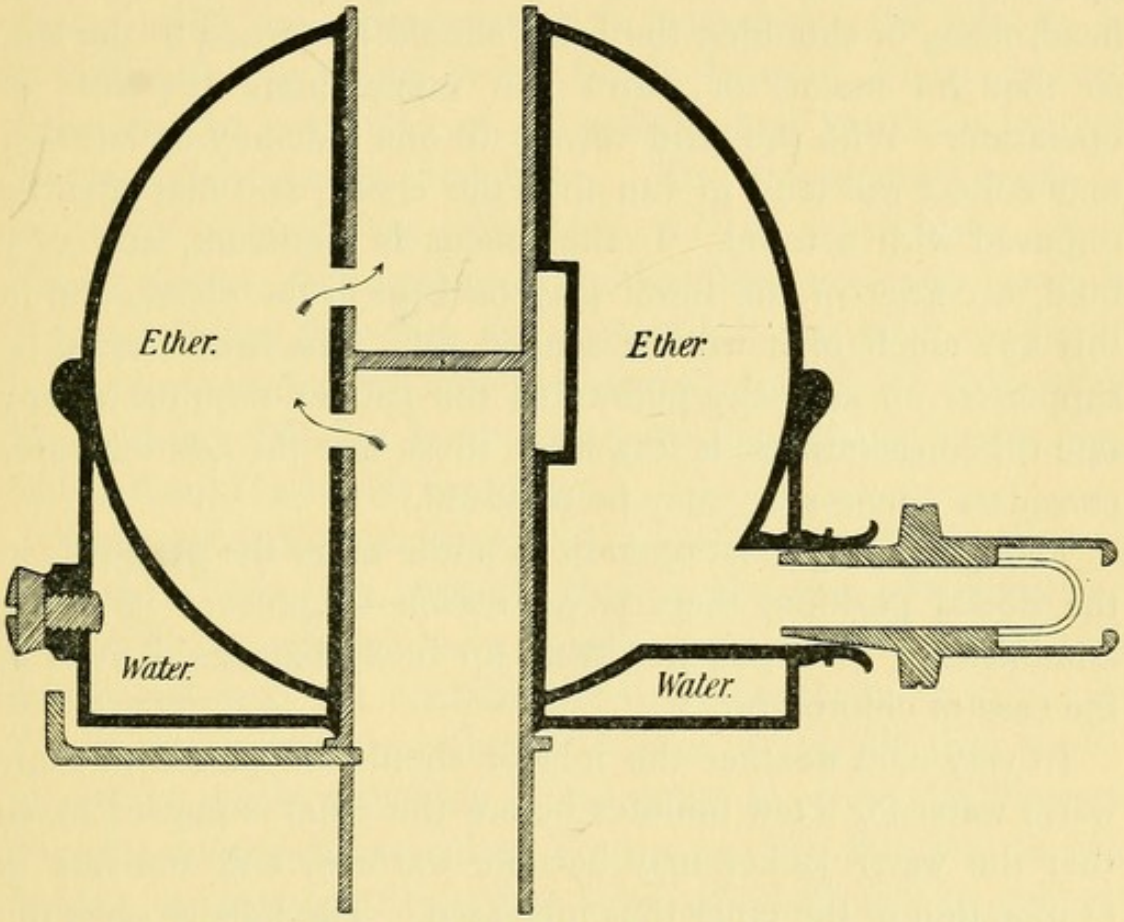


FIG. 19.—SECTION OF CLOVER'S INHALER WITH INDICATOR AT FULL. All the breath is now passing into the ether chamber, and out again.

passing into the ether chamber on its way to and from the bag.

The *face-pieces* are the same as those used in the administration of nitrous oxide (p. 61), and various sizes must be at hand. When one is being adjusted it should be seen that the indicator of the inhaler fits accurately into the slot of the face-piece, as otherwise the heavy upper part of the inhaler is apt to fall off while the administration is in progress.

Position of the Patient.

As stated in chapter I., the patient should if possible lie on his back, with his head only turned to the right. This will be the most convenient position for the administrator, and as a rule will not be uncomfortable for the patient. But if the operation is to be performed on the right side of the face, head, neck, or shoulder, the head should be turned to the left, so that no mucus or saliva can contaminate the seat of operation. With the head turned to one side any mucus that may collect will tend to run into the cheek, and may then be removed with a towel. If the mucus is abundant, and very fluid, a corner of the towel may be kept in the cheek, and in this way much of it will be soaked up. The head should be supported on as many pillows as the patient requires, at any rate till consciousness is lost, when those that the administrator considers unnecessary may be removed.

Though during most operations under ether the patient is in the dorsal position, there is no reason to prevent its being administered to a patient sitting up in a chair, as there is in the case of chloroform.

In very cold weather the inhaler should be placed in some warm water for a few minutes before the ether is poured in, so that the water jacket may become warmed, and the rate of evaporation of the ether thus increased. The inhaler must not be made hot, and of course it must not be placed in the warm water while any ether is in the chamber.

The Administration.

The usual examination of the patient, as described on page 5, is now to be made, special care being taken to ascertain the presence of any signs of bronchitis or emphysema. If the patient has been lying on his back in bed for some time, the bases of the lungs should be examined for signs of congestion.

The choice of the anaesthetic having fallen upon ether, a face-piece is selected which will best fit the patient, the air-cushion round its edge being distended.

A measureful of ether, in quantity about one and a half to two ounces, is now poured out, and smelt by the administrator before it is poured into the inhaler. It is a good plan to always smell the ether before it is poured into the inhaler, as occasionally the liquid in the bottle labelled ether has consisted for the most part of chloroform, and has been inhaled by the patient with a fatal result. The anaesthetist ought to be able to suspect pure chloroform, if in an ether bottle, by its greater weight; but a mixture of chloroform and ether has been detected by the fact that the anaesthetist has smelt the liquid before its introduction into the inhaler, and in all probability the patient's life has been saved by this simple precaution, which should never be neglected.

With the indicator turned to 2, before any fresh ether is poured in, any that remains from a previous administration should first be removed and thrown away. Ether should only be poured into the chamber when the indicator is at 2. If this is done while the indicator is at 0, all the air that is displaced by the introduction of the ether must escape through the hole by which the ether is entering. In this way it will bubble up through the ether, some of which will be spilt on the floor, and the room filled with its pungent smell.

As soon as the ether is in the chamber, and the selected face-piece is fixed on, the anaesthetist should blow vigorously through the apparatus to get rid of the vapour which hangs about the central column. If the inhaler is placed on the patient's face before this is done, the strong smell of ether will disconcert him, and may make him cough.

The bag is now adjusted empty, and the patient is instructed to take a good breath, and then to blow out into the bag. The inhaler is held some little way from the face during the

inspiration, but should be closely approximated to the face during expiration, so that the bag may in this way be distended with the patient's breath. Before applying the inhaler to the patient's face some administrators distend the bag with their own breath, but this practice is open to very obvious objections, and should always be avoided. Some anæsthetists let the patient breathe through the inhaler before adjusting the bag, but this is hardly necessary.

Holding the Inhaler.

With the head turned, as suggested above, to the right side, the face-piece is held in the right hand in the position shown in figure 20. The thumb and forefinger are placed round the central hole of the face-piece, while the weight of the inhaler rests upon the back of the hand. When adjusted to the patient's face the thumb approximates the upper part of the face-piece, while the forefinger—or if necessary the first two fingers—maintain the lower part of the face-piece in position. In this way two or three fingers are left free, and should be placed under the chin, where they will be of great assistance in keeping the jaw in good position. When the face-piece is removed for the patient to inspire air these fingers may still remain under the chin, and in this way the jaw will be kept in good position and an efficient air-way maintained. It is a common failing in the inexperienced anaesthetist to allow the jaw, and with it the tongue, to fall backwards when the patient is given a breath of air. By so doing the air-way is obstructed, the expected amount of air is not received by the patient, and a temporary asphyxia is produced. To remedy this the patient will often make a violent expiration resembling a cough, and this will often be a source of much inconvenience to the operator. In operations about the neck, too, the dropping back of the jaw, when control of it is abandoned by the anaesthetist, may effectively alter the field of operation, and

the partial asphyxia resulting from it will cause a venous engorgement of the part, which will further embarrass the surgeon. Thus it will be seen that the jaw should be kept in a suitable position when the patient is breathing air, as

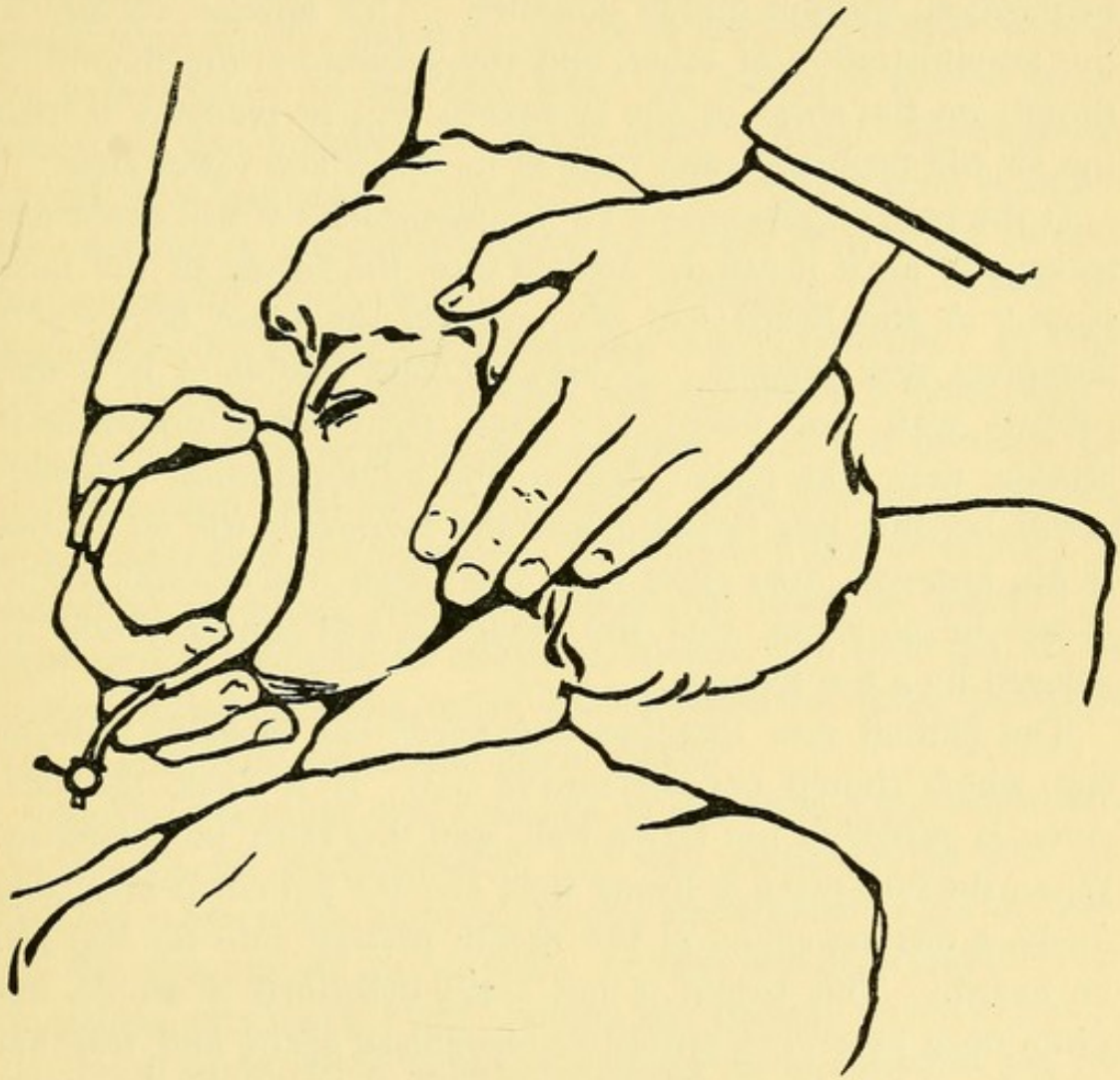


FIG. 20.—METHOD OF APPLYING FACE-PIECE FOR THE ADMINISTRATION OF ETHER. The body of the inhaler, which has been omitted in the figure, rests on the back of the hand.

much as when he is breathing into the ether chamber, and if the inhaler is held in the way suggested, this good position is easily maintained by the help of the fingers under the chin.

If during a long operation the right hand becomes tired, and there is no reason to the contrary on account of the operation,

the patient's head may be turned to the left, and the inhaler held for a time in the left hand.

As stated in the chapter on the administration of nitrous oxide, the face-piece will generally fit better if it is held lightly in position, without undue pressure. This applies equally to the administration of ether, and any pressure of the fingers or thumb on the sides of the face-piece will so elongate it, that the air will probably enter both at its upper and lower ends.

If the patient possesses a strong moustache it will cause less leakage of air if it can be tucked into the inside of the face-piece. A stiff beard will often render the exact fitting of a face-piece very difficult. It may give less trouble if it is well rubbed with hot water, but even then some unavoidable leakage may take place; but as the administration proceeds it will become less resistant, and the face-piece will fit better. If air, however, does enter from this cause, the amount will as a rule be so slight, that the induction will generally only be delayed by a few seconds.

The patient now breathes backwards and forwards into the bag, which should not decrease in size. If it does, the face-piece is probably not fitting well, and this must be remedied. When the face-piece is fitting well, and the patient is breathing freely, a distinct sound of the breath passing into the bag will be heard. This sound is not easily described in words, but when once heard can always be recognised again, and, together with the distension of the bag remaining constant, constitutes a certain sign that the face-piece is fitting well, and that the patient is breathing satisfactorily.

When the patient has respired into the bag five or six times the ether may gradually be turned on by rotation of the ether chamber, so that the part marked from o to 1 is passed over the indicator, which remains stationary. This movement should be very gradual, and cannot be too slow at first. If it is done too quickly, the patient will be made very conscious of

the presence of the ether, and will either hold his breath, or cough violently; whereas if it has been slow and gradual, he will become drowsy, and will not notice the gradually increasing strength of the ether. As long as the breathing continues regular, without any coughing, the ether may be steadily turned on; but if the breath is held, the inhaler should be kept applied to the face with the indicator at the same place, till the breathing is again fairly regular. If coughing occurs, it is better to turn back to a weaker proportion of ether till tolerance is established, when a stronger proportion should be gradually given again. This coughing will often be noticed in men who are habitually heavy smokers. It may sometimes be overcome in this way by giving a more dilute proportion of the ether for a short time; but if it persists, the opposite plan must be tried, and the ether pushed so that the coughing reflex is abolished. Occasionally the ether may be found so irritating, that the anaesthetic must be changed to chloroform or one of its mixtures, though if a little A.C.E. be given till the coughing reflex has disappeared, ether can then be administered again with good results.

By the time that the indicator is opposite 1, the ether may be turned on more quickly, but still gradually, so that the patient is not made to cough by the suddenness of the increase in the strength of the vapour. In this way in strong men the indicator may mark "full" before the patient is unconscious. In small children it is not necessary to go beyond $1\frac{1}{2}$, nor beyond 3 for women. In fact, the figure to which the indicator is rotated varies with different administrators; some anaesthetise their patients by allowing them to breathe for a long time a diluter vapour, while others soon render them unconscious by quickly increasing the strength of the ether. The mean between these two courses is probably the best, that is, to reserve "full" for vigorous men, especially if alcoholic, and in the case of most women not to advance

beyond 3, nor beyond 2 in the case of children. As the patient becomes unconscious a change will be noticed in his breathing, which now becomes more regular, and at the same time deeper. At this stage, too, many of the muscles will become relaxed, and the administrator must now see that the jaw is in a good position. While the patient is conscious it is quite unnecessary, and annoying to him, for the jaw to be violently pushed forward; but as soon as he begins to lose control of the muscles which prevent it from slipping back, the administrator must step in and assist.

To keep the jaw forward—and this of course implies that with it moves the tongue, so that the object in view is the maintenance of a good air-way—one of the fingers of the left hand of the administrator is placed behind the left angle of the jaw, and pressure is exerted in the direction of the mouth. If the inhaler is held in the way suggested on p. 116, much assistance will be derived from the fingers placed under the chin. If firm pressure does not seem to affect the position of the jaw, the face-piece should be removed for a moment to see if the lower teeth are caught behind projecting upper teeth, and, if so, the jaw must be depressed, and an attempt made to get the lower teeth in front on the upper ones. It occasionally happens that the tongue becomes caught between the front teeth, and if this is discovered it must of course be remedied.

With the jaw in good position, and the air-way thus clear, the breathing becomes deeper, and the patient begins to show some signs of cyanosis. When this becomes marked a breath of air should be allowed by removing the inhaler for one inspiration, care being especially taken, when it is re-applied, that this is done during expiration, so that the bag is kept distended. Care must also be taken that the face-piece fits as well as it did before it was removed. Much air should not be given till the patient is really anaesthetised, as in this way the ether becomes too much diluted, and acts as a stimulant,

exciting the patient, who then probably struggles violently. This withholding of air during the induction is one of the features of the "closed" method of the administration of ether, but of course air must be given when the patient really requires it, as will be shown by marked cyanosis. Another sign that calls for air may occasionally be seen when ether is being administered, and that is a slight clonic movement of the arms generally noticed most at the shoulders. This is not often seen, but when it does occur, the inhaler must be removed for two or three breaths, as the movement is probably asphyxial in origin, and is comparable to the jactitations seen in anaesthesia with pure nitrous oxide gas.

Signs of Anaesthesia.

When once the breathing has become deep and regular, the administrator seeks for further signs of unconsciousness. The upper eyelid should be gently raised with a forefinger. If any resistance to this is noticed, it is certain that the corneal reflex is also present; but if no resistance is felt, the corneal reflex should next be tried. To do this, while the upper lid is raised with the forefinger, the cornea is gently touched with the tip of another finger. If the reflex is present, some movement will be seen or felt in one or other of the lids. If there is no movement, the patient may be considered anaesthetised, and ready for most operations. For some operations, however, it is not sufficient to stop short at this stage, but the ether must be further pushed till the muscles at the seat of the operation are all relaxed. For instance, in abdominal sections, operations for the cure of hernia, etc., the abdominal muscles must be relaxed before the operator can proceed.

When once the corneal reflex is lost, the patient may be allowed a breath or two of air, and the inhaler should then be replaced with the indicator opposite a lower figure. For instance, supposing that the patient is a strong man, and that

when the corneal reflex was found to have disappeared the indicator was at "full," after a breath or two the inhaler should be replaced with the indicator at 2. If necessary for the further relaxation of muscles, or on account of the return of the corneal reflex, the strength of the ether may be again increased. In a similar manner the strength of the ether vapour should be decreased in all classes of patients when once the corneal reflex has disappeared.

The average time required to produce anaesthesia with ether in a Clover's inhaler may be reckoned as about five minutes. Of course much depends on the behaviour of the patient, *i.e.* whether he breathes freely from the first, and whether much struggling occurs. With a well-fitting face-piece there should be little struggling if the ether is only turned on very slowly and gradually, especially at the first; but if this is not done, and the patient inhales a strong proportion of the ether vapour while quite conscious, coughing and struggling will almost certainly result, and the time required for the production of the anaesthesia will be much increased. When the administration of an anaesthetic has once begun, it is most important, as stated on page 10, that the patient should not be disturbed by noises, or by the arrangement of blankets, or mackintoshes. All necessary preparations should be made before the inhaler is applied, or postponed till consciousness is lost. In the same way, the patient should never be forcibly restrained from movement at the beginning of an administration. It is important that assistance should be at hand in the case of necessity, but the forcible holding of the patient during the early stages of anaesthesia is more likely to produce struggling, than to prevent it.

If struggling does occur, the patient may be best kept on the operating table by pressure on both shoulders and above both knees, while a hand should press on the forehead. In this way no damage is likely to be done, but care must be taken in

superintending the help of over-zealous assistants. During his struggles the patient sometimes tries to remove his face from the inhaler, or to pull the inhaler away, and this must be if possible prevented, and the face-piece kept as well applied as the circumstances will permit, for it must be remembered that the struggling will probably be stopped more quickly by an increased strength of ether, rather than by a further admixture with air.

It is when struggling occurs that one of the great advantages of ether over chloroform is shown in the lesser tendency to syncope which accompanies the use of the former anaesthetic.

Refilling the Bag.

The bag must never be allowed to become empty, so that the sides are sucked together during inspiration, but if during

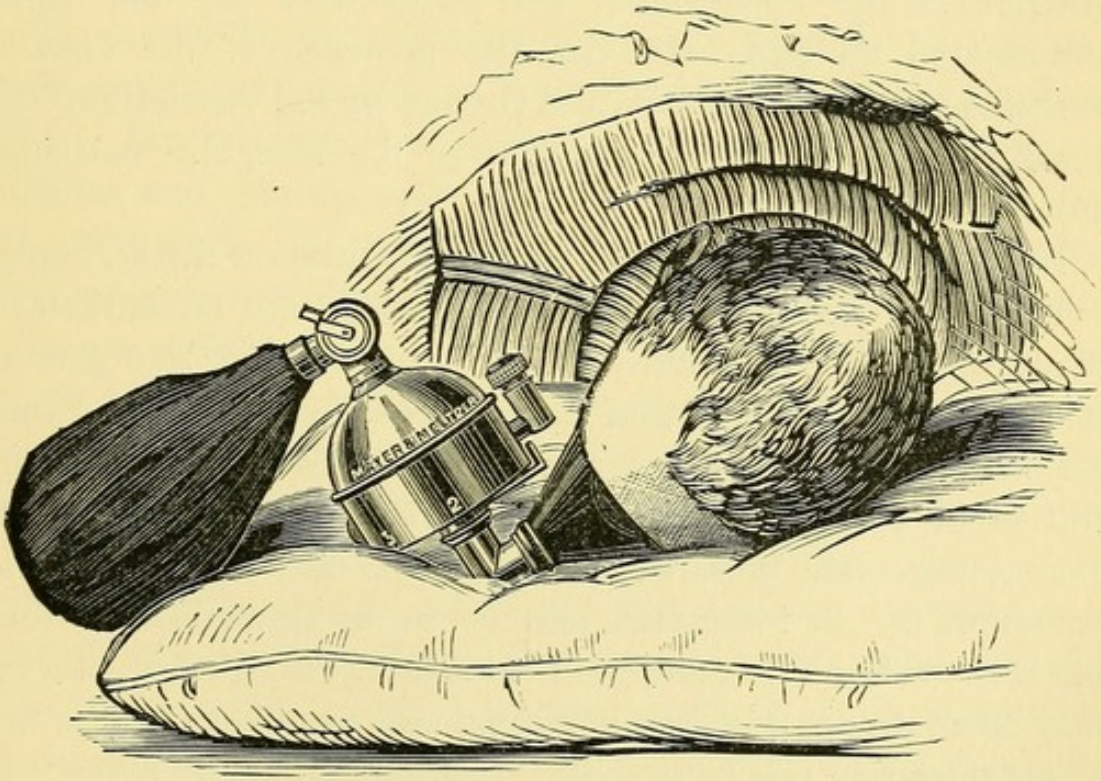


FIG. 21.—SHEPPARD'S ANGULAR ADJUSTER.

the course of the administration it becomes less and less distended, it must be refilled by removing the inhaler to allow the

patient to inspire air, and then quickly replacing the inhaler and catching the expired air in the bag.

When ether is being given to a patient lying almost in a prone position it will be found that it is very difficult to keep the inhaler properly adjusted to the face. To remedy this the late Dr. Sheppard suggested a short tube, bent at a right angle, which is inserted between the face-piece and the ether chamber, as shown in Figure 21. By the use of this tube the face-piece can fit accurately, while the rest of the apparatus will be kept quite clear of the pillows on which the patient is lying.

Regulation of the Anaesthesia.

The patient being anaesthetised, and ready for the operation, the administrator is now concerned with the proper maintenance of the anaesthesia, and must work by the signs enumerated on page 18—viz., the presence of the corneal reflex, the size of the pupils, the rhythm of the respiration, the character of the pulse, the colour of the face, and muscular movements.

In all important operations, especially those on the abdomen or other vital parts, the *corneal reflex* should not be allowed to return; but in operations on the limbs, where the part is steadied by an assistant, and a slight movement would not ruin the whole operation, the reflex may be allowed to reappear, and to be present for most of the period of anaesthesia. Of course, the mere presence of the reflex does not affect the operation on an important part, as in an abdominal section, but if the reflex is present, the next sign of the light anaesthesia may be straining, or actual vomiting, and by either of these the whole operation might be spoilt. In testing for the reflex it is best to try both eyes alternately, as by the frequent touching of one cornea it may become less sensitive, and conjunctivitis may be set up.

The *size of the pupils* is a very useful guide as to the depth of the anaesthesia. When the corneal reflex is first lost they will probably be somewhat dilated from muscular exertion, and partly from the amount of ether that has been given, but also from the limitation of oxygen which is unavoidable in the production of unconsciousness by the closed method. As air is given, however, the pupil soon becomes smaller, and the average size of the pupil of a patient well under ether is about 4 mm. in diameter, though this is perhaps rather a high estimate. If the pupil become larger, the cause must be sought and remedied, as described in the general consideration of the anaesthetic state (page 21).

The *respirations* should now be deep and regular, as shown by the regular distension of the bag, and the sound of the breath passing into it. By constant practice the administrator can work almost entirely by the respiration—that is to say, he can give just the right amount of ether to keep the patient in a most satisfactory condition through listening to every respiration. He will learn to appreciate all the little variations in rhythm and quality, and how the regular breathing may be re-established. But this only comes from constant practice, and he must carefully watch all the other signs that can give him any assistance, especially the colour of the face. If the respirations which were previously deep and regular suddenly stop, and the breath is "held," the corneal reflex will probably be present; in other words, the anaesthesia has been allowed to become too light, and more ether must be given. This may often be noticed when the first incision is made in a patient who is not sufficiently under. Another cause for this sudden alteration in the depth and regularity of the respirations is the slipping back of the jaw when the pressure behind the angle is relaxed, and by this, of course, the air-way is obstructed.

The respirations may keep perfectly regular, and yet the bag may not distend so well as it had previously been doing. This

is probably due to some change in the position of the face-piece, which does not now fit so accurately as before.

If the respirations, though still keeping regular in rhythm, become faster and more shallow, the ether has probably been given too freely, and more air should be allowed. If the deep respiration to which one is so accustomed in the administration of ether becomes unduly quiet, the cause will be one of two: either the ether has been given too sparingly, and with too free an admixture of air, or an overdose of the ether is being administered. In the first place, the corneal reflex will be present, and the pupil will either be the dilated pupil of reflex dilatation, or the very small, almost pin-point, pupil which is the precursor of vomiting. If this be the case, the ether must be given more freely. In the second case, when the respiration becomes quiet, with a dilated pupil and no corneal reflex, the ether has been pushed too far, and the inhaler must be withdrawn, and more air allowed.

Though it is necessary to listen to every respiration, it is quite unnecessary to keep a finger on the *pulse* throughout the administration. Ether has been described as having a large "manageable zone," and before the circulation becomes at all embarrassed there will be other signs of distress, as shown by the alterations in the respiration, the colour of the patient, etc. If these are attended to, there is practically no fear of trouble arising from the circulatory system while ether is being administered; and even if the respiration stops from any cause, the pulse will probably be found to be still fairly good, and if the respiration can be restored, the patient has a very good chance of recovery. This is often in striking contrast to the behaviour of the circulatory system under chloroform. Still, though a finger need not be kept on the pulse, it should be frequently examined, as from it are given the most reliable signs of the effect of the operation on the patient. The pulse, which was previously full, regular, and of moderate rate, may

become smaller, and faster, and perhaps irregular. This may be because too much ether is being given, or because the patient is suffering from the general effects of the operation; in other words, from "shock," or haemorrhage, or the two causes combined. If the pulse is deteriorating from an overdose of the anaesthetic, it will improve rapidly when more air is allowed, but this recovery will not take place if it is due to the general condition of the patient. If the inhaler is held as suggested on page 116, it will be found convenient to examine the pulse with the left index finger on the facial artery as it crosses the lower jaw.

The *colour* of the patient when the corneal reflex is lost for the first time will probably be somewhat cyanotic, on account of the limitation in the supply of oxygen, but it should rapidly improve when air is allowed. It is quite a mistake to suppose that the normal colour of the face under ether is one which more or less resembles that of a patient under pure nitrous oxide, and it should never be allowed to remain of a colour which at all approaches cyanosis. If the colour does not improve when the inhaler is removed, and air allowed to be respired, the fault may lie in the partial obstruction of the air-way. The causes of this are fully discussed on page 34. When all attempts to remedy this cyanosis by the removal of all obvious obstruction, and the admission of air, have failed, improvement may be effected by the substitution of an Ormsby's inhaler for the Clover apparatus. As will be described later, the former apparatus has a much larger bore, and so presents less obstruction to the respiration, and when the patient is an alcoholic man, requiring a large amount of ether, this change to the Ormsby's inhaler may be very satisfactory.

Some anaesthetists have sought to overcome this tendency to cyanosis by the administration of oxygen with the ether. This may be done by changing the small bag of the Clover inhaler for the large bag used for gas (p. 59), with the slots

of the stopcock closed so that the valves are out of action. The oxygen may be allowed to flow into the bag by the usual entrance for the gas, and the patient now respires his own breath, mixed with ether vapour, and with oxygen in any required proportion. A tap is sometimes fitted to the ordinary small bag, and oxygen supplied through a tube attached to it.

No attempt will here be made to describe any of the special apparatus for the administration of oxygen with ether, for I consider that if the cyanosis is so marked that oxygen is required to lessen it, the best plan would be to change the anaesthetic, and give A.C.E., or chloroform.

To maintain a patient in a satisfactory condition as shown by the above signs it will not be necessary to keep the indicator at a higher figure than 2, even for the strongest man, when once he has been anaesthetised. For weaker men, and for women, the indicator should remain at $1\frac{1}{2}$, while for small children 1 will be found quite sufficient.

When the corneal reflex is first lost, the inhaler should be removed for one breath in every four or five for the admission of air. This proportion may be maintained for some minutes, and then air may be allowed more frequently, the colour of the face being a very good index to the amount required. Weak patients and women may require more, and of course little children want much more. As the operation proceeds the amount of air allowed must be increased, and the amount of the ether administered lessened. It is sometimes necessary to point out to junior anaesthetists that in the administration of an anaesthetic the object in view is not to see how much a patient may inhale with safety, but to administer the smallest amount that will produce the required results.

"Ether Rash" and "Ether Tremor."

There are two phenomena which are more or less peculiar to anaesthesia with ether, as compared with that of chloroform

or any other drug; they are what are known as "ether rash" and "ether tremor."

The **ether rash** may occur in any patient, though it is more common in women and children than in men. It appears as a rule just as the patient is becoming unconscious, and takes the form of an erythema, which occurs most frequently on the neck and shoulders, but may spread to the chest and abdomen, and even to the thighs and legs. It may be accompanied with profuse sweating, and generally lasts for less than ten minutes. When seen for the first time, it suggests to the uninitiated measles or scarlet fever.

The **ether tremor** is a clonic contraction of the muscles of the legs, though those of the thigh may also be affected, and rarely the movement may be in the muscles of the upper extremities. It usually occurs in strong, healthy young adults who are imperfectly anaesthetised—that is to say, either as the patient is just going under, or coming round from the anaesthetic. This tremor seems to be allied to the rigor which is met with in patients suffering from various genito-urinary troubles. Like that nervous phenomenon, it is noticed most frequently in the same class of patients, viz., vigorous young men; or in connection with operations on the genitals, as urethrotomy, etc. As the movement will probably cause the operator inconvenience, it should be stopped by pushing the ether till the patient is in a deeper degree of anaesthesia.

Replenishing the Ether.

In the newer forms of the Clover's inhaler the stopper which closes the hole through which the ether is added to the chamber terminates in a glass bulb. The amount of the unevaporated ether can be estimated by noticing the angle to which the inhaler must be tilted, before any of the liquid is seen to run into the glass. Of course, if there are only a few

drops of the liquid ether left, these may be made to run into the stopper if the inhaler is tilted sufficiently far, but the amount of liquid present is estimated by the amount of tilting required to send any ether into the stopper.

If the patient be a man, the first measureful will be almost exhausted by the time that he is well under the influence of the anaesthetic; at any rate it is as well to pour a fresh measureful in before the operation is begun. This one will probably last for a quarter of an hour, the third measureful for from 20 to 25 minutes, and so on, less and less being required as the operation proceeds.

In pouring fresh ether into the chamber, the inhaler should be first removed from the patient's face, and rotated till the indicator is opposite 2. The stopper is now removed, the ether poured in, and the stopper replaced; but before the inhaler is reapplied to the patient's face, the indicator should be turned back to 1. The reason for this is that while the inhaler is removed from the face for the introduction of the fresh ether, the patient has been breathing air alone, and the strength of the vapour which he was inspiring before this may now be too much for him, and he may be inclined to cough from the increased proportion of the ether. After one or two breaths have been taken with the indicator at 1, it may be turned on to the figure it was at before the inhaler was removed.

If there is no glass bulb at its extremity, the stopper itself may be removed, and the amount of ether in the chamber seen by the tilting of the inhaler. A rough idea of the amount present may be obtained by feeling the uppermost part of the ether chamber, and then comparing it with the lowermost. If there is ether in it, the lower part will feel colder to the touch, from the evaporation taking place inside, but this test is not very delicate.

Care of the Apparatus.

After use, the face-piece should first be removed, and all mucus, etc., washed away. The bag should be half filled with a weak solution of carbolic acid (1 in 60-80), well washed round, then emptied, and left to dry, suspended by the small india-rubber loop attached for the purpose.

The stopper should be removed from the inhaler, and, with the indicator at 2, all the ether left in should be poured away. The central tube should then be removed from the body of the inhaler, washed, and carefully dried.

The body of the inhaler may now be immersed in warm water, and left there for a few minutes, but the water should not be too hot. When the body of the inhaler has been dried, the central tube should be greased with a little vaseline, and replaced. If care is not taken, the central tube will become rusty, and the body of the inhaler will only turn with difficulty. The ether chamber will often be found to contain a greenish coating. This is best removed by washing it well out with absolute alcohol.

ADMINISTRATION OF ETHER WITH ORMSBY'S INHALER.

Ormsby's inhaler, of which there are now many modifications, is of much simpler construction than Clover's. It consists essentially (Figs. 22 and 23) in a cage made of wire to hold a sponge, on to which the ether is poured. To one end of this cage is attached a large india-rubber bag, into which the patient breathes, and which makes the administration "closed" in character, and to the other end is attached a metal face-piece, with an air cushion round its edges so that it may better fit the face of the patient.

This is the simplest form of the apparatus, but many additions to it have been made. Among these are a hot-water chamber, to prevent the sponge becoming frozen from the rapid evaporation of the ether; an opening in the face-piece

by which air may be admitted in varying proportions; and there are many variations in the size of the bag, etc.

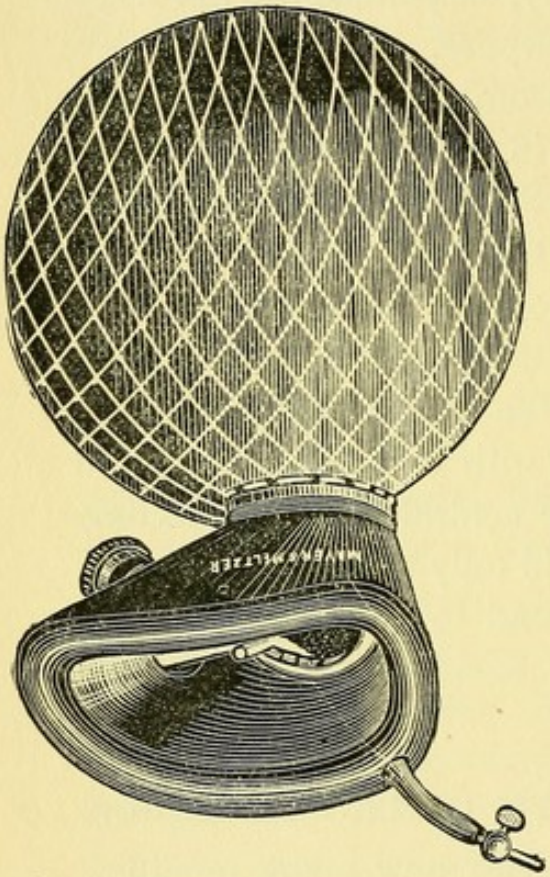


Fig. 22.—Ormsby's Inhaler.

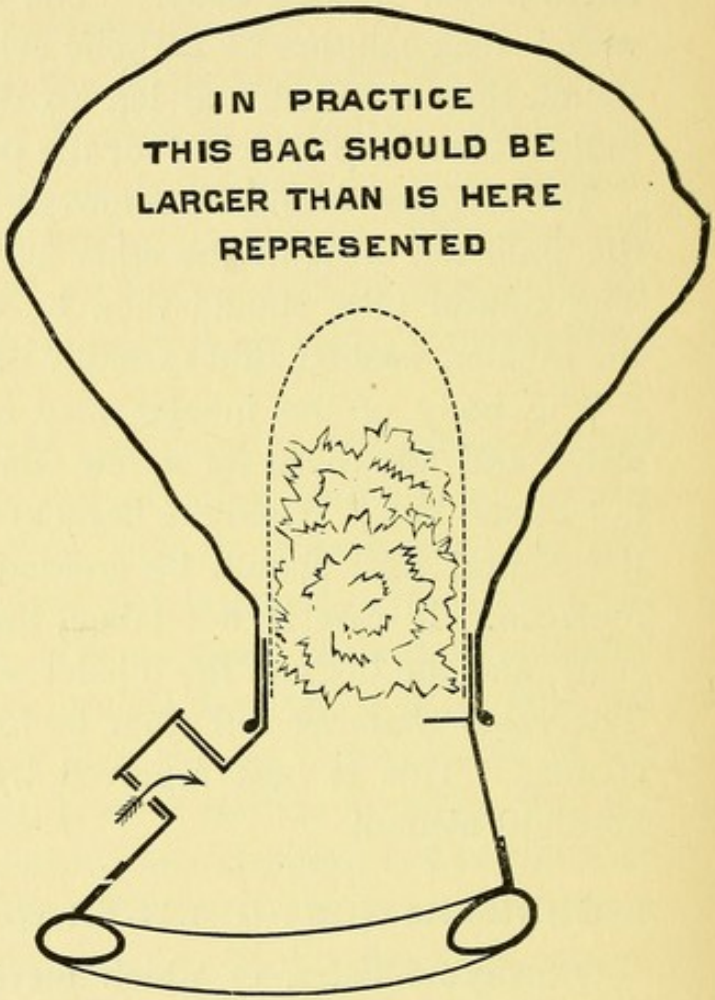


Fig. 23.—Section of Ormsby's Inhaler.

The Administration.

The sponge, having been wrung out in hot water, is squeezed dry and replaced in the cage, and on to it is poured about half an ounce of ether. The inhaler is now gradually placed nearer and nearer to the face of the patient, who is encouraged to breathe as freely as possible. If there is an air-slot in the face-piece it should be open at first, till the patient becomes accustomed to breathing into the inhaler. When once the patient can tolerate the ether, the inhaler is made to fit as well as possible, so that the bag may remain distended. If it becomes emptied,

it should be filled in a way similar to the bag of the Clover apparatus, by allowing the patient to inspire air, and then catching the expired air in the bag.

However well the anaesthetic may be administered with this apparatus, the patient will always be conscious of the smell of the ether, and will most probably cough or struggle, unless the ether is preceded by nitrous oxide.

As long as there is any ether vapour left in the bag, its presence may be detected by the two surfaces of the bag moving freely over each other when rubbed between the fingers; if the bag is empty, this movement will be accompanied with much more friction, which can easily be appreciated by the fingers. When the ether is exhausted, the inhaler should be removed from the face, and about half an ounce more of ether poured upon the sponge. If the sponge freezes, it should be replaced by another which has been wrung out in hot water as the first, and the same amount of ether should be poured upon it.

The *disadvantage* of the Ormsby inhaler is that with it the strength of the ether vapour cannot be regulated with any precision, and hence it is not suitable for the beginning of an administration. But if the ether is preceded by gas this objection vanishes, and the inhaler is very useful.

It presents a great *advantage* over the Clover in the fact that the part through which the patient has to breathe is larger, and so respiration is more free; and also that with it a greater strength of ether vapour can be given, which is much wanted in the case of alcoholic men. The student, however, is advised to practise thoroughly with a Clover before trying the Ormsby, as it is much better to learn the capabilities of one apparatus before giving it up for another; and with a little trouble, ether can be administered by means of a Clover's inhaler to any patient for whom it is a suitable anaesthetic.

The Administration of Ether to Children.

For little **children** ether is very conveniently given in the small felt cone mentioned on page 109. The ether is given by pouring a little on to the sponge, as in the Ormsby inhaler, and gradually bringing it nearer to the patient's face. The administration will be made much more pleasant if a few drops of the A.C.E. mixture are poured on to the sponge first, and pure ether substituted later. Care must be taken in giving ether in this way, that the sponge and the cone are not saturated, so that the liquid ether runs on to the patient's face.

If Clover's inhaler is used for small children, a concave face-piece will be found useful.

Special Difficulties and Dangers connected with the Administration of Ether.

These generally arise in connection with the respiratory system; and during the administration of ether, troubles due primarily to the circulatory system are rare.

Syncope under ether is practically unknown, and if in the course of a long operation the pulse fails, it is in almost all instances due to surgical shock, or to the loss of large quantities of blood. In patients with very degenerate arteries the inhalation of ether has been followed by cerebral haemorrhage, but these accidents are fortunately rare.

The principal difficulty during the administration of ether is the maintenance of a good air-way. The causes of this have been fully discussed on page 34, and here it need only be mentioned that the actual causes which tend to obstruct the breathing with ether are the narrowing of the air-way from congestion of its passage, especially when the ether is badly given, and the element of asphyxia is allowed to become too large; the accumulation of large quantities of mucus; and the difficulty in keeping the jaw in good position, on account of muscular spasm. All these causes which diminish

the air-way make themselves known by the bad colour of the face; and the bag will not distend as it should under normal conditions.

An excessive *secretion of mucus* is one of the drawbacks to ether in the performance of certain operations. Though in many cases, especially if they are for short operations, it is of small consequence, yet in others it is of such importance that it necessitates a change in the anaesthetic. If the head is well turned to one side, the mucus and saliva will tend to collect in the cheek rather than pass backwards and obstruct the air-way, and if a corner of a towel be placed in the dependent cheek, much of it may in this way be absorbed. Sometimes, however, in spite of all precautions, it collects in such large quantities that the mouth must be opened, and the mucus removed with a sponge. If this is neglected, it may be sucked back during inspiration, and, combined with what is already present in the larynx, may prove a formidable obstruction to respiration. If, when the mucus has once been sponged out from the back of the pharynx, it again collects there, it is wiser, when the operation has to be continued for some time longer, to change the anaesthetic for the A.C.E. mixture, or even pure chloroform.

Besides this accumulation of mucus in the mouth and pharynx, there may be a hypersecretion throughout the respiratory tract which will make itself obvious by rattling sounds heard in the trachea, and if these are noticed the ether should certainly be discontinued.

Any mucus collected in the pharynx and upper air-passages is generally removed by the first act of vomiting, or when the patient is sufficiently conscious to be able to cough. But this is not always the case; for instance, in operations on the abdomen, where the patient is probably feeble and lying on his back, or when the operation has been on some part of the chest, which is in consequence tightly

constricted with bandages and dressings, this removal by coughing is not at all easy, and the mucus either remains for some time as a source of irritation, or else the patient is worried by ineffectual attempts to remove it. Mucus is also said to form a favourable resting-place for the pneumococcus. In any of these cases it is better to change the anaesthetic on the earliest signs of an undue secretion of mucus.

Spasm of the larynx is also met with more frequently with the use of ether than with chloroform. It is considered on page 35.

There may be considerable difficulty with young men in keeping the lower jaw sufficiently forward, especially during the earlier stages of the operation. The finger must be placed well behind the angle, and pressure exerted in the direction of the mouth, while all possible help should be given by the fingers under the chin. If the skin is tender, part of the towel should be placed between it and the finger which is exerting the pressure, so that there will be less likelihood of a bruise resulting. Fortunately, as the operation proceeds the pressure necessary to keep the jaw forward becomes less, as the resisting muscles gradually lose their power.

Signs of an Overdose of Ether.

When ether has been given too freely, and the patient is in what has been described as the fourth stage of narcosis, the colour of the face becomes dusky and cyanotic, the pupils are dilated and fixed, the eyelids separated, and the corneal reflex entirely absent. The respiration may at first be rapid and shallow, but afterwards becomes slower and much quieter in character, the rhythm becomes intermittent, and the inspirations are jerky or gasping. When this condition is first noticed there may not be much change observable in the pulse, but if the condition is neglected, the circulation will

show signs of failure, and the pulse become faster and much smaller.

When the signs above enumerated are noticed by the administrator, the inhaler must at once be removed from the patient's face, and air allowed, and if the respiration is failing, it must be aided artificially. If necessary, it may be stimulated by a hypodermic injection of strychnine.

If these measures are taken promptly as soon as the condition becomes apparent, the patient may be recovered in almost every instance.

After-Treatment.

It is most important that all patients who have been inhaling ether for some time should be kept in a well-warmed room till their recovery is complete. This is essential to prevent all risks of the bronchitis, and even broncho-pneumonia, which sometimes follows the inhalation of ether. That this is often due to the exposure after the operation is suggested by the fact that in private nursing homes, where care is taken that the patients are kept warm, and free from exposure to draughts of cold air, bronchitis is very rare. It is somewhat more common in hospitals where, after the operation, the patient has to be removed from a warm theatre, through a cold corridor before the ward is reached; and here the ventilation is often too free for the perfect recovery of an anaesthetised patient.

Before the thorough return to consciousness there is often a single act of vomiting, which removes the mucus which has accumulated. The patient often does not retain consciousness of this, and if food is not given too soon, this is often the only after-effect, with the exception of the smell and taste of the ether. To mitigate this it has been suggested to suspend a handkerchief soaked in toilet vinegar near the patient's head.

ETHER PRECEDED BY NITROUS OXIDE—GAS AND ETHER.

This combination has the great advantage that with its use the patient is only conscious of the gas, and does not notice the unpleasant qualities of the ether; and in consequence there is less struggling, and the patient is anaesthetised more quickly.

There are two ways in which gas and ether may be given.

First Method.

By starting the administration with gas, and as soon as the patient is becoming unconscious, gradually giving the ether in increasing strength.

This can be better done with a Clover's inhaler than with an Ormsby, as with it the amount of the ether can be more gradually increased. The Clover inhaler (p. 110) should first be prepared as for ether alone, a face-piece fitted on, and a measureful of ether poured into the chamber. The gas-bag (p. 61) should now be filled, the tap at the lower end turned, and the bag detached from the tube. It should now be attached to the ether inhaler in the same way as the small bag is for ether alone, and the anaesthetist should blow through the face-piece to remove all traces of the ether, and to see that all the valves are working.

The inhaler is now to be applied to the patient's face, and he is allowed to breathe a few times through the valves. The gas is turned on by closing the lower slot, and should be expired through the valve till the bag is only half full. The upper slot is now closed by the tap, so that the patient is "rebreathing" into the bag.

After a few more breaths the ether is gradually turned on by rotating the inhaler, and this may be done more rapidly than when ether alone is being given. When the indicator has

reached 2, the large bag may be removed, and the small bag adjusted in its place, and this will be used for the rest of the administration.

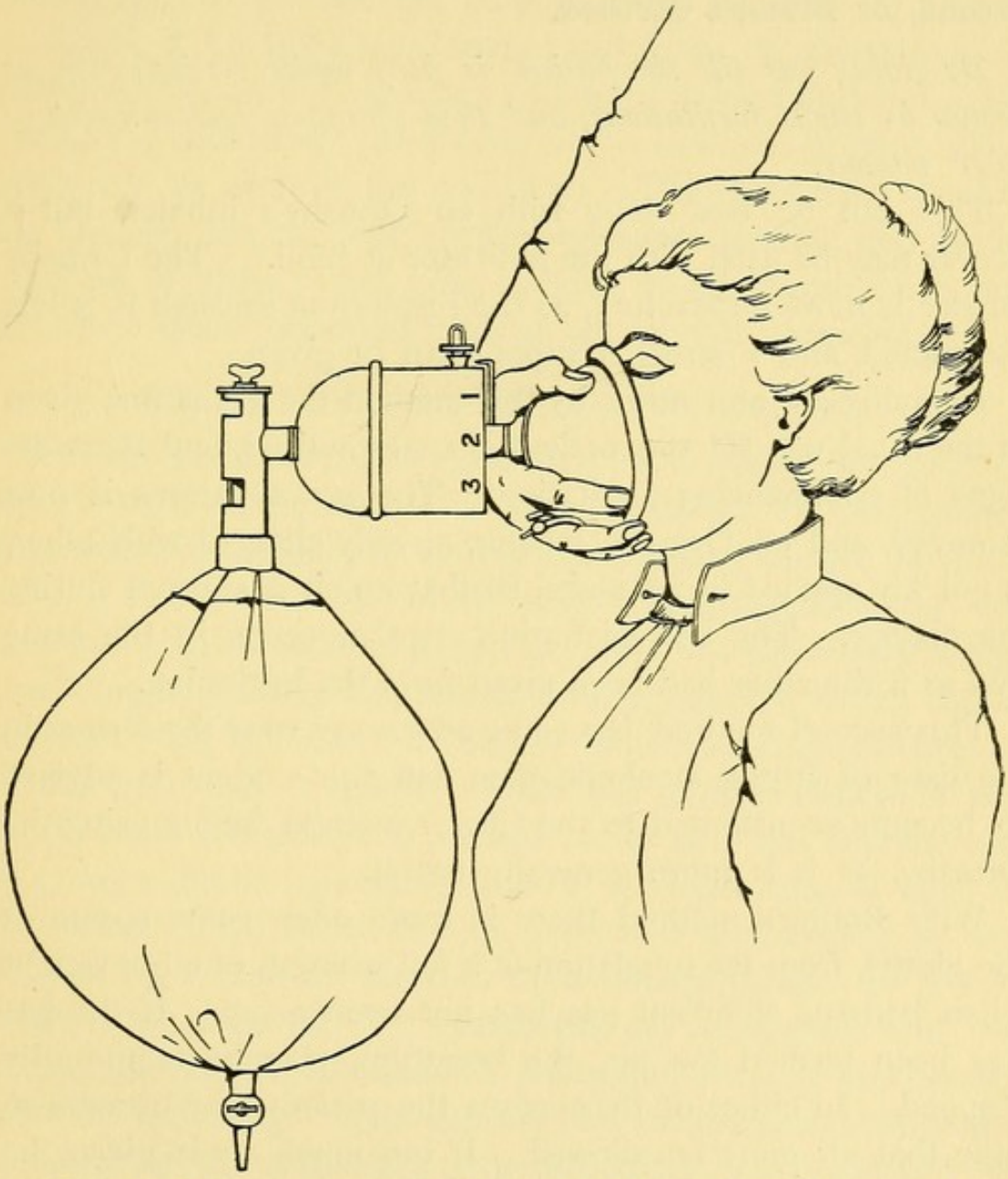


FIG. 24.—THE ADMINISTRATION OF GAS AND ETHER BY CLOVER'S APPARATUS, TO A PATIENT SITTING UPRIGHT.

The administration now proceeds exactly as with ether alone, except that it will probably be necessary to give some air earlier.

The above way is the best for giving gas and ether for a dental operation, as the quantity of ether administered can be

more easily regulated. It may safely be administered to a patient sitting upright in a chair, as in figure 24.

Second, or Braine's Method.

By giving gas till the patient is fully under its influence, as shown by slight jactitations, and then giving a full strength of ether vapour.

This can be best done with an Ormsby's inhaler, but a Clover may be used with the indicator at "full." The Ormsby inhaler is more satisfactory, as the respiration through it is less obstructed, and a stronger vapour can be given.

In giving gas and ether by this method the gas is first given in the usual way till the patient is anaesthetised, and there are signs of commencing jactitation. The gas apparatus is now removed, and an Ormsby inhaler, already charged with ether, is quickly applied in its place, so that no air is allowed during the change. The administration now proceeds in the same way as if the ether had been given from the beginning.

This second method has some advantage over the former in the case of strong alcoholic men, but the student is advised to become accustomed to the Clover method before using the Ormsby, as it is more generally useful.

With Braine's method there is more often some spasm of the glottis, from the inhalation of a full strength of ether vapour when perhaps sufficient gas has not been given. If the gas has been pushed too far, the breathing may be temporarily stopped. In either of these cases the patient may become so blue that air must be allowed. If too much air is given, he may pass into a stage of semi-anesthesia, the effects of the gas passing off before the ether has had time to become absorbed in sufficient quantity. This is more likely to happen than with the more gradual administration with Clover's inhaler.

ETHER PRECEDED BY CHLOROFORM, OR A MIXTURE.

If on account of the age of the patient it is considered inadvisable to precede the administration of ether by nitrous oxide, or if no gas is available, a few drops of chloroform, or better still the A.C.E. mixture, may be sprinkled on a Skinner's mask, and inhaled by the patient till he becomes drowsy, when ether can be given in the usual way. The cases most suitable for this plan are old people with degenerate arteries, and young children to whom it has been decided to administer ether, but for whom gas is not considered an appropriate anaesthetic.

ETHER ADMINISTERED BY THE RECTUM.

For the performance of operations about the mouth, such as the removal of the tongue or jaw, operations for cleft palate, etc., where the apparatus ordinarily employed for the administration of ether could not be used throughout, and also for operations for the relief of empyema, when it is desirable that the breathing should be hampered as little as possible by the use of inhalers, ether has been successfully administered by the rectum.

The procedure is simple. From two to three ounces of the liquid ether are placed in a small bottle, and this is immersed in a larger bottle containing water at a temperature of 120° F. The ether vapour which is thus generated is conveyed to the rectum by means of suitable india-rubber tubes. In a few minutes the usual signs of anaesthesia are manifested, and the operations may be satisfactorily performed without any inhalation of the drug. Occasionally the anaesthesia has been obtained in the ordinary way by inhalation, and continued by the use of the rectal tube.

The great *disadvantage* of this method is that it is likely to be followed by diarrhoea, which may be very severe, and deaths have occurred from its use.

For further information on this subject the reader is referred to Dr. Dudley Buxton's *Anaesthetics*, page 136.

CHAPTER V.

CHLOROFORM.

CHLOROFORM ($CHCl_3$) is a colourless liquid, with a faint, characteristic smell, and a sweet, burning taste.

The pure chloroform of the British Pharmacopœia contains some absolute alcohol, which is added to make it less liable to decomposition, and its specific gravity after the addition of the alcohol is between 1·490 and 1·495. Its vapour density is over 4.

For the preparation of chloroform, and an account of its chief impurities and their detection, the student is referred to the British Pharmacopœia; but if it evaporates without residue, and without giving off any unpleasant odour, it is probably fit for anaesthetic purposes. Two kinds of chloroform are used as anaesthetic agents: the pure chloroform, which is made from alcohol, and what is known as "methylated chloroform," which is made from methylated spirit. If this latter form is well made, and answers the tests of pure chloroform, it is perfectly satisfactory as an anaesthetic.

Chloroform is very liable to decomposition from exposure to heat and light, and so should be kept in a cool, dark cupboard. It is much better to obtain it in small bottles, than to have a large quantity exposed to the risks of decomposition. It is stated, however, that if some slaked lime be kept at the bottom of the stock bottle of chloroform, any impurities resulting from decomposition will be neutralised,

and the pure liquid when required may be decanted from the upper part. The vapour of chloroform is not inflammable, but if much of the anaesthetic is allowed to evaporate in a room lighted by gas or any other naked flame, the vapour decomposes, and a compound called carbonyl chloride, and hydrochloric acid are formed, which are peculiarly irritating to the respiratory tract; and during a long operation under these circumstances, both the surgeon and nurses assisting have been known to suffer from cough and headache, and afterwards from bronchitis, from the irritation produced by these products of decomposition. A feeling of faintness may also be experienced, but this may be due to the amount of chloroform vapour in the air.

Chloroform is twice as heavy as the same bulk of ether, and so can be easily distinguished from it by this means, as well as by the great difference in the smell of the two vapours. It is a much more powerful drug than ether; in fact, to anaesthetise a patient with ether about 40 per cent. of the vapour is required, while dangerous symptoms may arise if the proportion of chloroform vapour in the respired air is allowed to reach a higher percentage than 4. It thus follows that in the administration of chloroform as an anaesthetic, instead of trying to confine the vapour in a closed inhaler as in the case of ether, the object of the anaesthetist is to make sure that the patient is allowed enough air to produce the required dilution. This dilution to about 4 per cent. was carried out by an apparatus devised by Clover, but which is now never used.

Lister proved from experiments that the proportion of chloroform breathed by a patient inhaling the drug from a towel wet with chloroform, and held in front of the face, was considerably less than might be expected, and not more than 4 per cent., the majority of the chloroform evaporating into the air, or being blown away by the expirations. But if the access

of air is cut off, the proportion soon increases, and it was shown by Sansom that it could reach as high a proportion as 13 per cent., which would soon prove too strong. Hence it follows that if the drug is administered in what is called the "open" method—that is, sprinkled on lint or flannel, or even the corner of a towel—all may go well if the supply of air is sufficient, but if this is unduly curtailed, the result may be fatal.

Apparatus for the Administration of Chloroform.

The apparatus required for the administration by the "open" method is very simple. It is quite sufficient to take a small piece of lint, or even the corner of a towel, for the inhaler. If

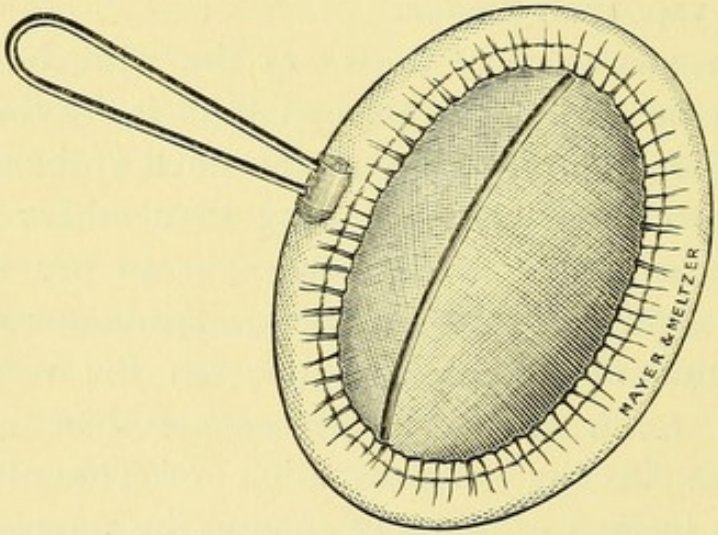


FIG. 25.—SKINNER'S MASK.

the towel is employed, the best way is to draw one corner of it through a safety pin till a small concave mask is formed, which will extend from the bridge of the patient's nose to the point of the chin. If lint is used it should be folded into ridges, and these secured at one end by a safety pin. In using either of these simple inhalers it is important to watch that their concavity is maintained throughout the anaesthesia, as if they are allowed to lie flat on the mouth and nose they will obstruct the respiration, the percentage of the chloroform will become too high, and if the patient survive, his face will be burnt by the chloroform.

The best form of inhaler is Skinner's mask, which is shown in figure 25. This is not the earliest shape, but the one that has proved most convenient. When not in use it may be folded quite flat, it is very light, and the handle at the side is most useful for the retaining of the mask on the face. The chloroform is dropped on to a single layer of flannel, which is shaped to cover the frame. This is removed after each

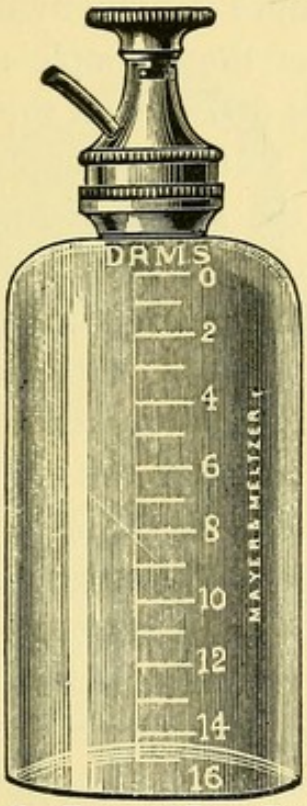


FIG. 26.—THOMAS' DROP BOTTLE.

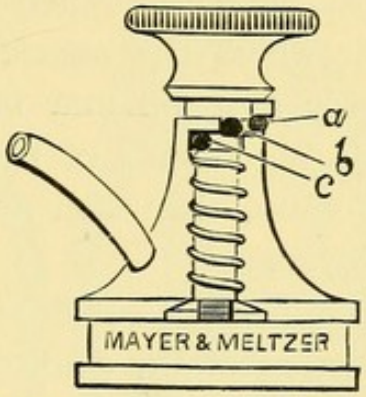


FIG. 27.—SECTION OF STOPPER OF DROP BOTTLE. With the pin at *a* no chloroform can escape, at *b* it will fall out in drops as the stopper is pressed, while, if fixed at *c*, the chloroform will run out in a steady stream.

inhalation, and the whole may be sterilised. In hot climates a double layer of flannel is sometimes used. With this mask, if used properly, the flannel is kept so far from the skin that there is little risk of burning the face unless the administrator is careless. Modifications of this mask have been made in which a piece of lint is stretched over a frame. This lint is destroyed after the inhalation.

The chloroform is dropped upon the mask from a drop-bottle, the best of which is known as Thomas' spring drop-bottle (see Figs. 26 and 27). In the stopper is a spring which

allows the liquid to come out only drop by drop, as the administrator touches the spring each time, or it may be allowed to run out in a minute stream, or if turned in the opposite direction no chloroform can escape, and the bottle can be carried without any leakage.

It is important that the chloroform should only be dropped on to the lint, as if it is violently jerked out of the bottle some may reach the patient's eyes, and produce conjunctivitis.

When chloroform is given by any of these simple methods, the percentage breathed by the patient depends on the amount of air which the anaesthetist allows. If this supply is sufficiently free, all may be well; but the safety of the patient lies in the hands of the administrator more in the case of chloroform, than with any other of the anaesthetics generally employed.

An apparatus was designed by which it is impossible for the proportion of the chloroform vapour to reach too high a percentage. It is known as Junker's inhaler, and the chloroform is contained in a bottle, and by means of bellows air is driven through it, and then conveyed to the patient by a tube. In this way the strength of the chloroform cannot pass above 4 per cent. There have been many modifications of the original simple form, but the principle of the inhaler remains the same.

Mistakes have been made, and the tube from the bellows has been attached to the wrong tube on the bottle, and liquid chloroform has been blown into the patient's mouth, with a fatal result. To obviate this, Dr. Hewitt designed a modification in which the tube conveying the vapour to the patient is placed inside a larger one, by which the air is pumped into the bottle containing the chloroform, and in this way it is impossible for the tubes to be misplaced.

Junker's apparatus is used most frequently for the maintenance of anaesthesia during operations about the mouth or

nose, though it may also be employed for the induction. The bottle should not at any time contain more than four or five drachms of chloroform, as if it is overfilled, liquid chloroform may be pumped into the patient's mouth.

If the Junker's inhaler is used for the production of anaesthesia, some sort of a face-piece is necessary, either one made

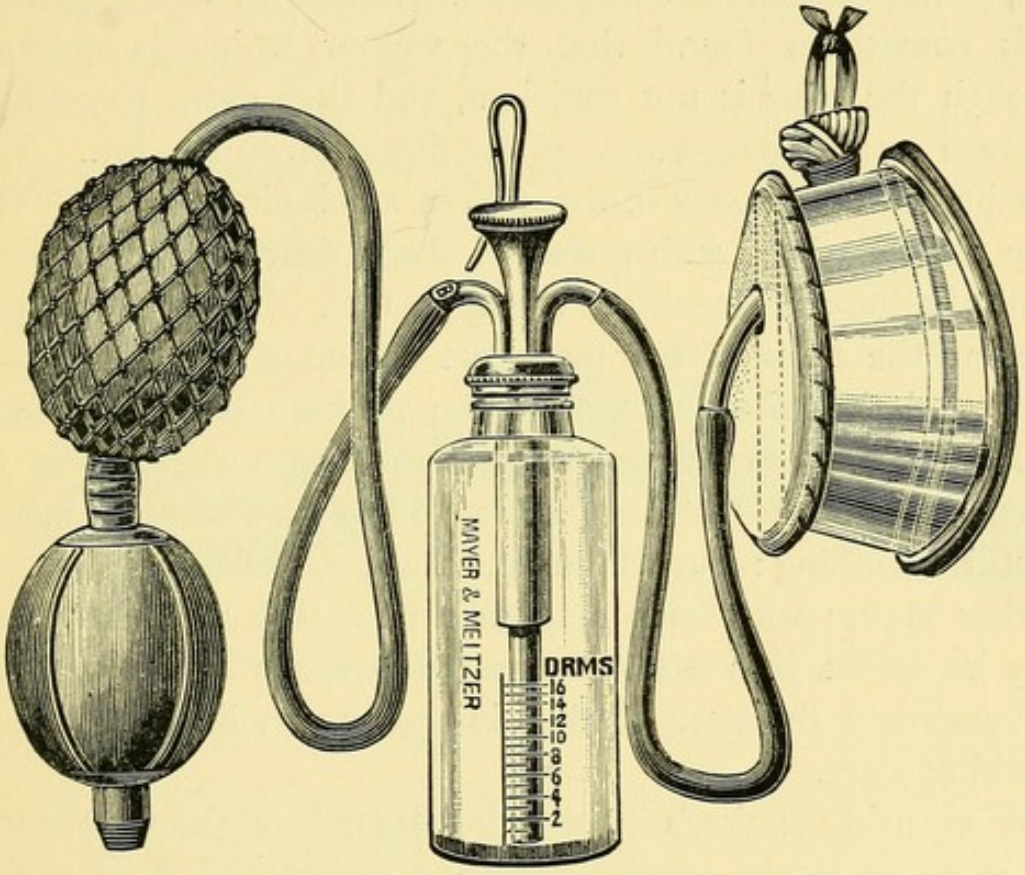


FIG. 28.—DUDLEY BUXTON'S MODIFIED JUNKER'S INHALER WITH GLASS FACE-PIECE.

of vulcanite, as in the original pattern, or of flannel stretched over a wire frame, or, what is better, a glass mask suggested by Vajna, and modified by Dr. Dudley Buxton (Fig. 28). This consists of an oval glass mask which roughly fits the face from the bridge of the nose to the chin. Stretched across its upper part is a layer of lint, which forms the roof of the space in which the chloroform vapour is contained. This lint is changed for each inhalation. Round the upper

rim of the mask runs a metal tube with many perforations, and through these the chloroform vapour is blown from the bottle.

Though the chloroform is thus inhaled from a confined space, there is no fear that the vapour will become too strong, that is, that it will contain more than 4 per cent. of chloroform, as it does when pumped into the mask; in fact, if the patient is being anaesthetised with this apparatus, it is sometimes found that the vapour which is pumped through the tube is not sufficient, and then more chloroform is given by dropping some of the liquid on to the lint. This will be often necessary in the case of alcoholic patients. This may also be done with a flannel mask described above, but would be impossible with a vulcanite one. Through the glass forming the sides of the mask the colour of the lips can be seen, and the whole apparatus can be kept perfectly clean.

Some face-pieces have been designed with a feather at the apex, which moves with respiration, and so shows that the patient is still breathing; but these are a source of danger, as the feather moves with such a minute puff, that the anaesthetist may be lulled into a false sense of security by seeing some movement of the feather, when in reality very little respiration is taking place.

When using Junker's inhaler the strength of the vapour may be to some extent regulated by the vigour and frequency of the compression of the ball forming the bellows. The maximum strength is said to be obtained with about sixteen firm compressions in a minute.

An attempt has recently been made to determine the exact amount of chloroform vapour pumped into the mask, by means of a graduated ball, and a mechanical pumping arrangement; but however accurate an apparatus may be made, the safety of the patient will depend on the skill and carefulness of the administrator, rather than on the perfect working of any mechanical contrivance.

When the operation to be performed is inside the mouth, the patient may be anaesthetised in the ordinary way with ether or chloroform, but the anesthesia must be maintained by means of chloroform pumped by a Junker's inhaler through the nose, or into the mouth. This may be done by attaching a soft rubber catheter to the end of the tube coming from the Junker bottle, and then passing it through one nostril till it reaches the post-nasal space. The catheter must not be pushed beyond this, as if it is, it will be caught by the superior constrictor of the pharynx, and the chloroform would then be pumped towards the stomach instead of the lungs, and

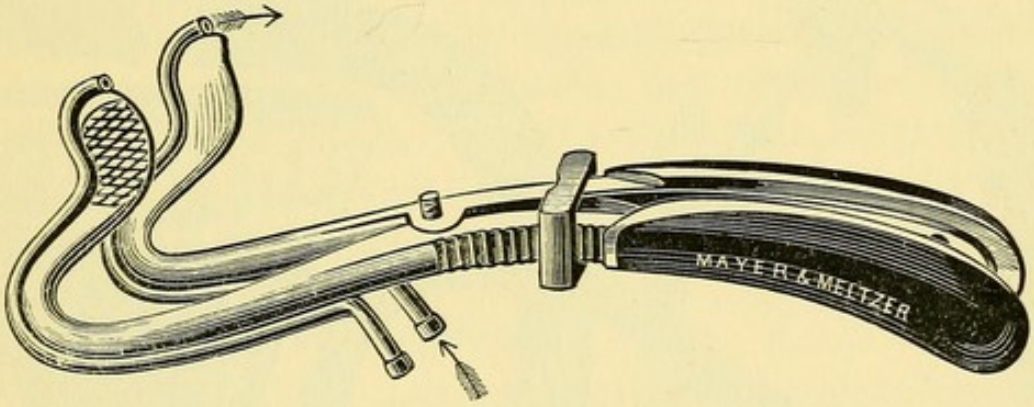


FIG. 29.—MASON'S GAG WITH HEWITT'S CHLOROFORM TUBES.

the presence of the catheter in the pharynx would probably set up vomiting in a patient not deeply anaesthetised. The other way to keep up the anaesthesia for an operation in the mouth, is to use a metal tube which is attached to the tube of the Junker bottle at one end, while the other is hooked round the cheek and opens into the mouth.

As during the operation the mouth will generally have to be kept open with a gag, Dr. Hewitt has designed one (Fig. 29), in which the chloroform tubes are attached to the arms of the gag, and this will be found much more convenient than a loose tube, which must constantly be kept in position. A tube is fixed to both arms of the gag, but the india-rubber tube from the bottle of the inhaler must be attached to the tube on the

arm which is fixed against the upper jaw. If fixed to the lower, the tongue is apt to rest against the orifice, and thus the exit of the chloroform vapour into the mouth will be prevented. The

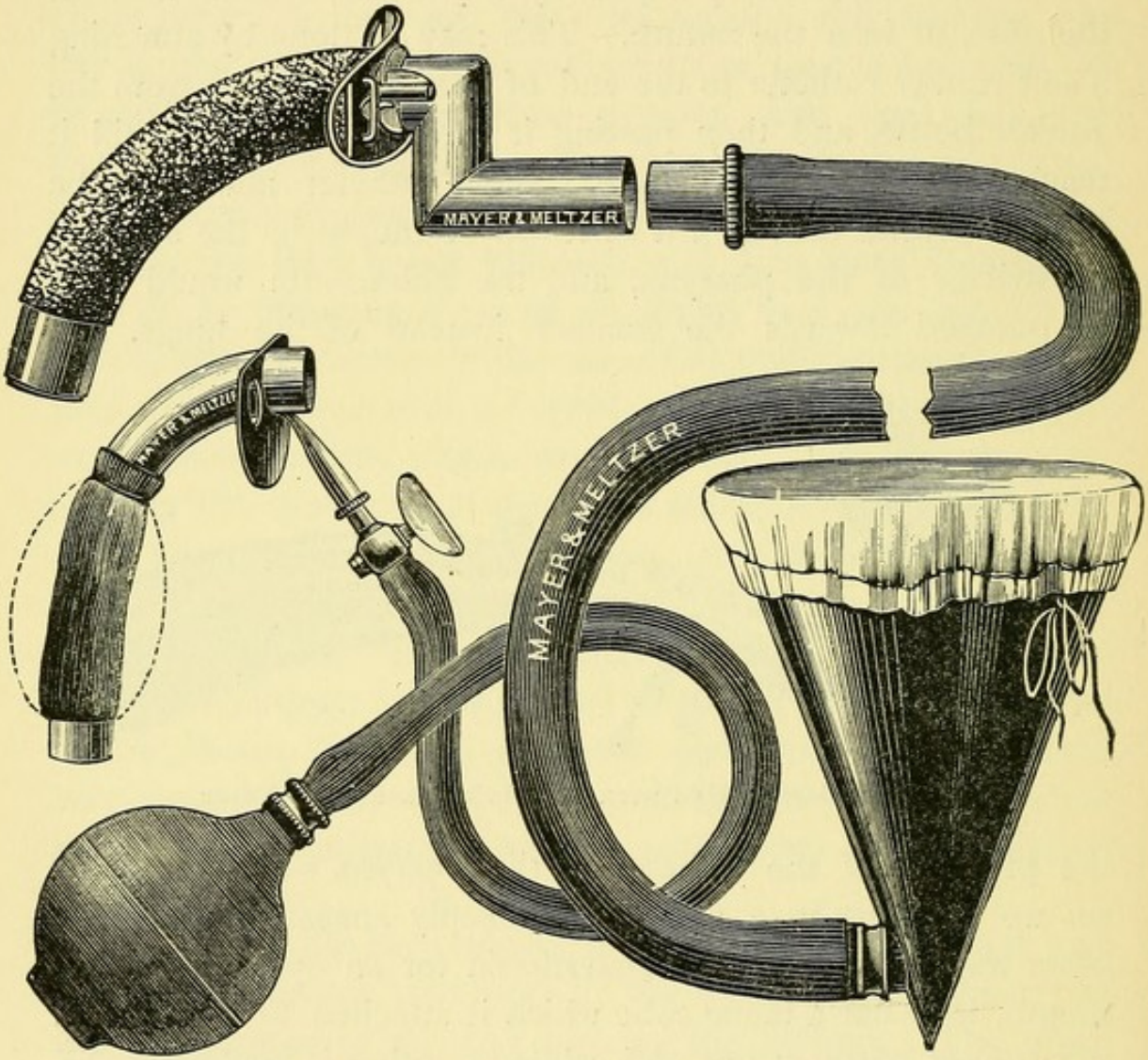


FIG. 30.—APPARATUS FOR ADMINISTERING CHLOROFORM AFTER TRACHEOTOMY. The upper tube with sponge is known as Hahn's, the lower, with a bag which is inflated with air, is Trendelenburg's.

drawbacks to the use of this gag are that the tube is very narrow, and it is sometimes hard to obtain sufficient vapour through it, and that it is practically impossible to keep the inside of it clean.

In some extensive operations about the mouth, such as the removal of cancerous growths from the back of the pharynx,

tracheotomy is first performed, and then chloroform is administered through the tracheotomy tube. This is best done with a tube by which blood is prevented from reaching the lungs, either by means of a small bladder which is blown up till it blocks the trachea (Trendelenburg's Tampon), or by a sponge which absorbs any blood that trickles down (Hahn's Tube, Fig. 30). Chloroform is administered by means of an ordinary Skinner's mask held near the orifice of the tube; but to the orifice of the canula a tube is sometimes fitted, of some two feet in length, and terminating at its other extremity in a small metal drum, over the upper part of which some flannel or domette is stretched, and on to this the chloroform is dropped. This tube enables the anaesthetist to stand further away from the patient's head, and to administer the chloroform without embarrassing the surgeon by being obliged to bring his hand near to the wound to sprinkle the chloroform on to the lint or Skinner's mask, when it is held just over the orifice of the canula.

Cases Suitable for Chloroform.

The cases specially suitable for the inhalation of chloroform are considered more in detail in chapter vii.

They are, in brief, persons at the extremes of life, young children and old people; those with bronchitis, or other chest trouble; cases of operation on the brain, or about the face, especially if a cautery is to be used; for some abdominal operations; when a light degree of anaesthesia is to be maintained, as in parturition; and to quiet the muscular spasm in tetanus.

The Administration of Chloroform.

Chloroform is administered in exactly the same way when given on a piece of lint, the corner of a towel, or a special mask such as Skinner's. It is most important that the patient should first be placed in the *recumbent position*. The use of

the upright position for a patient inhaling chloroform cannot be too strongly condemned ; and it is in a great measure due to the neglect of this precaution that the deaths from chloroform are still far too numerous. The fatal result which follows the practice of anaesthetising a patient with chloroform while in the upright position, occurs most frequently in dental chairs, where, besides the faulty position, the risk is increased by the administrator being often not very skilled in this branch of practice.

The head should be turned to the right, as suggested in the administration of ether, and there should be no constriction of the neck, chest, or abdomen by any tight clothing.

Two or three drops of the drug are first poured on to the lint or flannel, which is held some three or four inches or more away from the patient's face till confidence is to some extent established, and the patient begins to breathe regularly. As in the administration of ether, it is a great mistake for the patient to receive a strong dose of the anaesthetic with the first few inspirations. A patient already nervous will become extremely frightened, and will probably struggle, and even when one has made up his mind to take the drug with calmness, he will find his equanimity upset by inhaling a strong dose of chloroform with the first breath ; but, after beginning very gradually, the amount can be steadily increased till the area of the mask opposite the mouth and nose may if necessary be kept moist with the drug.

Chloroform should never be poured on to the mask in such quantities that it drops off the flannel, and burns the face. This burning of the face is more likely to occur if the chloroform is given from a folded piece of lint, and to prevent this, the face is sometimes smeared with vaseline or some such substance before the administration is begun.

If at any time the patient holds his breath for some seconds, the respiration may be stimulated by briskly rubbing the

lips with a towel, and as soon as the breathing improves, more chloroform may be dropped on to the mask; but it is useless, and indeed dangerous, to keep on pouring the drug on to a mask while the breath is held, for after a prolonged holding of the breath a long inspiration must be taken, and if a mask soaked with chloroform is held near the patient's face at this time, he will at once inhale so large a dose of the drug that it may prove fatal. It is most important that though the patient must have a sufficient strength of the drug at this time, the supply of air which is admitted with it should be quite free. This holding of the breath generally occurs about the time when struggling is manifested, and the two are often simultaneous. Struggling must be met by an increased dose of chloroform, with a still freer supply of air; and the same may be said of attempts at vomiting, which can generally be stopped by giving the drug more freely. But if vomiting has actually occurred, the mouth must be quite cleared of all vomited material before any more of the anaesthetic is administered. If any were allowed to remain, it might be sucked back into the larynx with the first vigorous inspiration.

While administering chloroform, the great guide for the anaesthetist is the respiration of the patient. Each expiration should be either heard, or felt by the anaesthetist by means of fingers placed near the face. It is not enough that a small amount of respiratory movement is seen in the chest and abdomen, for this may occur when very little air is passing to and from the chest. If all administrators worked more consistently in watching every respiration, the deaths from chloroform would soon diminish.

Very faint breathing calls for attempts at stimulation by means of rubbing the lips with the towel, as suggested above, and as it becomes deeper, the amount of chloroform should be increased. This shallow breathing is often connected with a tendency to vomit, and this is especially noticeable when

the patient is allowed to emerge from a deep anaesthesia into a lighter one.

It is not necessary, indeed it is misleading, to keep a finger on an artery during the whole period of the administration, but the pulse should be frequently examined. For this purpose it is best to keep the same artery under observation during the whole period, and the facial, as it passes over the jaw, will generally be found the most convenient.

If the chloroform be given too sparingly, the patient may pass into a quiet sleep, from which he will waken with a start when the operation is begun. This false anaesthesia, or sleep, is more often noticed in the case of children, especially young infants. In adults the corneal reflex will be present if the patient is not really anaesthetised, but in infants this sign is unreliable, as movement will often occur when the corneal reflex cannot be obtained. In infants it has been stated that a more certain reflex with which to work, is the closing of the fingers when the palm of the hand is stimulated, while others employ pinching of the skin as the stimulus with which to gauge the depth of the sleep.

When a patient becomes anaesthetised, and loses the corneal reflex, the respiration becomes deeper, and less constrained, and this by itself is one of the best signs of unconsciousness. The condition of the pulse is of no assistance as a guide to the depth of unconsciousness. The general signs of anaesthesia are described in chapter i.

The **time** required to anaesthetise a patient with chloroform varies according to many factors, but may be reckoned as between five and ten minutes. It depends, in the main, on the regularity and depth of the respirations, with the rate at which the drug is poured on to the mask, and with the amount of struggling exhibited.

The **dose** which different patients require varies even more considerably than the time required to produce unconscious-

ness, and alcoholic patients may inhale a dose which would seem enormous in the case of an ordinary patient, without exhibiting any signs of anaesthesia beyond muttering or singing. Children often seem to require more in proportion to their size than do adults, but this is probably due to the small amount which they receive with each inspiration.

General Condition of a Patient under the Influence of Chloroform.

The *respiration* will be found much quieter than that of one under ether: in fact it sometimes becomes almost inaudible. If this happens, care must be taken to watch that the patient is not inclined to come round.

There is no excessive secretion of mucus, such as occurs during the inhalation of ether, but though there may apparently be little trouble arising from the respiratory system, it is just as important that the jaw should be kept in good position, and a clear air-way maintained.

If the jaw is allowed to slip too far back, the difference will not be shown so much by the increased noise of the respirations, as commonly happens with ether, but rather by a gradual change in the colour of the patient, and by a distinct weakening of the circulation, as shown by the greater frequency and smaller volume of the pulse. If the patient is breathing very quietly, but is otherwise in a satisfactory condition, the jaw may be allowed to slip back just sufficiently far to enable the administrator to hear a faint snoring sound with respiration. If this can be done without any change for the worse in the colour of the patient, or in the character of his pulse, it will be of assistance to the administrator in enabling him to be accurate in estimating any change in the respiration of the patient; but if this produces any change for the worse in the general condition of the patient, the jaw must be pushed forward again to its full extent.

If the surgeon is allowed to begin the operation before the patient is in a sufficiently deep stage of anaesthesia, a crowing sound, due to some amount of spasm of the larynx, will often be heard, but this will as a rule disappear as more chloroform is given.

While the patient is passing through the early stages of the inhalation the *pulse* is subject to very many changes, but when the period of surgical anaesthesia arrives, it should settle down into a full regular rhythm of about the normal rate, and may even be slower than normal, especially in old people. If this regular and satisfactory rhythm is not established the cause must be sought, and remedied. As the operation proceeds the tendency is for the pulse to gradually become smaller in volume and faster in rate, and any obstruction to respiration will soon hasten this change.

The *face* is not flushed as with ether, but somewhat paler than normal, and this tends to become more marked as the operation proceeds, and the pulse becomes feebler. If the face suddenly becomes pale during an operation it may be due to a condition of too light anaesthesia, and indicates a tendency to vomit. The other signs of this condition will be holding of the breath, the large size of the pupils, and the return of the corneal reflex. If this occurs the breathing should be stimulated by rubbing the lips, and more of the drug should be given. The colour of the face may also become changed for the worse when caused by an overdose of the drug, which will be considered later.

The average size of the *pupil* under the influence of chloroform is smaller than that under ether, and is given as being about 2·5 mm. in diameter. It is subject to the variations as described in chapter i.

The *muscular system* is completely relaxed more quickly with the use of chloroform than with ether, and for this reason it is to be preferred in certain operations, as to obtain

a sufficient relaxation the ether must occasionally be pushed to an extreme limit. However, if a patient has been anaesthetised with ether, and more complete muscular relaxation is required, this may often be accomplished by the use of very little chloroform.

Signs of Return to an Insufficiently Deep Anaesthesia.

The respirations, which will probably have been gradually becoming very quiet, will almost or entirely cease for a time, the face become pale, and the pulse will be found small and fast; the pupils, which had previously been quite small, will suddenly be found widely dilated, and there will be a brisk corneal reflex. Swallowing movements may occur, and the abdominal muscles, which had been relaxed, may now become contracted, and attempts at vomiting will be made.

Treatment.—If vomiting does not actually take place, the lips must be rubbed to stimulate the respiration, and more chloroform given. If the patient vomits, the mouth must be carefully cleaned before the administration is continued.

Signs of an Overdose of Chloroform.

An overdose of the drug may be administered during the early stages, when it will be followed by the appalling signs of syncope, described on page 47, which are so startling to the onlooker, and so fatal to the patient. The overdose may also be gradually given during the performance of an operation, when the onset of the symptoms may in consequence also be more gradual, and the prognosis more favourable.

The respirations become quieter and quieter, and finally cease. The pulse becomes smaller and smaller and imperceptible at the wrists, and the rate so increased that the beats can hardly be counted, and finally the circulation entirely fails. The face becomes livid, and cold to the touch, with a cold, clammy sweat on the forehead. The corneal reflex

will be entirely absent, and the pupils widely dilated. The eyelids become separated, and the globes fixed.

The *treatment* of this condition is described on page 55, and may here be stated to consist of withdrawal of the chloroform, opening the mouth with a gag, and pulling the tongue forward with a forceps or a finger, artificial respiration, and the hypodermic injection of strychnine, with an enema of brandy in hot water. The patient should be kept thoroughly warm during all attempts to restore the circulation.

Special Difficulties and Dangers of Chloroform.

The dangers of chloroform arise in connection with the circulation rather than with the respiratory system, and are described in chapter ii.

Apart from these, there is no special symptom to be connected with chloroform, as the secretion of mucus, the appearance of a rash, etc., are connected with the inhalation of ether.

After-effects of Chloroform.

The risks of bronchitis and other respiratory troubles are much less after the use of chloroform than after ether, though such complications do arise. Any existing bronchitis will generally be increased by the inhalation of any anaesthetic.

Vomiting after chloroform is slightly less common than vomiting after ether, but when it does occur, it comes on at a somewhat later stage of the return to consciousness, when the patient is more capable of appreciating its unpleasantness, it is much more severe, and will last for a longer period. The treatment is described on page 27. After the inhalation of chloroform the circulation remains depressed, and the patient should not be allowed to sit up for some hours after the return to consciousness. If this precaution is neglected *syncope* may occur, and has proved fatal.

CHAPTER VI.

MIXTURES CONTAINING CHLOROFORM AND ETHER.

CHLOROFORM and ether mixed in different proportions, in some cases with the addition of other drugs, have been employed in the hope that by combination the unsatisfactory effects of the one will be neutralised by the effects of the other, and that the resulting compound will present the advantages of both. To some extent this hope has been realised. The mixture most in use is the A.C.E. mixture, which will be first described.

A.C.E. MIXTURE.

This was suggested by Dr. George Harley, and was recommended by the Anaesthetics Committee of the Royal Medical and Chirurgical Society in 1864 as the most satisfactory of the mixtures examined by them. It consists, as its name denotes, of a mixture of one part of alcohol, two parts of chloroform, and three parts of ether, all measured by volume. As in the case of ether and chloroform, either the pure or the methylated varieties may be employed, so in the mixture both forms are satisfactory. The specific gravity of the mixture is about 1.

The use of the alcohol in the mixture has given rise to much discussion. It acts as a diluent of the chloroform, and is said to lead to a more intimate connection between the chloroform and ether, and to make the mixture more stable, and less liable to decomposition than one of chloroform and ether alone. At any rate it is useful in disguising the smell of the ether, as that of the mixture is decidedly pleasant.

It is still undetermined whether any chemical change takes place during the preparation of this anaesthetic, or whether it is simply a mechanical mixture. Without doubt some amount of heat is generated during the process.

The objections to the use of this mixture are mainly theoretical. It is stated that it is very unsatisfactory to work with two poisons, and not know the precise proportion of each one that is being administered; for the ether evaporates more quickly than the chloroform, while the alcohol remains till the last. This is undoubtedly to a great extent true, though the alcohol prevents the ether from evaporating as fast as it would if it were only mixed with chloroform. But practically the objection does not carry any weight, for the anaesthetic has been given in many thousands of cases with most excellent results.

The character of anaesthesia it produces lies midway between those procured by means of its two principal constituents, chloroform and ether, when used separately. By its use a quiet sleep is obtained resembling that of chloroform, while unfavourable signs of circulatory depression are not so marked, in fact there is generally a marked improvement in the pulse soon after the substitution of this mixture for pure chloroform.

It may be given alone throughout the operation, or simply as a pleasant start for the administration of ether; and it is also most useful when a change is required on account of the amount of secretion produced by the latter drug.

Apparatus.

The apparatus required for the administration of the A.C.E. mixture consists of a Skinner's mask, and one known as Rendle's (Fig. 31).

The Skinner's mask is the one used for the administration of chloroform, and on this the mixture is given to young children, and very delicate adults. The evaporation from this form of mask is so rapid, that it is unsatisfactory for the anaesthetisation of an adult patient, and a semi-closed inhaler was suggested. It is dangerous to administer the mixture without a sufficiently free admixture of air, and fatal results have followed its unintentional inhalation from a Clover's inhaler.

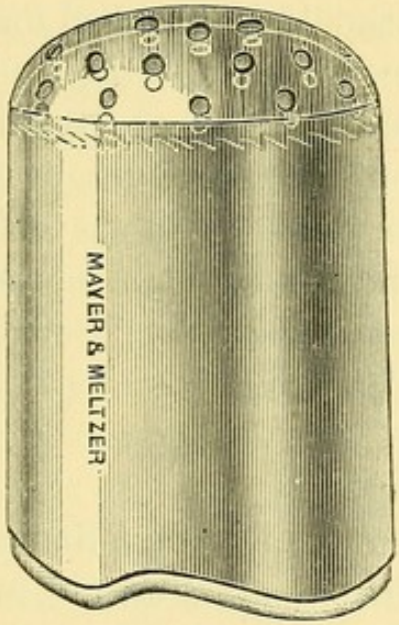


FIG. 31.—RENDLE'S INHALER.

Rendle's inhaler was formerly made in leather; but as this soon becomes contaminated, and cannot be easily cleaned, Dr. Silk substituted a celluloid form which can be easily cleaned, and is by far the best for general use. It consists, as shown in fig. 31, of a more or less cylindrical inhaler made of celluloid, with holes at the closed end for the free admission of air, the other end being open, and approximately

of the shape of the face, and with a notch to accommodate the bridge of the nose. Plenty of air can pass through the holes, and the inhaler is not "closed" in its action, that is, re-breathing does not take place to any great extent, as it does when an india-rubber bag is used. The part which is applied to the face does not fit at all accurately, and there is no air cushion round the edge of the mask. The interior is lined with a flannel bag which contains a sponge, on to which the mixture is poured. If the bag becomes saturated during the course of a long operation, it should be changed for a fresh one.

These masks are made in three or four different sizes. A drop bottle should be used, as in the case of chloroform, but to prevent confusion, it should be of a different colour to the one used with the latter drug. After an administration the sponge should be wrung out in hot water, the flannel bag should be washed, and the inhaler cleaned in a weak solution of carbolic acid in cold water.

The Administration.

The A.C.E. mixture is given on a Skinner's mask in precisely the same way as chloroform, but it must be remembered that the mixture is much weaker than chloroform, and so more will have to be dropped on to the mask, and that the time required to produce anaesthesia will be longer. Care must be taken that too much is not poured on to the mask, as when the flannel is saturated, the liquid will run on to the face, and blister it. In administering the A.C.E. mixture in any way it must be remembered that the evaporation of its constituent parts is not equal, that is to say, the ether comes off more rapidly than the chloroform. To obtain the greatest advantage of the ether it is best to give frequent small doses of the mixture rather than occasional large ones, for in the former instance the patient will frequently receive the beneficial effects of a small dose of ether, whereas in the latter case he will

soon exhaust the good resulting from the ether in the mixture, and for the rest of the time will simply be breathing diluted chloroform.

This method of administering frequent small doses can be easily practised when the mixture is given from a Skinner's mask, as the inhaler in this case does not require to be moved when a fresh dose is applied; but when the Rendle's mask is in use, it must be removed from the patient's face, and inverted, before any fresh dose of the mixture can be poured on to the sponge. While this is being done the patient only breathes air, and so for the first part of the administration, that is till the patient is anaesthetised, larger doses must be given at longer intervals, and when a satisfactory state of anaesthesia has been obtained, then frequent small doses can be employed. In this way, when the administration is begun with a Rendle's mask, about a drachm of the mixture is poured on to the sponge, and the mask is held some three or four inches from the patient's face. As he becomes accustomed to the smell of the drug the mask is gradually approached to the face till eventually it is fitting loosely. The mixture is a most pleasant anaesthetic to take, and coughing will seldom be met with if it is given with due care. After three or four minutes another dose of from half, to one drachm should be poured on to the sponge. It is important that the liquid should be really poured on to the sponge, and not on to the flannel bag, as in the latter case the flannel will soon become saturated, and the liquid will trickle down on to the face and burn it. When the mask is applied to the face, care must be taken that the upper part of it is not held too close to the eyes, as in this way it has been allowed to become a source of conjunctivitis, from some of the liquid trickling into the eyes. When the head has been kept well on one side during the inhalation, the conjunctivitis will be more severe in the eye that has been lowermost. The position of the patient, and the general management

should be the same as during the administration of chloroform. When nitrous oxide is not available, or is considered unsuitable, ether may in some cases with advantage be preceded by some of the A.C.E. mixture. To do this, some of the mixture is first given on a Skinner's, or Rendle's mask, till the breathing begins to become regular, when ether is substituted. If necessary it may be given first on a Skinner's mask, and then on a Rendle's, before the ether is given.

In the case of very feeble patients, or those suffering from heart disease, when the administration of any anaesthetic is a matter of great anxiety, this mixture will generally be found to give the best results. It should be given very gradually on a Rendle's mask, preceded if necessary by a Skinner's, till the patient is anaesthetised. Then if there is any sign of failing circulation, instead of pouring more of the mixture on the sponge, pure ether may be given, or doses of the mixture may be given alternately with doses of ether, and this method will generally enable any patient to be kept unconscious. The addition of pure ether to the sponge will also be found very useful when any patient who is inhaling the mixture shows signs of shock or haemorrhage.

If a change is desired from ether, on account of the excessive amount of mucus secreted, the A.C.E. mixture is the drug that should be resorted to. Under ether the respirations will be vigorous, and there is less risk of an overdose being given when the mixture is employed, than there is if pure chloroform is substituted for the ether.

The **drawbacks** to the use of the mixture are that it is slow in its action, and many patients, especially if they are alcoholic, take ten to fifteen minutes before they are well under its influence.

The **advantages** of the mixture are that it combines the good effects of chloroform and ether, without the bad results being so marked.

Under A.C.E. the *breathing* is quiet and regular, not so vigorous and noisy as that of the patient under ether, but more easily heard than when chloroform is employed.

The *pulse* too is fuller than under chloroform, though it is not so stimulated as by the inhalation of pure ether. There is less risk of trouble arising from causes connected with the circulatory system than there is with chloroform, and if any does occur, the onset will be less sudden, and treatment of more avail, so that it is less easy to administer an overdose with this mixture than it is when pure chloroform is employed.

When the patient is well under the influence of A.C.E. the *pupils* will be somewhat larger than the pupils of chloroform anaesthesia, and smaller than the average ether pupil.

The signs of the administration of too little, and too much of the mixture are practically the same as in the case of chloroform (see page 157); and if a death occur with A.C.E., it will resemble one from chloroform.

The recovery after the use of the mixture is usually good. If vomiting occurs, it resembles that after chloroform in the onset being later than the vomiting which follows ether.

There will as a rule be rather more *mucus* secreted with the mixture than with chloroform, especially if it is given to young children, though of course there will be very much less than with ether.

Laryngeal spasm may occur more frequently in the case of children than it does when pure chloroform is employed.

MIXTURE OF CHLOROFORM AND ETHER IN EQUAL PARTS.

The liquids should be freshly mixed at the time of the administration, and the mixture may be given in the same way as the A.C.E. mixture, on a Skinner's mask, or in a Rendle's inhaler.

It is a very useful anaesthetic for young children, as the little patient is not so inclined to simply go to sleep, as is so often the case with chloroform; while the breathing is quiet, and there is practically no abnormal secretion of mucus as there so often is with ether.

CHAPTER VII.

THE CHOICE OF THE ANAESTHETIC, ETC.

Relative Safety of the Anaesthetic Agents.

BEFORE considering the choice of an anaesthetic for any special patient, or for the performance of any particular operation, it is well that the student should have some idea of the relative safety of the drugs at his disposal.

By taking as the measure of their safety the number of deaths reported from these agents in proportion to the total number of cases in which they have been administered, we find that nitrous oxide, either alone, or mixed with gas and oxygen, is the safest. Next comes ether, then mixtures of ether and chloroform, and last of all, that is the one from the use of which most deaths have been reported in proportion to the number of times it has been given, is chloroform.

The number of deaths which have occurred under **nitrous oxide** are so few, that they have never been reckoned against the enormous number of times that the gas has been given with perfect safety, and so no figures indicating the proportion of deaths to those of the successes can be given; but there is no doubt that the anaesthetic is the safest that we possess. If one may judge by the published records of the cases which have ended fatally, it seems that this undesirable result has

nearly always been due to the insufficient supply of air to the patient, rather than to any effects of the gas itself, in other words the patient always seems to have died of asphyxia; but one or two cases at least have occurred in which the patient is believed to have died of syncope.

With the use of **gas and oxygen** no fatal cases have yet been published. This is due to the fact that it is hard with this method to cut down the supply of oxygen to the patient to such an extent as to produce death from asphyxia: and also to the fact that the apparatus is somewhat complicated, and in consequence, few but skilled specialists are in the habit of using it.

With the use of **ether** there are more definite figures to go on. Various tables have been drawn up, but on taking the average of these the number of deaths may be given as about 1 in 16,000.

When we turn to the **chloroform** the number of deaths reported soon increases, and may be reckoned as about 1 in 3000.

Many of the fatal cases with both these anaesthetics are never reported, but these figures indicate sufficiently well that the greater proportion occur with the use of chloroform, in fact that death is five times more likely to happen with its use than with ether. The greater safety of ether was emphasised by Paul Bert, who described the administration of an anaesthetic as a journey along a road beset with difficulties on either side; but while that of ether was fairly broad, the path of chloroform was so narrow, that a step to one side might prove fatal.

The greater danger from chloroform has also been noted in the recently published report of the Anaesthetics Committee of the British Medical Association.

There are no records of a sufficiently large number of cases to give any proportion for the **mixtures of chloroform and**

ether; but they would seem to occupy a position between those of ether and chloroform given separately.

It is said that patients die from chloroform on the operating table before the eyes of the anaesthetist, while those who die from ether live for some days, and finally die in their beds from bronchitis or pneumonia. This is to some extent true, for it is an undoubted fact that a death from chloroform generally occurs during the early stages of the administration, while a death on the operating table from the effects of ether is very rare indeed. On the other hand, bronchitis and pneumonia, though not common, are less rare after ether than chloroform, and are the most frequent cause of the fatal issue after this anaesthetic, though such complications have other factors in their production, such as exposure, etc.

THE CHOICE OF THE ANAESTHETIC.

Leaving the question of the relative safety of the agents with which we have to deal, the actual choice of the anaesthetic for individual cases must now be considered. This depends on two factors: the condition of the patient, and the necessities of the operation.

The Condition of the Patient.

This depends on the age, and the general condition and state of health.

Age.

It has been laid down as a general rule that ether should be given only between the ages of six and 60, and that beyond these limits chloroform should be the anaesthetic chosen. There is a great deal of truth expressed in this statement, but it must not be too rigidly applied. For instance, a man of fifty or less may be so aged beyond his years that he will be a much less fit subject for ether than

a hale old man of seventy; in fact, the life a patient has led, together with his constitutional strength, are of much more importance than the actual number of years of his existence.

Still the fact remains that ether is better as an anaesthetic for youth and middle age, rather than childhood and old age. It may be given to infants a few days old, or to patients at the other extreme of a long life, but in these cases it is liable to cause too much irritation of the respiratory tract; and chloroform, either pure, or in a mixture with ether, will be a better form of anaesthetic. For young infants the pure chloroform is probably better even than the mixtures, but children from three to six do best with a mixture of chloroform and ether, either in the form of the A.C.E. mixture, or that of equal parts by volume of the two drugs. From six upwards ether may be tried, but it is much more satisfactory after the little patient has reached the age of ten. If it is being given soon after six, it is best to precede it with a little A.C.E., or even a few drops of chloroform, and reserve the use of nitrous oxide for the beginning of the administration to patients over ten.

When the patient has reached the age at which it is no longer desirable to give ether, chloroform must be the main anaesthetic, though a mixture with ether is probably nearly always better than pure chloroform.

To sum up only with regard to the age of the patient: Up to the age of three years chloroform is the best anaesthetic; from 3 to 6, a mixture of chloroform and ether should be given; from 6 to 10, ether preceded by A.C.E. should be tried; from 10 onwards ether preceded by nitrous oxide should be given up to about 60. After 60, if it is decided to give ether, it should be preceded by A.C.E. rather than by nitrous oxide, as the arteries will probably be degenerated; but as a rule, a mixture of chloroform and ether, such as the A.C.E. mixture, will be the best anaesthetic.

General Condition of the Patient, and State of Health.

Stout patients with short thick necks do not as a rule take ether well, because of the limitation of air by the inhaler, and the swelling of the tongue and upper air passages from congestion. It is better in these cases to begin with A.C.E., or chloroform, and when the patient is unconscious to try the effect of ether. They often become very cyanosed if gas is administered before ether.

Anaemic patients can take any anaesthetic, but very soon come under its influence ; they should be allowed as much air as possible, and gas should never be pushed.

Alcoholic patients can take ether or chloroform, but will want a much greater quantity to produce anaesthesia. The same remark also applies to persons who have been in the habit of taking large doses of morphia or other drugs. In alcoholic patients struggling and shouting will often be marked.

Strong *muscular* men will generally give the anaesthetist more trouble than women, and it should be remembered that a certain proportion of the deaths from primary cardiac syncope have occurred when chloroform has been given to a labourer, fresh from his work, for the performance of some trivial operation. For these gas and ether should undoubtedly always be administered, unless contra-indicated by the nature of the operation.

Heart disease.—In administering an anaesthetic to a patient suffering from heart disease, the most important point to determine is whether the compensation is good or not. The colour of the face, the character of the pulse, the difficulty of breathing, the presence of signs of back-pressure, such as albuminuria, enlargement of the liver, etc., with moist sounds heard at the bases of the lungs, are signs that the heart is not doing its work well, and that if an anaesthetic is required, great care must be exercised in its selection and administration. A systolic murmur heard at the

apex is not of itself a contra-indication of the use of ether, though in any such case a careful watch should be kept upon the colour of the patient, so that the supply of air is not unduly curtailed. But in a case of imperfect compensation a closed inhaler should never be used. For these patients the best anaesthetic is the A.C.E. mixture, which is preferable to chloroform on account of the ether in its composition. It may be given at first from a Skinner's mask, which may afterwards be changed for a Rendle's inhaler. The supply of air with the anaesthetic should be very free, and the patient should be very carefully watched for signs of heart failure. Some patients with grave heart affections take this mixture very well. If the pulse shows signs of failure some ether should be poured on the sponge of the inhaler, and if the result is satisfactory the quantity may be increased, until the patient is practically inhaling only ether. Ether may perhaps be given from the first from an open inhaler, but this is not advisable on account of the suffocating feeling which it will produce in the patient.

Thoracic aneurysm.—For patients suffering from this disease the A.C.E. mixture is most suitable, as it is the most pleasant of the anaesthetics, and with its use there is generally the least amount of struggling, which of course must if possible be avoided. The circulation will not be unduly stimulated as if ether were given, nor will it be so depressed as it is with chloroform.

Atheroma.—Patients suffering from marked atheroma should have chloroform or A.C.E. Those with a less amount may have ether, but in these cases it is more advisable to precede it with a little chloroform, or better A.C.E. on a Skinner's mask, rather than to begin the administration with nitrous oxide. The possibility of the occurrence of cerebral haemorrhage in these patients must be remembered, and the circulation should not be unduly stimulated.

In patients suffering from *acute congestion or inflammation of the respiratory tract*, such as laryngitis, acute bronchitis, or phthisis, ether is inadmissible as an anaesthetic, and pure chloroform should be administered. In cases in which the condition is *chronic*, as old bronchitis with emphysema, the A.C.E. mixture will generally prove very satisfactory.

When much *dyspnoea* exists from the narrowing of air passages from within, as in cases of diphtheria, or from the pressure of tumours from without, as in enlarged thyroid gland, etc., chloroform should be chosen as the anaesthetic, and the anaesthesia should be as light as possible for the satisfactory performance of the operation.

In all these cases of respiratory trouble, especially if the operation to be performed be a short one, it should be remembered that nitrous oxide and oxygen may be suitable. It will not increase the congestion or inflammation that is present, and unless the patient is alarmed by the sight of the apparatus, its inhalation should produce no distressing symptoms. It is perhaps hardly necessary to state that considerable previous practice with this anaesthethic is absolutely essential before it can be given to such cases, and even then it may be found best to change to chloroform or A.C.E., but especial care must then be taken that an overdose is not administered.

In cases of marked *cellulitis of the neck* ether is unsatisfactory as an anaesthetic. Not only would it further increase the congestion that already exists, but, as in these cases there is generally also some oedema of the glottis, and this would be aggravated by the irritating influence of the anaesthetic, the respiration of the patient would be further embarrassed. For these cases, if not very severe, the A.C.E. mixture will be satisfactory, but for bad cases pure chloroform will be required.

Albuminuria.—Ether in any quantity should not be given to patients suffering from albuminuria ; for it must be remembered

that this drug is excreted in part by the kidneys, and if much has been inhaled, the nephritis may be made worse, and the amount of the albumen in the urine increased, and in severe cases there will be a risk of total suppression of urine. Chloroform is the best anaesthetic for severe cases, but for those in which the amount of albumen present in the urine is small, the quantity of ether in the A.C.E. mixture will probably not do any harm, though ether alone as the anaesthetic should be avoided.

Shock and collapse.—Patients in a state of severe shock and collapse from accidents, loss of blood, or prolonged exposure, etc., as a rule require very little anaesthetic for any operation that is urgently needed. Ether is unquestionably the most suitable, though it should only be given sparingly, and with plenty of air. It should not be given however when there is any coexistent respiratory trouble, or any haemorrhage that might be increased by its stimulating effect, and for these cases a little chloroform or A.C.E. may be tried.

The Operation.

The operation to be performed affects the choice of the anaesthetic in two ways: (1) by its probable length, (2) by its necessities.

Length of the Operation.

For short operations, that is those not lasting more than a quarter of an hour, the use of gas and air, or gas and oxygen, should be considered. The advantages of nitrous oxide for these short cases are that it is pleasant to take, is very safe, and that as a rule the recovery is rapid, and without unpleasant complications such as vomiting.

For longer cases it is generally better to resort to one of the other anaesthetics, except under exceptional circumstances, as when it is important that the patient should be able to return

home as quickly as possible after the return to consciousness. Under such special circumstances gas and air, or gas and oxygen, may be given for cases lasting an hour or more; but the longer the anaesthesia, the more chance there is of recovery being complicated by vomiting, headache, and giddiness, which may render the patient in some cases as prostrate, and as unable to move, as he would be after one of the other anaesthetics. Whenever gas and oxygen is being given for the performance of a long operation, it is most important that the necessary apparatus for the continuation of the anaesthesia by some other means should be ready at hand, as the gas may prove unsatisfactory, either from the insufficient degree of anaesthesia obtained, or from the supply running short, through the operator requiring more time than was at first anticipated. When it is necessary to make a change from gas, recourse should be had to ether, and not to chloroform, unless there is some definite reason against the use of the former drug.

The Nature of the Operation.

If **nitrous oxide** is considered satisfactory as regards the length of time required by the surgeon, there are very few operations for which it may not be employed. It is of course specially suitable for those in which great relaxation of the muscles is not required, and where a slight muscular movement would not spoil the operation; and it is therefore more satisfactory for operations which do not require great delicacy in their performance. The size of the necessary apparatus makes its administration inconvenient for operations about the face in which a continuous administration has to be kept up; but in these cases, the gas may be given by means of the nose apparatus described on page 98, or, after the patient has been anaesthetised with the ordinary face-piece, the supply of gas may be kept up by means of a mouth tube, or a soft catheter passed into the naso-pharynx. For quite short operations, the

gas may be given as for a dental operation, and the face-piece then removed; but the anaesthesia thus obtained will not be long enough for the performance of most surgical operations. If for any reason gas is not considered advisable, the choice now lies between ether and chloroform, or one of their mixtures.

Ether is safer than chloroform, and should therefore be considered first. It may be said that ether should be tried in all cases, except those which fall under the following heads:

(1) When it would be unsatisfactory on account of the *congestion* it produces, as in operations on the brain, removal of the thyroid gland, operations for glaucoma, and other operations on the eye, and also for tracheotomy, and operations on the larynx and trachea.

(2) When an excessive *secretion of mucus and saliva* would increase the difficulties of the surgeon, as in some operations in the mouth and larynx.

(3) When *inconvenience* would be caused by the size of the apparatus, as in operations on the eyes, nose, lips, and tongue. It should be remembered, however, that many of these cases may be anaesthetised with ether, and chloroform substituted later when necessary.

(4) When a *cautery* has to be used near the mouth, it is better to administer chloroform from the beginning.

(5) In all cases where only a *light degree of anaesthesia* is required chloroform is preferable to ether; such cases are painful labour, eclampsia, and tetanus.

(6) In some cases the surgeon will specially wish for chloroform—often for *abdominal sections etc.*—on account of the quieter breathing, etc.

In all other instances, unless there is some good reason to the contrary in the general condition of the patient, ether should be tried as the anaesthetic, though, of course, it may prove to be unsatisfactory, on account of the secretion of

mucus, etc., when a change must be made to **chloroform** or **the A.C.E. mixture.**

NOTES ON CERTAIN OPERATIONS.

Operations on the Brain, etc.

Under this heading may be considered all operations on the cranial nerves, etc., for the relief of persistent neuralgia.

Chloroform is by common consent the best anaesthetic for these operations, as by its use much less congestion is produced. A hypodermic injection of morphia has been recommended and tried just before the administration, because with its use the congestion was supposed to be still less, and less of the anaesthetic is required. This has now been abandoned by many operators.

The patient should be anaesthetised in the dorsal position, and when he is quite unconscious, gradually lifted into the position that the surgeon requires. He will often have acquired a habit of taking morphia and other drugs on account of pain, and will then require more of the anaesthetic than usual. Many of the patients have a marked tendency to vomit. It is very important that a good air-way should be kept, as if there is any obstruction to free breathing, the veins will become dilated, and the area of operation as congested as if ether had been administered.

When the operation is in progress the anaesthesia is best maintained by means of a Junker's inhaler with the modified glass face-piece of Dr. Dudley Buxton (see page 174). By this means the patient can be kept in a suitable degree of unconsciousness, without the administrator having to bring his hand near the wound to sprinkle fresh chloroform on a mask. The face-piece being of glass can be made aseptic, and a fresh piece of lint, with an outer layer of antiseptic gauze, can be used to cover it. The colour of the lips can be well seen through the glass, and their movement in respiration. If the

patient is breathing vigorously, and any saliva collect on the lips which might be blown about, this mask is of service in preventing anything from reaching the wound or the surgeon's instruments, as it can be kept closely applied to the face on the side nearest the seat of operation, and elevated on the other for the admission of air.

The patient can be anaesthetised with this apparatus, and if more chloroform is required than can be pumped through the tube, some may be sprinkled on the lint covering the face-piece. As one of the administrator's hands will be required to pump the chloroform, the other must be employed to hold the face-piece and to keep the jaw in good position, and this is best done by holding the face-piece by its lower end, and by keeping some of the fingers of the same hand under the patient's chin. The anaesthesia should not be allowed to become too deep, though straining or coughing must be prevented, as these would often render the operation impossible.

Operations on the Thyroid Gland.

As mentioned before, chloroform is the best anaesthetic for these cases, as it produces the least amount of congestion. It may be administered from a Skinner's mask, or by means of the glass face-piece with a Junker's inhaler described above; and it has been remarked that after once being anaesthetised, these patients often require very little to maintain the proper degree of anaesthesia.

The administration of an anaesthetic to these cases is always attended with some anxiety, as this class of patient seems particularly liable to syncope under chloroform. The air-way is probably already narrowed by the pressure of the enlarged gland, and in the course of the operation the manipulations of the surgeons may still further diminish the calibre of the trachea. On this account the patient should never be anaesthetised more deeply than is necessary. The skin

incision is said to be the only painful part of the operation, so that when once this is made, it is advisable to try a lighter anaesthesia. Muscular movements, swallowing, and attempts to vomit, are signs of insufficient anaesthesia; and if the corneal reflex can be allowed to return without these troublesome complications, it should certainly not be abolished again.

Several cases have been recorded, in which the respiration and circulation have failed during one of these operations, generally when the main vessels and nerves were being manipulated, or when the tumour has been lifted from its bed; and death has sometimes resulted. We cannot now discuss whether this is generally due to a closure of the trachea through traction on the gland, or whether it is due to some nervous stimulation exerted through the manipulation of the vagus and its branches, or through the sympathetic nerves. If respiration ceases under these conditions it is useless to attempt to restore it artificially until it is certain that there is a sufficiently free air-way. Owing to the size of the tumour, tracheotomy below the obstruction may be impossible, and in these cases intubation may be of great service.

On account of the special danger in these cases attempts have been made to perform this operation without a general anaesthetic, but simply with local anaesthesia obtained by cocaine. But although the operation, after the skin incision, is said to be practically painless, the mere knowledge that an operation is being performed would often do a patient more harm than the anaesthetic; while the swallowing and muscular movements would embarass the surgeon.

The pressure of the enlarged gland often causes the trachea to assume a sinuous course, and as it is possible that tracheotomy may be necessary during the removal of the tumour, it has been suggested that the exact position of the trachea should be made out by auscultation before the operation is begun.

Tracheotomy.

For this operation chloroform is the best anaesthetic; but the degree of the anaesthesia should be as light as possible. The difficulty of breathing is increased by fright, but a little of the anaesthetic will soon relieve this, and the breathing will often become much easier after very little of the anaesthetic has been inhaled, and the neck will become less congested as the struggling passes off. In performing the operation for the relief of urgent dyspnoea it is unwise to push the anaesthetic beyond this stage of quiet.

The patient should be in a position as nearly dorsal as possible, though the difficulty of breathing may render the absolutely supine position too trying for the patient. The head should be extended, and the chin exactly in the middle line; and it must be rigidly kept in this position by the anaesthetist, as if the head is allowed to turn to one side or the other the surgeon will find that the difficulties of the operation are enormously increased by the altered relation of the parts. In this position the tongue will of course tend to fall back against the posterior wall of the pharynx, but the air-way must be kept as clear as possible by keeping a finger behind the angle of the jaw on one side, if not on both. If this is insufficient to keep the tongue far enough forward, the tongue forceps must be used.

Removal of Post-Nasal Adenoid Growths.

There is perhaps no operation in surgery which has so many methods of performance. The surgeon may wish the patient to be sitting bolt upright in a chair, sitting up with the head bent well forward, or lying in the dorsal position with the head extended, or even hanging over the end of the operating table or couch.

The length of the anaesthesia required varies with the amount of growth, etc., to be removed, and with the speed

at which the operator is accustomed to work. For some operations the 40 seconds of anaesthesia which may be obtained as the result of one administration of gas and air, or gas and oxygen, will suffice. On the other hand, some operations will last as many minutes, and for these gas would be quite useless. As the routine anaesthetic for the long cases, gas and ether is the one to be chosen on account of its greater safety, though some surgeons prefer chloroform, or the A.C.E. mixture, on account of the secretion of mucus and saliva which so often accompanies the inhalation of ether. Chloroform is of course the only drug by which the anaesthesia can be maintained after the operation has begun, but the patient runs less risk of an accident if anaesthetised in the first instance with ether.

In giving gas and ether for these cases, it should be remembered that if the nose is more or less completely obstructed by the growths, and the mouth is kept closed by the hand which holds the face-piece, the patient will soon be practically asphyxiated, as will be shown by the bad colour of the face. To overcome this, it is well before beginning the administration to see if the patient's nostrils are fairly patent, by asking him to blow down his nose. If they seem at all occluded it is best to place a small dental prop between the teeth on the right side, so that an air-way through the mouth shall be maintained throughout the administration. This prop must always be secured by a piece of cord or silk to another prop or some other object, so that there may be no chance of the patient trying to swallow it. It is better placed on the right side, as it will then be out of the way of the gag, which is generally placed on the left.

The patient should be anaesthetised with the head turned to the right. When once under, he should be allowed a few breaths of air, and then the inhaler should be re-applied for 5 or 6 more breaths, and this repeated so that enough ether

may be absorbed to last as a reserve of anaesthetic. This should be continued till the reflex has been lost, when the inhaler should be removed and the gag inserted. Care should be taken that it rests on sound teeth, and as far back as possible. The upper arm of the gag should lie across the left external auditory meatus, and should be kept stationary, while the lower arm should move till the mouth is opened as widely as desired. As the gag is opened widely the lower jaw is gradually forced towards the sternum; and to counteract the obstruction to respiration which would ensue as the result of this, the jaw must be pushed forward by means of a finger behind the angle. This can conveniently be done by one of the fingers of the left hand, while the gag is kept in its place by the others (see Fig. 32). If a detached tube is being used to convey the chloroform to the mouth from the Junker's inhaler, it should lie between the two arms of the gag, but it is more convenient if the tube is fixed to the gag, as suggested by Dr. Hewitt, and shown in Fig. 149.

The surgeon will probably like the head to be kept in the middle line, and this position must be maintained by means of the anaesthetist's hands placed one on each side of the head, the ball of the bellows of the Junker inhaler lying in the palm of the right hand.

When blood has to be sponged from the back of the mouth the head should be turned over to the right side, and replaced in the middle line as soon as the surgeon is ready to continue the operation. By turning the head to the right when blood has accumulated in the mouth, less of it will be swallowed, and the patient will be less likely to vomit on coming round.

If both tonsils are to be removed, it is as well to have two gags at hand, so that no time is lost in changing the one from side to side. By the use of the gag shown in Fig. 33, which I have modified from one suggested by Doyen, this change is rendered unnecessary, as the gag rests on teeth

which are further forward, and does not get in the way of

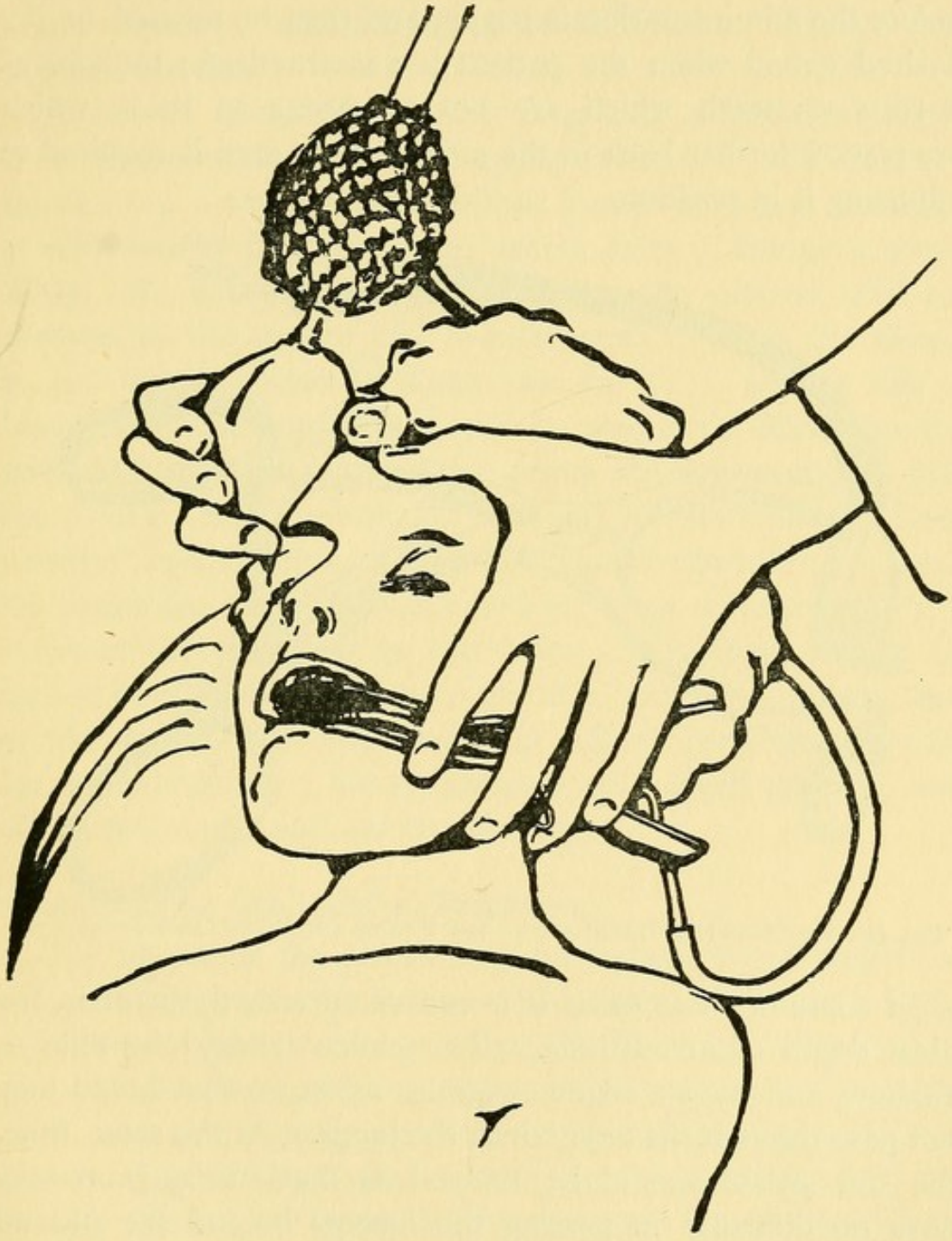


FIG. 32.—THE ADMINISTRATION OF CHLOROFORM WITH A JUNKER'S INHALER FOR THE REMOVAL OF POST-NASAL GROWTHS.

the tonsillotome. Chloroform may be given through a tube attached to the upper arm of the gag, and this tube can

be easily cleaned. As this gag fits closely to the patient's face, it may, if desired, be placed in position in the mouth before the administration is begun, and then be opened to the desired extent when the patient is anaesthetised; though, as it rests on teeth which are not so strong as those which are placed further back in the mouth, more care is required in adjusting it in position.

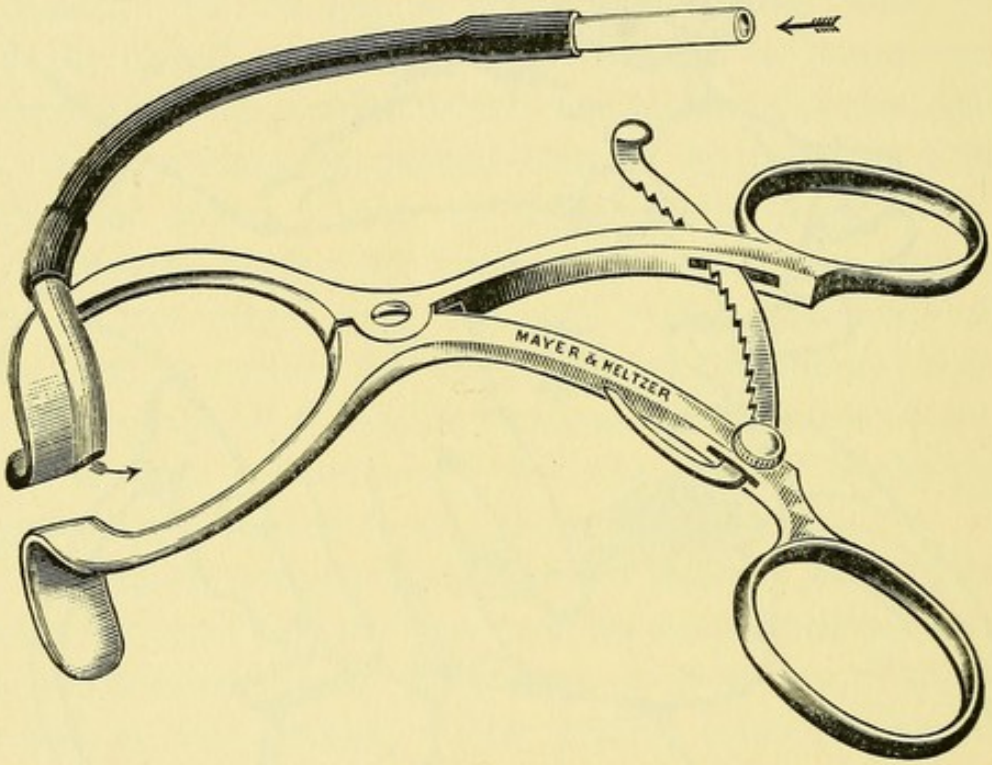


FIG. 33.—NEW GAG FOR OPERATIONS IN THE MOUTH AND POST-NASAL SPACE, ETC.

In some of these cases it is not at all easy to maintain the ideal depth of anaesthesia. The patient should be able to swallow, and have a slight coughing reflex, so that blood may not pass through the larynx into the lungs. At the same time, the soft palate should be relaxed so that the surgeon may have no difficulty in passing the forceps behind it; and no attempt at vomiting should be caused by the contact of the finger with the pharyngeal wall.

When the patient has been anaesthetised with ether it is occasionally found that the soft palate is still rather hard,

while the patient is otherwise quite ready for operation; under these circumstances, the parts will become relaxed after a few seconds' administration of chloroform through the Junker's inhaler.

When the operation is not a long one, a sufficient depth of anaesthesia may be kept up by means of the Junker's inhaler, but if the patient is robust, it may be found necessary to occasionally give a stronger vapour from a Skinner's mask. While this is being done, the gag may be relaxed with advantage, as the patient will breathe more freely if the mouth is not widely opened. When the mouth is almost full of blood, and the surgeon's finger is practically filling up the post-nasal space, it is useless to pump chloroform vapour into the mouth. The anaesthetist must wait till the blood has been removed, and there is a channel open for the chloroform to reach the lungs, and the patient is breathing more or less regularly.

When the operation is concluded the patient should be turned bodily over on to the right side, and the right leg bent at the knee to prevent him from rolling from side to side. In this position any blood that may collect will probably run out of the mouth and not be swallowed.

Operations for the relief of Empyema.

The choice of the anaesthetic for a patient suffering from empyema depends principally on his general condition. If the collection of pus is not very large, and the respiration is easy, gas and oxygen may prove very satisfactory, except in those cases where the mere presence of the large apparatus is a source of great discomfort to the patient. Failing this, the A.C.E. mixture, or even chloroform, may answer very well. The anaesthetic should be given very gradually and cautiously. It is best to start with a little on a Skinner's mask, and if the A.C.E. mixture is being given, a Rendle's inhaler may be used after the first two or three minutes.

Ether should not be given except in very slight cases, and even then it is better avoided. On the whole, the A.C.E. mixture will be found the best routine anaesthetic for these operations. The anaesthesia should always be light, and the corneal reflex never lost. If no rib is to be resected no more anaesthetic will generally be required after the skin incision.

The *position* of the patient for this operation is most important. The administration should be begun with the patient in the position which he naturally assumes as the one of greatest ease. During the actual performance of the operation much of course depends on the wishes of the surgeon, but the anaesthetist must see that the position adopted is also satisfactory from the patient's point of view.

It is most important that the sound lung should be uppermost, and that the chest should not be hampered in its work by assistants leaning on it. If the diseased side has been placed uppermost, and the empyema has a communication with the bronchus, the pus from the diseased side may run into the bronchus of the sound side, and the patient in this way be asphyxiated.

One very good position is for the body of the patient up to the waist to rest on the operating table, while the head and shoulders rest on another table placed at the side, or are supported by an assistant. In this way the sound side can be kept uppermost, while the surgeon has plenty of room to get at the affected part. The arm rest shown in Fig. 34 may also prove useful.

Operations through the Loin.

For operations in this region, such as are mostly performed on the kidney, as nephrectomy, nephro-lithotomy, etc., the position of the patient is of importance to the anaesthetist

as well as to the surgeon. For the convenience of the operator the patient is placed on the sound side, and a small pillow is generally placed under the loin. In this position respiration is not very easily performed, especially when, by the desire of the surgeon, force is exerted in pressing the kidney near to the incision. The patient cannot use the lung of the de-

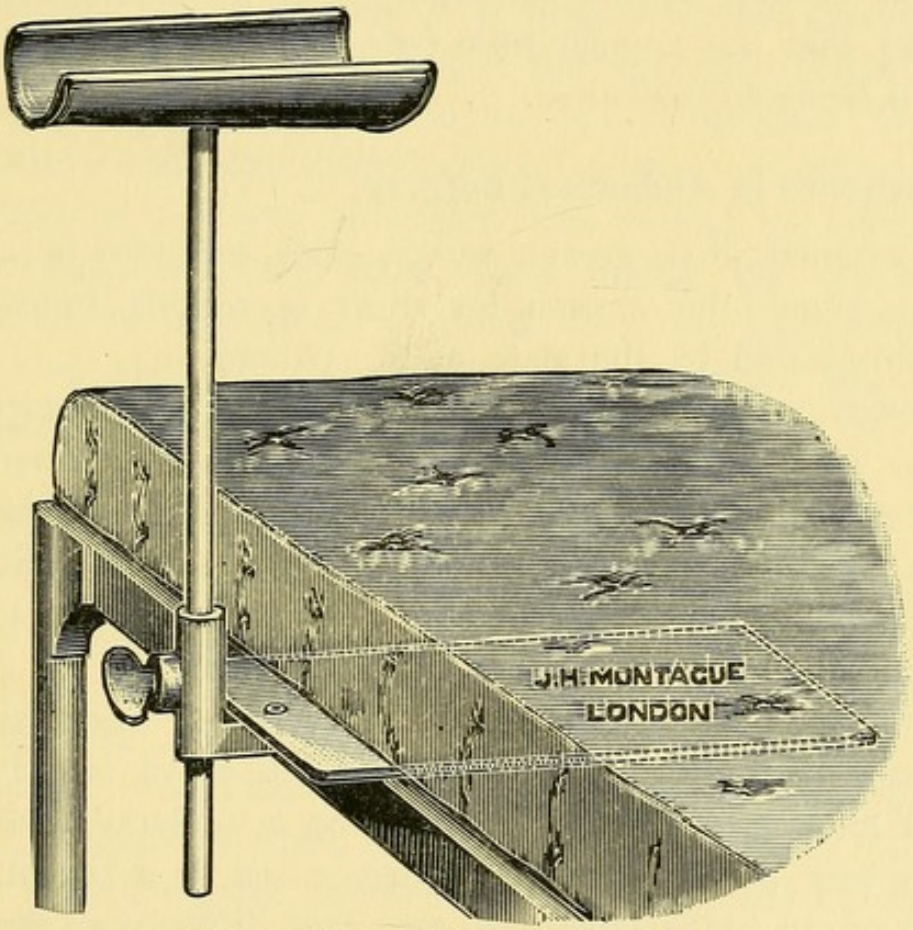


FIG. 34.—CARTER BRAINE'S ARM REST.

pendent side to its full extent, and tends to bury his face in the pillow; and it becomes the duty of the anaesthetist to see that he is using the uppermost side of the chest to the best possible advantage. To ensure this, the shoulder which is uppermost must be kept in position by an assistant, or by bending the arm to a right angle and fixing it in this position by bandaging, or by the use of a rest suggested by Mr. Carter Braine (see Fig. 34). This consists of a broad iron

plate, which is kept in position by being pushed under the mattress on which the patient is lying, and which forms the base of the apparatus, while to it is attached an adjustable sliding rod, at the upper end of which is the support on which the arm rests. With the use of this simple contrivance the breathing is much less hampered, and the patient remains still in the position desired by the surgeon. It is for patients in this position that the angular tube (see page 123) is useful when ether is being administered.

Anaesthetics in Abdominal Surgery.

On account of its greater safety, ether, preceded if possible by gas, should be chosen for short operations, unless it is contra-indicated by the state of the patient.

Though extreme muscular relaxation is not secured as quickly as with chloroform, still the necessary amount can nearly always be obtained in a short time.

For many delicate operations the depth and rapidity of the respirations under ether may be troublesome for the surgeon, and then a change must be made to the A.C.E. mixture, or pure chloroform. This change may also be necessary if the secretion of mucus and saliva is excessive; and it must be remembered that even a moderate amount of mucus may prove a source of discomfort to a patient, who on his return to consciousness may find difficulty in removing it, on account of the position in which he is lying, and from the increased reluctance to cough which is caused by the abdominal wound. If this is not borne in mind, and much mucus is allowed to accumulate, bronchitis, or even broncho-pneumonia, will be more likely to follow.

Another reason against the prolonged and excessive use of ether in these cases is that during the operation the amount of shock which the patient is suffering is masked by the temporary stimulation of the ether, but when this is

withdrawn, and the patient is back in bed, a very grave condition of shock supervenes. It is from fear of this, and with a wish to know the exact condition of the patient, so that if much depression is caused, the operation may be curtailed, that chloroform is still regarded as the best anaesthetic by many abdominal surgeons.

Personally, I believe that it is best, whenever possible, to start with gas and ether, and if the operation seems likely to be prolonged to change to the A.C.E. mixture, or even pure chloroform, after about twenty minutes, or half an hour, according to the way in which the patient is taking the ether. But there are many cases which do better with chloroform or one of its mixtures from the beginning, and these can only be recognised after a certain amount of practical experience.

Anaesthetics in Midwifery.

For the purpose of relieving the pain caused by strong uterine contractions a very slight degree of anaesthesia is all that is necessary, and this may best be obtained by means of chloroform, or one of its mixtures, as the A.C.E. mixture. Chloroform is sometimes given in this way by means of a Junker's apparatus, when the bottle is suspended to the head of the bed, and the patient herself pumps the chloroform which she inhales. It is said that this method is perfectly safe, as when the patient becomes sleepy from the chloroform she naturally relaxes her hold on the bellows, and thus the supply of vapour is stopped. But this course cannot be recommended, any more than that of allowing an unskilled nurse to administer the anaesthetic.

For the low application of forceps a similar degree of anaesthesia will generally be found sufficient, if indeed any is needed; but for a difficult high operation the anaesthesia must be more profound, and it may be necessary to abolish

the corneal reflex. In these cases, and for the other operations of midwifery, such as turning, and the immediate suture of a badly lacerated perineum, the anaesthesia may be obtained by chloroform or A.C.E.; but ether is applicable, and of course safer.

CHAPTER VIII.

LOCAL ANAESTHESIA.

In this country the use of local anaesthesia is very small compared with that on the Continent and in America; but when in those countries cocaine or some such drug would be employed locally, we are more accustomed to perform the operation under nitrous oxide, and for the great majority of operations consider this plan far more satisfactory.

Advantages of Local Anaesthesia.

The principal advantage of this method is that no preparation of the patient is necessary, in fact it is better that he should recently have taken food than that he should have fasted for some hours.

Though the part is rendered anaesthetic, or more correctly analgesic, the patient does not lose his consciousness, which is to some people a great cause of dread, even when the general anaesthetic to be taken is as pleasant as nitrous oxide. In some operations it may be of assistance to the surgeon that the patient is able to make certain movements when directed to do so; but this can be so seldom, that it can hardly be counted of much value.

The **disadvantages** of local anaesthesia are as follows:

In the first place, the knowledge that an operation is being performed on his person, however slight that operation may

be, and although no actual pain may be felt, may cause such a general nervous disturbance, that the patient may be more collapsed than after a general anaesthetic. This is intensified by the sight of the instruments and the movements of the operator.

If the patient is not nervous, and bears the operation calmly, yet some movement on his part, or even a cough, may ruin a delicate operation. At all times the action of local anaesthesia is uncertain, and it is well to have a general anaesthetic at hand to fall back on in case of need.

If the operation is extensive, or lasts a long time, symptoms of poisoning by the drug employed may be observed, and a fatal result has followed the use of one grain of cocaine.

Local anaesthesia is quite inapplicable for some operations in which it has been tried, as for instance in some operations on the stomach and other hollow viscera, which it is impossible to anaesthetise by local measures.

After the performance of an operation under a local anaesthetic suppuration follows more frequently than when a general anaesthetic is given, and if cold has been employed as the means to produce the required analgesia, the pain is sometimes very great as the part becomes thawed, and occasionally the skin may slough.

When much liquid is used, especially in the infiltration method, the parts become so swollen and oedematous that they are with difficulty recognised, and a delicate dissection is impossible.

Cases suitable for the Use of Local Anaesthesia.

The cases which are most suitable for the employment of a local anaesthetic, and to which the use is confined in this country, are mostly small operations on the fingers or toes, when the part can be so steadied that a slight movement will probably not do much harm; removal of tumours

from the mucous membranes or skin, as polypi in the nose; the use of the cautery, as for granular pharyngitis; the removal of foreign bodies from the eye, etc.; as a preliminary to the passage of a urethral or Eustachian catheter; for opening abscesses that are already pointing; for a simple incision into some part, or before an exploratory puncture; or for the performance of some severe operation on a patient who is almost moribund, or whose general condition precludes the use of a general anaesthetic.

Methods of producing Local Anaesthesia.

There are three principal ways in which anaesthesia may be obtained locally: by cold, by the use of drugs such as cocaine, and by means of Schleich's infiltration method.

The Use of Cold, or Freezing.

This was one of the earliest ways in which local anaesthesia was produced, but it is not often employed now in the original form, which consisted in freezing the part to be operated upon by a mixture of **ice and salt.** If other means are not at hand, however, this may still be of service in some cases, and may be applied by making a mixture of two parts of ice pounded into small pieces with one part of salt. This mixture should be placed in an india-rubber bag, and laid on the part till it is frozen, as may be judged by the whitened appearance of the skin, its hardness, and its insensitiveness to touch.

When the skin is thus rendered insensitive the operation may be performed, but it should not consist of more than a simple puncture or incision, as the now frozen skin will prevent any more delicate operation.

The great drawbacks to this method are that a much larger area of skin is rendered insensitive than is actually necessary for the performance of the operation, that when thawing is

allowed to set in the pain may be very severe, and that the whole area of skin that has been frozen may ultimately slough.

A better way of freezing the skin is to make use of the cold produced by the evaporation of volatile liquids such as ether, and in this way the area of the skin to be frozen can be more accurately limited to the actual seat of the operation. This may be done by the **ether spray**, which consists of a bottle containing ether, to which a small india-rubber ball-bellows is attached. When the ball is compressed the ether is driven out in a fine stream. In using this method of freezing care should be taken that the bottle is held sufficiently far from the part to be frozen, so that the ether may not fall on to it in an undivided stream, but in a fine shower of spray, for in this way the freezing effect will be much sooner produced. The ether used in this apparatus may be the ordinary methylated ether which is used for inhalation, or what is known as "anaesthetic ether," which should only be used for this purpose, and not for inhalation. Other volatile liquids are employed to produce cold for this purpose, as **ethyl chloride**, "**anaestile**," etc. They are quite satisfactory, and are supplied in very convenient bottles, so that when held in the hand the heat will be sufficient to drive a small spray on to the part to be frozen.

The Use of Drugs.

The drug most commonly employed to produce local anaesthesia is **cocaine**, but as the alkaloid itself is practically insoluble in water, the hydrochlorate is the salt which is generally used. This is freely soluble, but the solution should, if possible, be fresh, as if it is kept for any length of time, fungi will grow in it freely. To remedy this, some antiseptic such as boric acid, or 5°/₀ of salicylic acid, should be added to the solution, which will then keep better, though not perfectly well. Cocaine is used in solutions of different strengths,

generally of about 5 to 15, or even 20°/₀, but of late years it has been found that solutions of much weaker proportions produce equally good results, and for many purposes the strength has been reduced to 1 or 2°/₀.

As stated above, one grain of cocaine used to produce local anaesthesia has resulted in the death of the patient, so when the operation is extensive or prolonged, this possibility must be remembered, and not more than a half, or at the most three-quarters of a grain should be given. Even this might be too much for some patients, and watch must be kept for any indications of poisoning, such as will be enumerated later.

Methods of Application of Cocaine.

1. *Instillation.* A few drops of a 4°/₀ solution are dropped into the eye, this is repeated in two or three minutes, and then after about ten minutes the patient will be ready for operation.

This is the method now generally employed for the removal of foreign bodies from the cornea, operations for cataract, etc., and for others in which the surgeon does not require a general anaesthetic.

Instead of instillation a soluble tabloid is sometimes placed under the lid; or for the removal of a Meibomian cyst the lid may be turned back, and some of the alkaloid rubbed on the seat of operation.

2. *Spraying.* This method is practically confined to work on the nose, mouth, or throat, and a solution of 4%, used in a small ball-bellows spray producer, will generally be sufficient. The part is sprayed two or three times, and then five minutes should be allowed for the drug to take effect.

3. *Painting.* For mucous membranes a solution of 10°/₀ is painted on the seat of operation. This may be repeated, and after the usual interval of five minutes, the operation can be performed.

For anaesthetising the skin this strength will not be sufficient, but the solution must be increased to 20°/₀.

Instead of painting the part with such a strong solution, a small piece of cotton wool may be soaked in a weaker solution, about 5°/₀, and then kept on the seat of operation for five minutes.

4. *Hypodermically.* In this method from three to five minims of a 5 or 10°/₀ solution are injected under the skin at the seat of operation. If the area is large, two, three, or more injections should be made in different directions, and if the operation is prolonged these must be repeated. Care must be taken that the fluid is not injected directly into a vein.

In operations on the fingers the effect of the cocaine will be increased if an india-rubber band be applied as a tourniquet round the base of the finger, and it is probable that in this way the effect of the cocaine is more completely confined to the affected part.

For the passage of a catheter the urethra may be rendered almost insensitive by a previous injection into it of a few minims of a 2°/₀ solution of cocaine.

For certain dental operations, as the fixing of rubber round the teeth, the patient may be spared much pain by the use of a 10°/₀ solution rubbed on the gums.

Injections of cocaine into the gums are given before the extraction of teeth, but the results are not uniformly satisfactory, and symptoms of poisoning have followed the use of the large doses which are sometimes necessary.

Eucaine.

Under the names of eucaine hydrochloride, α and β, are two substances chemically different, but both possessing local anaesthetic properties. They are less powerful than cocaine, but are more or less free from the toxic properties of the latter drug.

Eucaine α is soluble to the extent of about 1 in 10 of cold water, and β eucaine 1 in 20; while both are much more soluble in hot water—β eucaine to a proportion of at least 1 in 10—but as the solution cools down all the drug above the former proportion is deposited. Still this solution is of great service in work in the nose and other mucous membranes.

In *ophthalmic* work α eucaine is unsuitable on account of the irritation which it produces. This is not noticed with β eucaine, while both possess a great advantage over cocaine in the fact that when producing their anaesthetic effect, they do not cause dilatation of the pupil.

A saturated solution of eucaine in cold water, that is between about 5%, is very suitable for *hypodermic* injection, and is very rarely followed by any of the constitutional symptoms which are a great drawback to the extensive use of cocaine. Up to 1½ drachms of the solution may thus be used, and the anaesthetic effect is soon produced.

Symptoms of an Overdose of Cocaine.

In considering the question of an overdose of cocaine it must be remembered that patients vary very much in their susceptibility to this drug, and what may be in one an insufficient dose to produce an anaesthetic effect, may to another be poisonous, and sufficient to cause alarming symptoms, and perhaps even death. Some fatal cases have been recorded in which the dose seems to have been very small.

The symptoms of an overdose are varied. The principal is a feeling of giddiness, accompanied with a great difficulty in breathing. The patient becomes pale with dilated pupils, and a cold clammy sweat appears on the forehead. The pulse is generally slow and feeble, and palpitation is frequently noticed. The patient is often extremely restless and may be delirious, or irregular convulsive movements may occur.

Treatment.

If the patient seem very nervous, and has not taken food for some time, the preventive treatment consists in giving a little stimulant before the application of the cocaine; and whenever the nature of the operation will allow it, the recumbent position should be chosen.

When the first sign of an overdose appears he should be laid flat on his back, with his feet raised and head dependent.

Ammonia, or nitrite of amyl, should be held to the nostrils, and if the breathing is deficient, artificial respiration must be employed. Any clothing that may be obstructing respiration must be loosened. Hot bottles should be placed round him, and if he is able to swallow, he should be given brandy and water to drink. If swallowing is not possible, some brandy should be rubbed on the lips and tongue till he is able to take more. He should not be allowed to leave the operating couch till he is quite recovered, and hot tea or coffee will often be of use in restoring a feeling of comfort.

It has been stated that if antipyrine in about the proportion of one grain to eight of the cocaine be mixed in the solution, the poisonous effects of the cocaine will be less marked.

SCHLEICH'S INFILTRATION METHOD.

By this method, what is essentially a normal saline solution containing a small proportion of cocaine is injected first into the skin, and then into all the deeper structures at the seat of operation.

For his first experiments Schleich used a saline solution without any drug which could produce any local anaesthetic effect; but he afterwards found that he obtained far better results when cocaine, even in very minute quantities, was added to the solution.

He advises the use of three solutions, varying in the amount of the cocaine which they contain—the first, or the strongest,

for operations where a greater degree of anaesthesia is required; and the third, the weakest, for those where the anaesthesia required is only slight.

Their compositions in grammes are as follows:

	1	2	3
Cocaine hydrochlor., - -	2·0	1·0	0·1
Morphia hydrochlor., - -	0·2	0·2	0·05
Sodii Chlorid., - - -	2·0	2·0	2·0
Aq. destil. et steril., - -	1 Litre.	1 Litre.	1 Litre.

It has been found by experience that the second solution is the best in the great majority of cases, the first being generally only required when the part to be operated upon is naturally very tender, or has become so from inflammation. The third or weakest solution is the one which is employed when the operation covers a large area, or is very prolonged, so that many applications of the fluid are necessary. Of the first or strong solution no more than 25 cc. should be used, while 100 cc. of the second, or 500 cc. of the third or weakest, have been used for one operation.

Method of Procedure.

After the skin has been sterilised some of the fluid is injected into the skin at the seat of operation. It must be pointed out that at first the injection is into the skin, and not under it, as in the ordinary hypodermic injection of cocaine. The syringe is specially constructed so that it may overcome the resistance of the skin to the injection of fluid into it, and it can be easily sterilised. It holds about 10 cc. of the solution.

The presence of the solution in the skin raises a small wheal, and into the edge of this the next injection must be made, this process is continued till a ring of wheals has been formed round the area of operation. The fluid is next injected under the skin, and when necessary, into the deeper structures.

When properly performed the skin is by this method rendered quite insensitive to the knife, but as the first incision is made, much of the fluid escapes. As a rule the anaesthetic effect lasts for about twenty minutes, but frequent applications of the fluid may be necessary to prolong the effect. The fluid should not be injected into parts which contain much loose connective tissue. As in the use of the other local anaesthetics, it is better for the patient to have had some food within a short interval of the operation rather than be starved as for a general anaesthetic, and a stimulant given just before the injection will help in preventing an undue amount of shock.

As stated above, this method is not received with great favour in this country. Considerable time is taken to render the part anaesthetic for the operation, and fresh additions of fluid must be made during it. This so alters some structures as to perplex the surgeon who is not accustomed to the method. After any of these methods of local anaesthesia there is more risk of suppuration occurring. In an extensive operation shock may be so severe, and the general condition of the patient become so bad, that the method may have to be abandoned, and the operation concluded under the influence of a general anaesthetic.

BIER'S METHOD.

This consists in rendering the skin and underlying tissues anaesthetic by means of Schleich's method of infiltration, and then puncturing the sheath of the spinal cord in the lumbar region. With a syringe as much of the cerebro-spinal fluid as is considered necessary is removed, and then a solution of cocaine is injected in its place.

By this means the lower part of the body is said to be rendered insensitive to pain. No record of the use of this method in this country has as yet been published.

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