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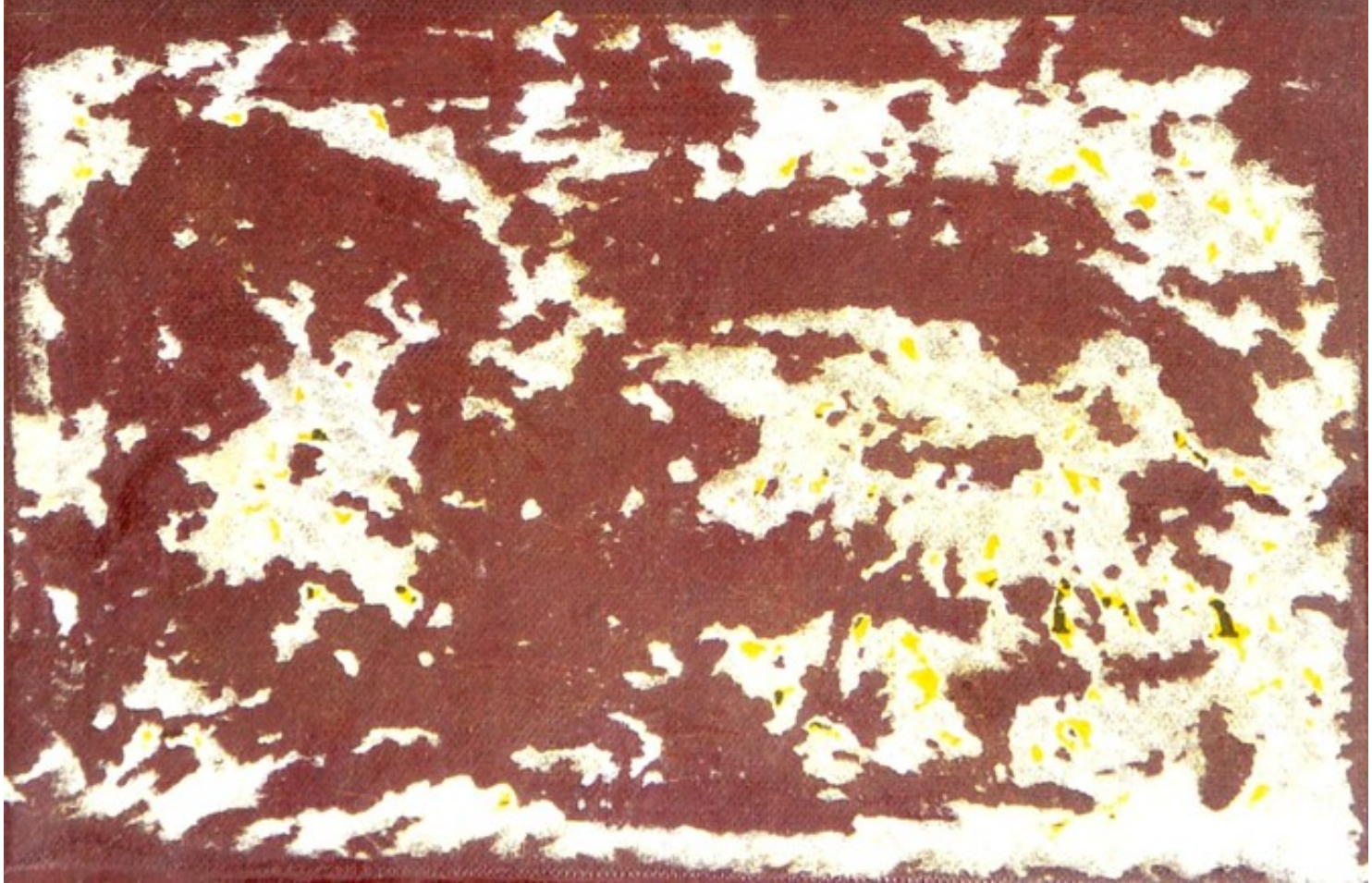
NOTES ON ANÆSTHETICS.

UNDERWOOD.



KING'S College LONDON

NOTES ON ANÆSTHETICS

IN

DENTAL SURGERY.

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IN

DENTAL SURGERY.

BY

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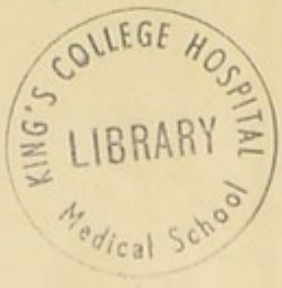

PREFACE TO THE SECOND EDITION.

THE second edition of these Notes is mainly different from the first in that Mr. Carter Braine has placed his technical skill and knowledge at my service, and between us we have striven to make the book a really thorough and practical manual. As joint authors, one seeing the matter from the anæsthetist's, the other from the operator's point of view, we trust we have been successful in our aim. A great deal of care has been bestowed upon the many new illustrations, and it has been our endeavour to confine the subject-matter to the region of dental surgery as far as possible.

Dr. Hewitt has kindly allowed us to use his diagrams illustrating his method of administering nitrous oxide and oxygen, and for the note on the administration of gas with air we are indebted to Mr. George Rowell.

The chapters on ether and chloroform have been entirely re-written.

We venture to hope that the book will be of value in the daily practice of many of our confrères, while for those who would dip deeper into the science and curiosities of the subject the literature is already rich enough in good text-books.

A. S. UNDERWOOD.

11, *Bedford Square, London, W.C.*
March, 1893.

PREFACE TO THE FIRST EDITION.

I FEEL that the appearance of my name as author of a book on Anæsthetics requires some few words of explanation. It may seem at first sight an anomaly that such a work should not proceed from the pen of a specialist in this department of medicine, and, possibly, I may be taxed with presumption, on the ground that the task I have undertaken demands an extensive personal experience, in order that the statements advanced may carry with them the weight of authority.

This very natural criticism may be disposed of at once by the avowal that I have not relied upon my own resources. In this particular my friend Mr. Woodhouse Braine has been kind enough to read my manuscript and correct, modify, or endorse its statements of practical detail; it was the promise of his assistance that emboldened me to undertake the work, and it is the value of his authority that constitutes its principal claim to the notice of the profession.

I cannot sufficiently thank my friend Mr. Bailey for assistance and advice most readily given, of which I have taken full advantage. Finally, during the last few years of pleasant mutual work at

Leicester Square, I have not failed to gather many valuable hints from my colleague Mr. Bird.

I have therefore no fear that the following pages will be found to lack the wisdom that is born of experience, or to contain matter in any sense unpractical. I have made free use of the standard literature on the subject, sparing no pains to search out much interesting matter, hitherto scattered through the pages of journals and hidden away in the transactions of learned societies.

I have thought it convenient to arrange such matter as quoted cases, illustrations, and descriptions of apparatus, and some other notes, which, although closely related to my subject, were not absolutely part of it, in a separate appendix at the end of the book, with the object of avoiding a continual interruption of the text, and of making the work readable and clear.

My thanks are due to the Secretary of the Royal Humane Society for the loan of plates Figs. 23 and 24, illustrating Dr. Sylvester's method of artificial respiration; to Messrs. Maw, Son, and Thompson for the engravings bearing their name; and to Messrs. Ash and Sons for the remainder of the blocks, and such descriptive matter relating to them as I have thought fit to use.

Having explained my indebtedness to others in the production of this little book, I have, I trust, made it plain that I must look for praise or blame rather as having discharged the duties, well or ill, of compiler than those of original author. My work

has been principally one of selection and comparison, the weighing of opinions, the condensation of treatises, and the impartial statement of the views of various authorities, but not the putting forward of new and original views of my own.

If I have performed this task judiciously, I do not hesitate to say that the value of the book is enhanced by the fact, that the author not being a specialist, and having no pronounced views of his own to advocate, is content to sink his own individuality, and to discuss the views of others without bias or prejudice.

With these few words of explanation and introduction, I leave the book in the reader's hands, with the assurance that it contains to the best of my knowledge no statement without authority, and in the hope that, while the expert in the science and art of Anæsthetics will meet with nothing very new in its pages, it may prove of service to those who are not experts and feel in need of guidance.

ARTHUR S. UNDERWOOD.

11, *Bedford Square, W.C.*
September, 1885.

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CHAPTER I.

Introductory Remarks.

Almost every one knows that nowadays the terrors of a surgical operation are so modified, by the employment of anæsthetics, that pain has been practically banished from the operating-room. The lay world can appreciate this as well as the profession, and if this diminishing or deadening of pain were the only benefit derived from anæsthetics, we should still be inclined to regard their discovery as one of the greatest achievements of the century. But when we come to consider the number of operations that have been rendered possible by their help—operations which have saved life again and again, yet which, if performed without an anæsthetic, must have themselves caused death from shock; the benefits of the extension of time and the absence of any need for hurrying (rapidity being no longer a matter of great importance in the capital operations);

the tranquillity of the patient, and the absence of after depression—it may safely be said that their use has not only dismissed pain from the operating table, but has also removed many of the chances of death that used to attend the use of the knife, and has brought within the reach of cure, diseases which were otherwise beyond it.

In the case of dental operations, the issues involved are, comparatively speaking, small, yet there may exist conditions in which the acute agony of the extraction of a tooth is sufficient to cause absolute danger to the nervous system; in all cases it is undesirable to suffer needless pain, and though the tortures inflicted by dentists must be classed among minor troubles, yet the anæsthetist, when he obviates the necessity of these sufferings, confers a boon, the value of which has been experienced by a large number of the human race.

It is with a sense of proper pride that a dental surgeon considers the question of anæsthetics, seeing that but for the experimental genius of Dr. Wells and Dr. Morton, both American dentists, we might still be in the dark upon this important subject. As the history has frequently been written, and the object of the present manual is simply to supply a practical want, it would be a waste of time and space to do more than summarise it here. Priestley discovered nitrous oxide towards the close of the 18th century, and Sir Humphry Davy observed that it possessed anæsthetic properties about 1800; but his suggestion, that it might be valuable in

surgical operations, does not seem to have been acted upon at that time.

In the year 1844, Dr. Horace Wells, a Connecticut dentist, observed this property of nitrous oxide, and, moreover, reduced it to practice by administering it in his own surgery; but the results in those early days, with an imperfect apparatus, were not altogether satisfactory. No doubt the discouragement which the world is always ready to shower upon all who advance new ideas, or try to improve upon old ones, was liberally bestowed upon Dr. Wells. At any rate he died a disappointed man, leaving the discovery in its infancy.

Then Dr. Morton, a former partner of Dr. Wells, but who had, strangely enough, received no hint or suggestion from him, instituted a series of experiments, quite independently of his old associate principally upon the lower animals, which resulted in the discovery of sulphuric ether. Much discomfort being experienced from the pungency of this agent, chloric ether was employed instead; and from this Mr. Waldie, of the Apothecaries Hall, Liverpool, separated chloroform, which was first administered by the late Sir James T. Simpson, in the autumn of 1847.

For a time, nitrous oxide, which had had the honour of being first in the field, was eclipsed and almost forgotten. Meanwhile, the tide of fashion fluctuated between the other two anæsthetics. First chloroform superseded ether, because it was more agreeable, then a few fatal cases frightened the

public, and a rush was made in the opposite direction. Ether was pronounced less dangerous, because it did not depress the heart's action, but on the other hand stimulated it.

This continued until 1861, when Mr. Lister (now Sir Joseph) published an article in Holmes' 'System of Surgery,' in which he attributed the dangers of chloroform to the omission of a few simple precautions, and brought forward the weighty argument of the actual results of the constant use of chloroform at Edinburgh, and the absence of fatal cases. The Scotch school had administered chloroform on a napkin, without any special inhaler, for many years; they had also disregarded the pulse, and watched only the respiration, for reasons which will be detailed presently; and certainly Syme, Lister, Chiene, and others could point to very wonderful results.

But in 1864, a committee appointed by the Medico-Chirurgical Society to investigate the subject, published a report in the Society's 'Transactions,' much in favour of ether, as a less dangerous agent, principally because of its stimulating action on the heart.

In 1870, Professor Lister again upheld the cause of chloroform, in an addition to his previous article. Nine years' additional experience still found him in the happy position of being able to say that he had never lost a patient under chloroform; moreover, Mr. Syme's long career of active practice presented a similar unbroken record of satisfactory results.

Professor Lister's position seemed now a very strong one. He explained that, with certain precautions, chloroform was almost perfectly safe; he analysed the deaths that had brought the agent into discredit, and showed that necessary precautions had probably been omitted; moreover, he described some cases in which fatal results would probably have occurred, had he himself not interfered to employ the precautions omitted by the surgeon administering the anæsthetic. Lastly, he described cases in which patients had died from shock when some accident had prevented the administration of the anæsthetic and the operation had been performed without it. [Had chloroform been given, no doubt the fatal result would have been attributed to its use.] He showed the flaws in his opponents' theories, he pointed out the errors in their practice, and then triumphantly turned to the record of those who followed his own method—a record unsullied by a single failure.

While the rival merits of Ether *v.* Chloroform were being fought out by their several champions, protoxide of nitrogen, which had pioneered the whole question of artificial anæsthesia, was disused and forgotten. It is impossible to say who really first rescued it from the obscurity into which it had fallen, probably Dr. Q. D. Colton is entitled to that honour in America; but as far as England is concerned, we owe our knowledge of nitrous oxide a second time to an American dentist. On the 31st of March, 1868, Dr. T. W. Evans, of Paris, having

recently brought over the nitrous oxide gas to this country, exhibited its anæsthetic properties at the Dental Hospital of London, and, moreover, assisted the profession in every way to carry out further experiments on this subject.

Committees were promptly appointed, by the Odontological Society, and by the committee of management of the Dental Hospital, to act in conjunction, and report upon the question. Their preliminary report was very favourable; the rapid anæsthesia, the rapid recovery, the absence of after-effects, &c., were all dwelt upon.

In November, 1872, the committees published their full report, which was equally favourable. In the volume of the 'Transactions,' Odontological Society, 1872–3, many papers and discussions, which are very interesting and instructive, show what a deep interest was taken in the subject of nitrous oxide, and how widespread its use had become in the four years that had elapsed since its introduction by Evans, and from that time forward this agent became generally preferred to all others for dental operations. Wells who first used it, Colton who revived it in America, and Evans who brought it to England, were all dentists, and all Americans. For this invaluable addition to our scientific possessions, we therefore owe our transatlantic brethren a debt that can scarcely be over-estimated.

In 1880 another committee, appointed by the British Medical Association, published a report of some very careful investigations, the general result

of which was to show that ethidene dichloride was a valuable agent, and that ether in a concentrated form might be administered without any depressing effect upon the heart's action. In their report, this committee once more insisted upon the danger to the heart from the sedative action of chloroform. Sir Joseph Lister, however, again pointed out that as far as chloroform was concerned, there was a source of error in the experiments that rendered this result quite valueless, because the chloroform had been administered through a tube fixed into the trachea, and, therefore, in a concentrated form, and he showed that what was thus demonstrated was not the danger attending the administration of chloroform, but the danger attending the *close administration* of it; in fact, he might have added that by a systematic omission of all points essential to the safe administration of chloroform, the agent might, nay, would be rendered dangerous to life.

The Commission held at Hyderabad in 1889, which owed its existence to the vigorous defence of chloroform by Surgeon-major Laurie, and to the generosity of the Nizam, who supplied the necessary funds, came to conclusions that were so favourable to chloroform that, to remove any possible suspicion of bias, Dr. Lauder Brunton went out to Hyderabad to repeat the experiments, and give an impartial verdict upon their value. The result completely confirmed the original report, and there can be little doubt but that, if it is satisfactory to base deductions as to the effects of drugs upon man upon

observations carried out upon small animals, the victory rested with chloroform; but this is a large "if." The present work aims at being a practical notebook for dental surgeons; and those readers who wish to study the important physiological questions discussed at the Commission and ever since, are referred to the able works of Buxton and others for a complete account of the matter.

CHAPTER II.

General Considerations.

Before turning our attention to the several anæsthetic agents, which are in common use at the present day, it will be advantageous to consider the physiological effects of anæsthetics in general, and the precautions that may be considered indispensable to the safe administration of any of them.

The continuous inhalation of certain vapours, known as anæsthetics, paralyses the nerve centres in a certain order.

1. *The cerebrum*, destroying volition, so that action is no longer designed or controlled by the intelligence of the individual.

2. *The sensory centres of the cord*, after which movement is erratic, and not even responsive to a sensory stimulus.

3. *The motor centres of the cord*, after which movement ceases.

And, lastly, *the sensory and motor centres of the medulla*, after which respiration, the heart's action, and all the functions of life cease.

If the cerebrum only has been paralysed the irritation of a sensory nerve will produce a reflex muscular action, as in the case of the unconscious winking of the eye-lid when the conjunctiva is

touched, the patient's power of feeling is already gone in one sense, that is, his brain is no longer aware of the touch, nor does he remember it, but his reflex apparatus is still intact. If his finger be pricked he will unconsciously withdraw it; if severe pain be inflicted he will unconsciously struggle. The very manner of his struggling shows that his movements are not under the control of his brain proper; he will do things for which he is irresponsible, and which he would not do were his brain unclouded, and which he will never remember because they have left no record there. The struggle or scream may be exactly synchronous with the injury, but beyond a few unmeaning movements there is no purposeful struggling, nor action directed by the patient's will.

A stage later and the connection between the sensory centres and the motor centres is broken; any movement now is quite irrespective of injuries received; it is perfectly random and irregular; twitchings of the extremities, opisthotonos, rolling of the eyes, and many other muscular phenomena may occur, but they are quite independent of anything that is done to the patient.

A stage later still, and the motor centres are involved, and nothing remains at work but the cardiac and respiratory centres; there is no movement but the movement essential to life; and this is the most favourable moment for operation.

The various centres recover their powers in inverse order.

Having thus briefly referred to the stages of

anæsthesia, it will be well to enumerate a few precautions to be adopted in all cases.

It is always necessary for the administrator to look into the patient's mouth, to ascertain if artificial teeth are worn, and at the same time to notice the existence of pivoted or loose teeth, and to remember their position. In the case of dentures it must not be forgotten that the smaller they are the more dangerous they become, and, therefore, they should invariably be removed prior to the administration.

There is one exception to this rule only, and that applies to general surgery; it is when a patient is met with wearing a complete upper and lower set united by springs. These are left *in situ*, because by their removal the jaws approximate, and at every inspiration the cheeks and lips are drawn in, allowing very little air to pass, and so forming a mechanical impediment to respiration, the patient being compelled to breathe through the nares. There is no danger of their becoming detached and impacted in the throat on account of their large size.

Pivoted and loose teeth become a danger when, the prop having slipped, it is necessary to use a Mason's gag to open the mouth; these teeth are then apt to be forgotten and liable to become dislodged.

Before operating it is as well for the administrator to try the facepiece on his own face to see that it is in working order.

All instruments should be close to hand, but not visible. A cloth placed over them previous to the

patient's entry into the room can be easily removed when he or she is becoming unconscious.

As a last but not least important precaution, it is as well for all parties concerned that the bladder and rectum should be emptied before administering the anæsthetic. Micturition occurs more frequently in the female and children than in the adult male, and it should be one of the duties of the maid in attendance to warn lady patients of what may happen when the bladder is full.

The anæsthetist should always be provided with tongue forceps, props, Mason's gag, scalpel, retractors, tracheotomy tube, Eau de Cologne, nitrate of amyl capsules, and hypodermic syringe. The most convenient forms are here illustrated.

MOUTH PROPS.

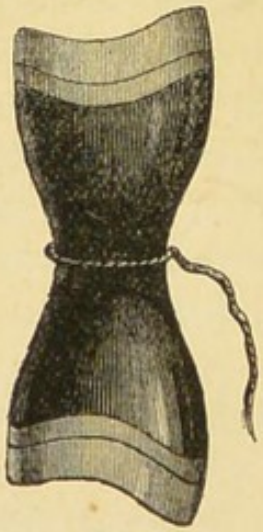


FIG. 1.

The Mouth Prop illustrated in Fig. 1 is about the best kind that can be employed. It was originally brought to our notice by Mr. Pillin, a late house

surgeon at Leicester Square, who kindly made several in vulcanite for us. The essentials in a prop are:

1. That it should be as little in the way as possible.
2. That it should *never slip.*
3. That it should *be easily cleaned.*

It is better to have several sizes than one which will adjust, for the simple reason that the adjusting part, whether it be a screw or a spring, has the *appearance* of being difficult to clean, and *appearance* is very important when a fastidious patient has to hold an object in his or her mouth for some time. It is a comfort to see at a glance that it can be perfectly cleaned in a few seconds. The prop here shown has this advantage to perfection; and the shape is calculated to prevent it from slipping when used at the side of the mouth, because the teeth rest upon the whole surface of the pads, instead of only on one corner.

Two props should always be connected by a strong red silk, to prevent the possibility of the one in use being swallowed. A couple of corks tied together with a V-shaped incision at each end, will form a workable, though very clumsy make-shift; but props made of cork, or any absorbent material, should be destroyed after having been used once, for self-evident reasons, and this constitutes a serious objection to their employment.

It may be added that it is a somewhat dangerous habit to pull away the prop, and operate without. Very bad bites have been known to result from the

practice, in nitrous oxide cases, but the muscular relaxation under ether renders the prop less important.

Mr. Alfred Smith relates two interesting cases which, being very exceptional, demand attention.

The first was the case of a healthy young woman, with apparently strong teeth. Mr. Smith intended to remove a molar on each side of the upper jaw, and the patient, who complained of tenderness in a lateral tooth, begged that the prop might be allowed to rest on the central only. This was done, but as soon as she became unconscious the mouth closed, and forced the central clean out of its socket. The tooth was replaced, but there was nothing to indicate beforehand that it was not firmly implanted, or to raise the suspicions of the surgeon. The other case was one of a canine which stood alone, and such teeth are never supplied with much alveolus; this also was forced from its socket.

The moral to be deduced from these cases is this: first, never place the prop further forward than the bicuspids if it can be helped; but if this is unavoidable, place it between the incisors and select a prop which involves two or more teeth; and, secondly, beware of applying the prop to upper front teeth which project much, for the danger in such cases is considerably increased.

Fig. 2 shows in outline a vulcanite prop with soft india-rubber pads, and the figure to the right of it the size of the pads. It is enormously strong and is considered very useful by Mr. Woodhouse Braine.

Fig. 3 represents a mouth prop designed by Dr. F. W. Hewitt. It is made of steel, nickel-plated, and

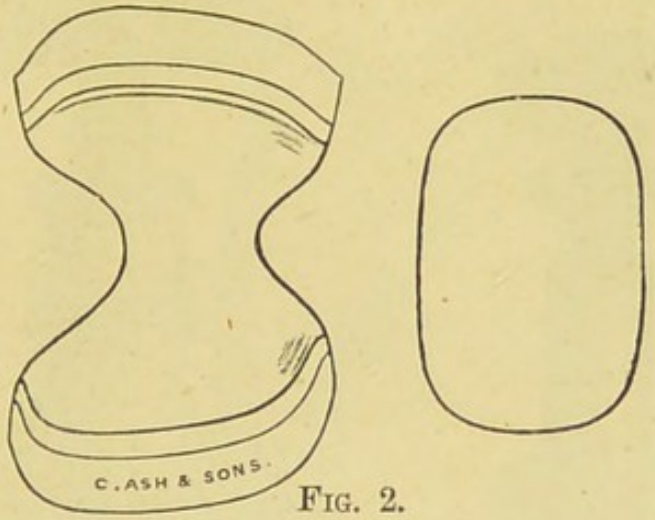


FIG. 2.

furnished with india-rubber pads for the patient to bite on. It is readily applied, and so constructed that

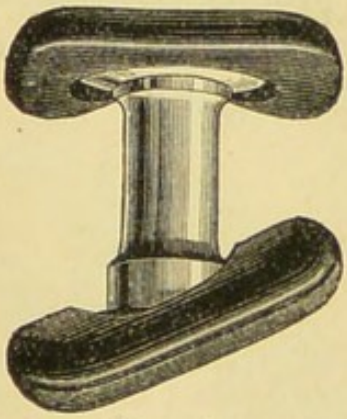


FIG. 3.

it adapts itself to the wedge-shaped space between the teeth which is formed by opening the mouth.

It should be passed back as far as possible, when it will be found that it is held very securely in position. It is very strong and simple in construction, and hence can be used with confidence for patients with powerful jaws.

Figs. 4—8 show various forms of spring mouth-props.

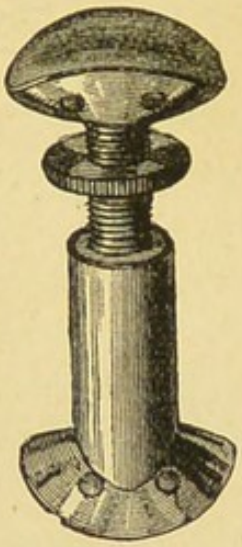


FIG. 4.

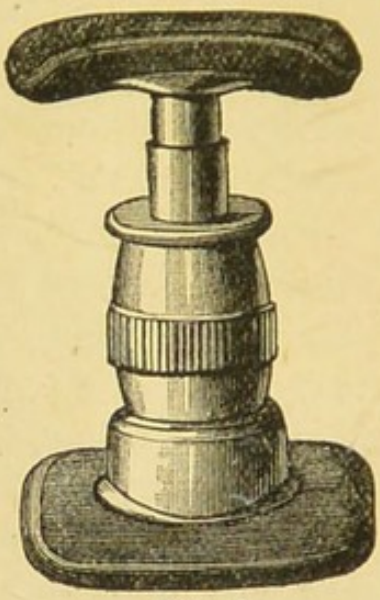


FIG. 5.

Fig. 5 shows a prop specially adapted to toothless gums. It is easy to introduce, as it can be screwed up to the requisite height when in position.

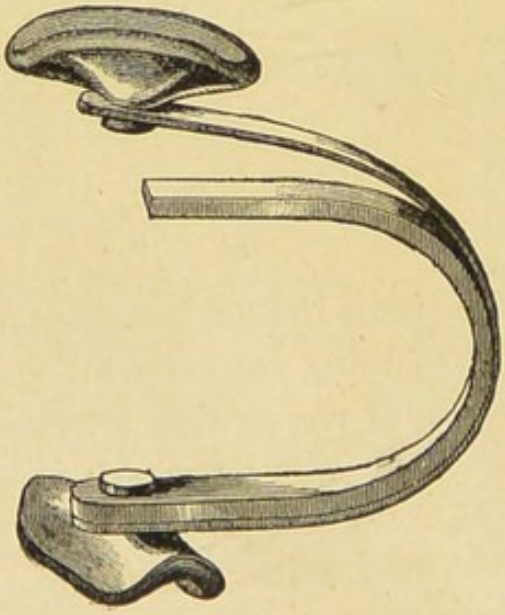


FIG. 6.

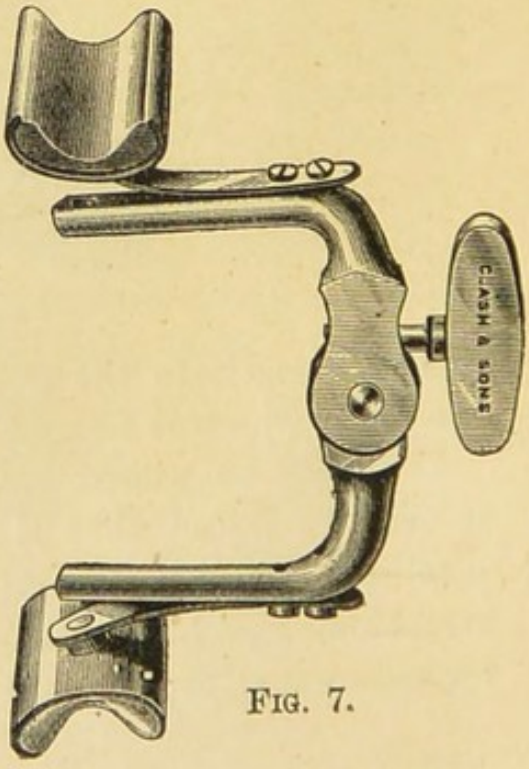


FIG. 7.

ADJUSTABLE PROP.

(MR. F. MASON'S.)

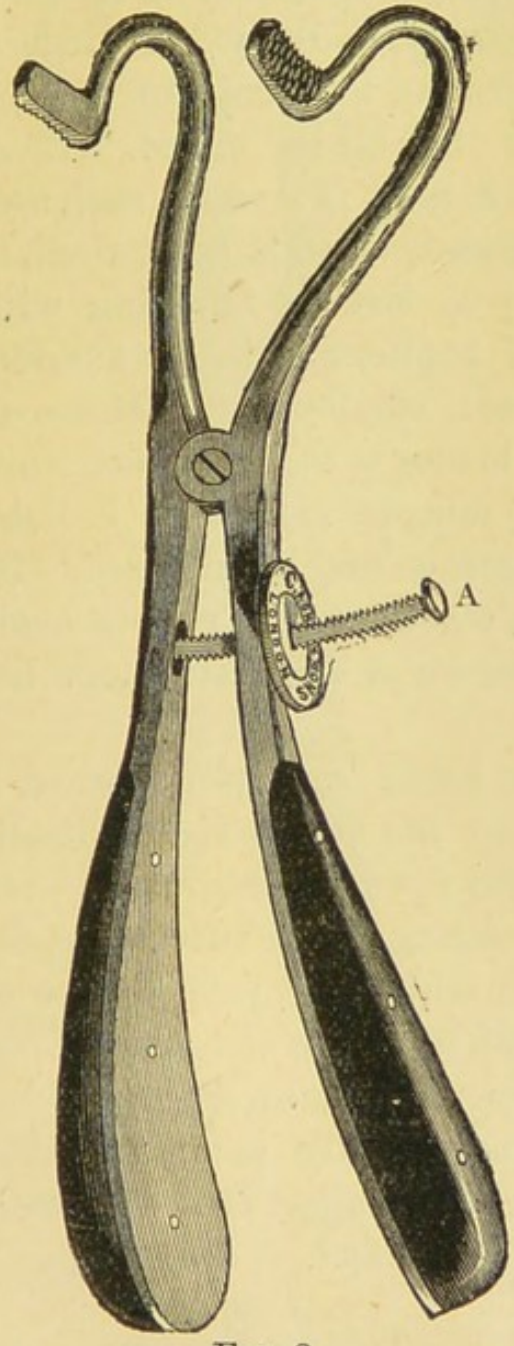


FIG. 8.

This prop (Fig. 8) can be secured at any height by means of the adjusting screw on the moveable

rod A. The beaks are padded with india-rubber, to protect the enamel of the teeth from injury.

It is of great importance that the joint should work very loosely, and that the little screw should be so adjusted as to admit of the handles being opened and the blades closed. If any difficulty arises in working it, it is worse than useless, because, on those occasions when it is required, there is never any time to be lost in fumbling with the screw, quickness of application being absolutely essential to its successful employment. Moreover, any fixing open of the blades is inconvenient, since, should the gag slip, the mucous membrane is liable to be torn before the screw can be released. By discarding the screw altogether this risk is avoided, and the general efficiency of the instrument in dental cases increased.

It will be found very useful when the ordinary prop slips and the mouth spasmodically closes, and also when the operator desires to extract on both sides at one sitting, when success depends upon the rapidity with which the prop can be changed from one side of the mouth to the other.

It is likewise important, when the beaks are shut and the handles fully extended, that the latter should not be so far apart that they cannot be fairly grasped with one hand.

Tongue Forceps.

This is perhaps the best form of tongue forceps that can be employed, because it does not slip, and

is strong enough to do all that is required of it. The sharp serrations on the inner surfaces of the

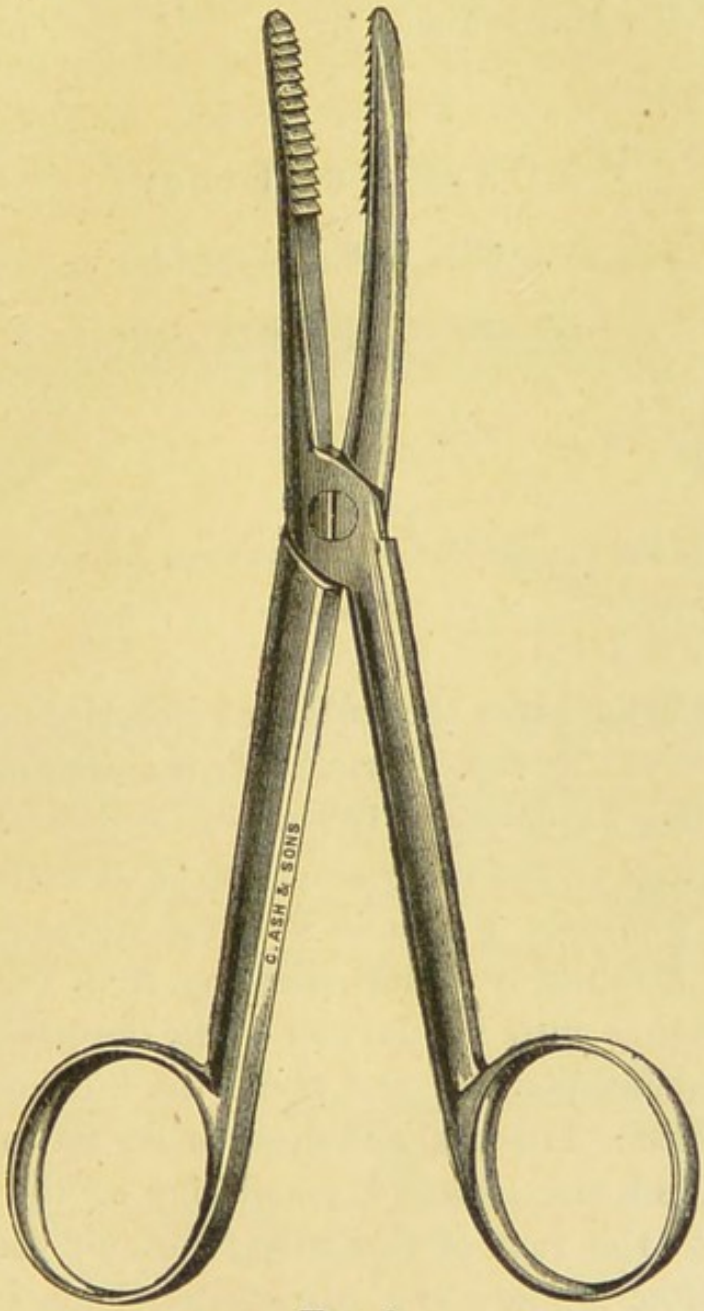


Fig. 9.

blades are of great service in securing the tongue. When closed they form a wedge, tapering to their extremity, and they are then very useful in opening

clenched jaws, as they can be easily insinuated between the teeth, and room thus made for introducing the Mason's gag.

Oral Net Spoon.

(Mr. T. S. Carter's.)

For use during Extractions under Anæsthetics.

Fig. 10.

Mr. Carter gives the following description of this instrument in the *Journal of the British Dental Association* for January 1885 :—

"Owing to the increasing use of anæsthetics for dental purposes a serious danger has arisen, viz., that of a tooth or stump escaping from the forceps and passing into the larynx when the patient is in a recumbent position and under the influence of an anæsthetic. The position favours its falling backwards, and the lessened sensibility of the glottis, added to the rush of the current of air during an inspiration, renders the patient particularly liable to the occurrence of an accident of this kind.

"By the use of this instrument not only may an obvious danger be avoided, but a great source of anxiety is removed from the mind of the operator."

Dr. Dudley Buxton has rendered this spoon much safer by carrying the shank to the end of the bowl (see Fig. 10), thus remedying all tendency to separation of the bowl from its handle, a danger present where the original spoon is much used through loosening of the rivet and solder.

Case of Tracheotomy Instruments.

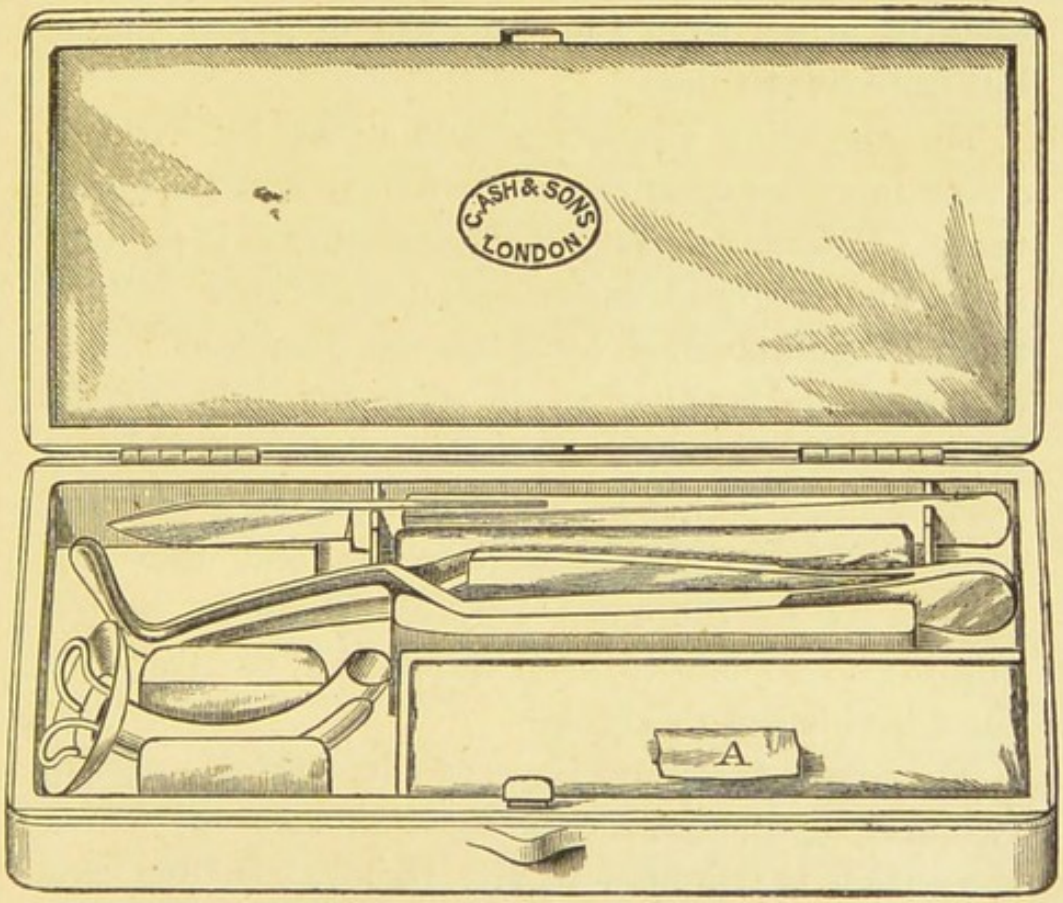


Fig. 11.

Duties of the Operator.

A few points remain to be considered which, while they cannot be said to fall exactly within the scope of

the title of this little book, may without irrelevancy be touched upon in this preliminary chapter.

First and foremost, some advice may be offered concerning the duties of the operating surgeon while the anæsthetic is being administered, the only apology for the apparent impertinence of such advice being, that it is the opinion of more than one leading anæsthetist that much inconvenience frequently arises from the disregard of a few simple but important rules.

The operating surgeon should never by word or action interfere with the administration of the anæsthetic. It is the province of the anæsthetist to produce a safe and thorough anæsthesia; to do this well he must be undisturbed by hints or questions. The operator has nothing to do with the pulse or the heart, or anything—save the operation. Having assured himself that he has room to operate, that the prop is where he desires it to be, and that the patient is in the most suitable position, he has nothing to do but to keep quiet, and be ready for the administrator's signal.

To enforce the importance of this advice, a case or two may be quoted, for the facts of some of which the author is indebted to Mr. Bailey. In one case the gas had to be administered twice, because the nervousness of the surgeon induced him to repeatedly implore the anæsthetist not to give too much, thereby exciting the patient with groundless fears and flurrying the administrator. In another case an injudicious argument between the surgeons suddenly interrupted

the anæsthesia, and awakened the patient, who jumped up, excited by the ether, to *join the discussion.*

In another case the patient was a medical man, for whom a tooth had just been extracted under gas, and who remarked afterwards, that just as he was becoming insensible he was half roused to consciousness by an incautious remark that had been made, and consequently the anæsthesia was considerably delayed. On one occasion at the Dental Hospital the extractor asked the question, "Are you ready?" when the patient was only half under the influence, and the result was a terrific struggle on his part. He was a powerful man addicted to alcohol. The excitement lasted several minutes, and if he had succeeded in freeing himself, someone might have been injured.

Anæsthetists of experience have pointed out that there is no greater mistake than to fasten a patient to the chair, or to clutch at him unnecessarily; either is sure to provoke struggling. Mr. Bailey prefers not to restrain even swinging of the arms and legs, provided there is no risk of injury to the patient or bystanders. Such movements usually subside of themselves, but if they do not, it is better to tell the patient gently to keep still than to use any force.

In arranging the attitude of the patient, it is well to remember that the head should be as nearly as possible in a straight line with the axis of the body, neither bent backwards nor forwards. This is essential to free breathing, a fact very easy to demonstrate

by sitting in a chair and assuming the various attitudes, and observing the comparative facility or difficulty of breathing. In this connection it is well to point out another mistake, frequently made by operators who use hawks-bill instruments for lower molars, namely, that of pushing the tongue backwards with the left hand, and thereby often shutting off the respiratory tract altogether; in the eagerness of extraction, the danger of pushing the tongue too far back is often forgotten. This error should be carefully avoided, for the results may be very unpleasant should the operation be protracted by any misadventure.

At the same time it is of course very right to interpose a finger to avoid the tongue being wounded by the forceps, because such an accident is always distressing to the patient after the operation.

Many operators confess to a certain scepticism with regard to the usefulness, in practice, of spoons for protecting the tongue or the larynx. The ingenuity of their construction is unquestionable; but the presence of a prop and a spoon in the mouth leave but little room for the operator. Moreover, there is a certain loss of time attending the application of such apparatus; perhaps, however, the question resolves itself into this: different operators will incline to different methods to protect their patients, and the personal skill of each will render his method the best *in his own hands.*

Very careful inquiries on the question of idiosyncrasy, undertaken in order to discover, if possible,

what ground there is for asserting that certain individuals are readily susceptible to the influence of nitrous oxide gas, while others are the reverse, have resulted in the satisfactory conclusion that there is practically no such thing as idiosyncrasy.

Dr. Snow did not attach any importance to the question.

There are isolated cases from time to time in which patients are an inexplicably long time in becoming insensible; but the longest time in Mr. Bailey's experience is two minutes twenty seconds, while Mr. Bird does not recollect any case of a patient remaining conscious more than one minute, unless by chance or design air has been mixed with the gas.

The time usually required to produce anæsthesia with pure nitrous oxide is not inconvenient to anyone; but the same cannot be said of any given mixture of gas and air, and this, as suggested by Mr. Bird, possibly forms one of the chief obstacles to M. Bert's method.

CHAPTER III.

Nitrous Oxide Gas.

For short operations, including almost all that fall within the sphere of dental practice, nitrous oxide gas is the best anæsthetic at present known to the profession. The after-effects are usually so slight that they are scarcely worth considering. The administration is attended with hardly any appreciable discomfort to the patient, excepting in some rare cases. Lastly, the risk to life is so small, that it may safely be said that supposing a cardiac condition existed that rendered nitrous oxide gas a dangerous agent, in such a case any operation, even the extraction of a tooth *without an anæsthetic*, would be attended with still greater danger. To put the case in other words, every short operation becomes less dangerous to life when performed under gas than when the anæsthetic is not employed.

Dr. Snow said that every case for operation was a case for an anæsthetic, and no doubt he was not far wide of the mark. Of course, *if* a condition existed in which to sit down on a chair a few inches lower or higher than was expected would cause death from shock, such a patient might die under

the gas, but it must be remembered that, in a case of this kind, the extraction of a tooth without gas would as certainly cause death. The gas administered with ordinary care by some one whose entire and undivided attention is devoted to its administration, renders less, and *not* greater, the risk to life, if any such risk be supposed to attend the extraction of a tooth. No one seriously dreads any danger to life from such an extraction, yet a more acute shock cannot well be conceived. There are many conditions of the heart which render a shock of any sort exceedingly dangerous—serious, yet unsuspected conditions, in which the heart, although doing its utmost, is overtaxed; as for example, when disease has enfeebled its powers, when its walls, that should be muscular, are mostly fatty, or when its valves do not act properly. Under such conditions a man is living on sufferance, for the slightest increase in his heart's beat, or the slightest extra pressure, may force the already enfeebled organ to make its last desperate effort to meet the strain, when it fails and death ensues. I have known cases in which the effort of getting out of bed has been fatal to the already overburdened heart; in such cases the extraction of a tooth would very likely be followed by instant death, but the risk of death would be diminished by the administration of nitrous oxide gas.

The first time chloroform was proposed to be administered at Edinburgh, Mr. Simpson had arranged to give it on a certain day. He was, however, unavoidably prevented from attending; the operation

was proceeded with without the anæsthetic, and at the first incision the patient died. Chloroform might have saved this patient from the fatal shock, but it certainly could not have added any risk to the operation, although had it been given and had death ensued, the anæsthetic would no doubt have received all the blame.

The number of lives that have been saved by means of anæsthetics, from an almost certain death from shock, is probably very great, while of the deaths that have occurred during artificial anæsthesia, it is not too much to say that several of them would have been certain to have occurred had the anæsthetic not been used; that they occurred *in spite* of its use, and not in consequence of it.

It is to be observed that this statement applies only when the anæsthetic is *properly administered.* The precautions necessary to its safe administration are very few, but they are all essential, and if any of them be disregarded, the element of risk to life is introduced, and the security of the patient is no longer assured. Some of these essential precautions are repeatedly omitted; happily, untoward results of carelessness or ignorance have been very rare, but a risk altogether unnecessary has been run in every such case; the patient has, in happy unconsciousness, been dangerously near death, while the operator has stood with only an accident between him and a very painful event, and chance has kindly stepped in to the rescue.

It is the exact nature of these few precautions

that must be laid clearly before the reader, and this is the main object of this book; but before doing so, it will be well to briefly consider the apparatus and method of administration most in favour among experts at the present day.

Apparatus.—The gas itself is compressed into the liquid state in iron bottles of various sizes; the most convenient are the five-and-twenty, the fifty, and the one hundred gallon size. Two five-and-twenty gallon bottles coupled together are quite sufficient to carry in a hand-bag, together with the remaining apparatus. It is always well to have two bottles in the bag, as one bottle cannot be relied upon; an accident may happen with the turnscrew, and either no gas can be turned on, or the administrator, having turned it on, cannot turn it off again; or, after the one administration, it may be put away in the bag with the tap not quite screwed down, then there is a slight leak, and this would very soon empty the bottle. With two bottles the anæsthetist always feels safe, having one full bottle in reserve.

In dental institutions, where there are many cases following one another, the gas is usually kept in gasometers, which are filled from the bottle.

There are several modifications in the inhaling apparatus; there is almost always a Cattlin bag of about three gallons capacity, communicating with a facepiece. The bag is in communication with the reservoir, bottle, or gasometer, by means of an india-rubber tube.

When the numerous facepieces are examined, it

is found that they can be grouped into two classes: (1) those with an expiratory valve only; (2) those with both expiratory and inspiratory valves. The space at command in this little volume will not permit of more than one typical form out of the many in each class being described.

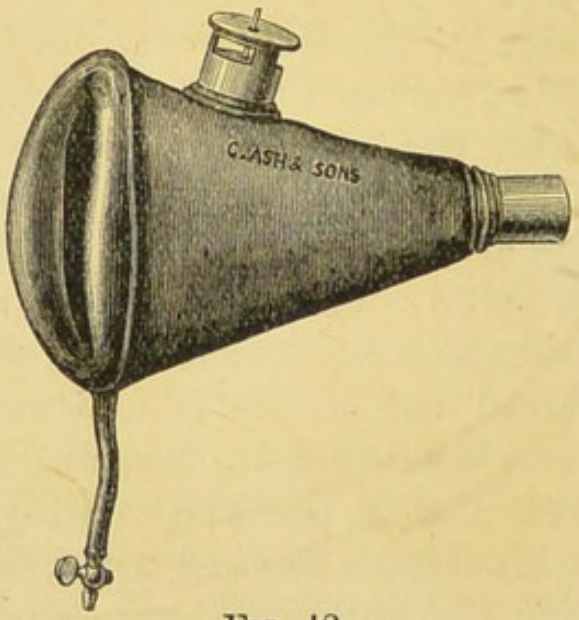


FIG. 12.

Fig. 12 is an illustration of an apparatus containing no inspiratory valve. It consists of the usual Cattlin bag, with a two-way stopcock, on to which is fitted a Clover's facepiece, containing the expiratory valve in its side. The apparatus is so exceedingly simple, and yet so efficient, that it fully meets the requirements of everyday practice.

The Administration.—All air is first squeezed out of the bag, and the stopcock turned back. The bag is then filled with nitrous oxide, and the facepiece applied to the patient's face. He is allowed to

breathe air through the opening in the stopcock for a few respirations, and then, at the end of an expiration, the gas is turned on and the airway cut off by one and the same movement of the stopcock.

The bag is kept distended with nitrous oxide throughout, so that during expiration the valve in the facepiece is brought into action. Should the supply of gas run short it can be converted into a supplemental bag at any moment by merely placing the finger on the expiratory valve.

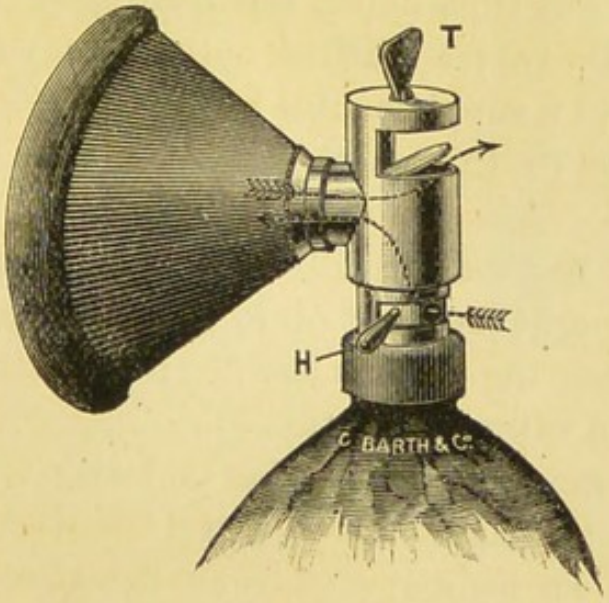


FIG. 13.

Fig. 13 is an illustration of Dr. Hewitt's apparatus, containing both inspiratory and expiratory valves. The facepiece contains no valves. The expiratory valve can be seen in the figure in action; the inspiratory valve is situated more or less vertical in the chamber between the expiratory valve and the

stopcock H, and can only be seen from the front of the facepiece.

The Administration.—All air is forced out of the bag, and the handle H placed in the position seen in the figure. The bag is filled with nitrous oxide. The facepiece is then applied; air then enters and leaves the apparatus as indicated by the arrows. At the end of an expiration the stopcock H is pushed over to the left, and gas is breathed instead of air, and expired through the upper valve. In case the supply of gas runs short, the turning of the tap T throws all valves out of action, converting the Cattlin into a supplemental bag.

The bag in this method need not be kept full of gas.

In both methods it will be noticed that the gas bag is brought as near up to the facepiece as possible, so that the patient has not to draw the gas up through an intervening tube.

A few words remain to be said about the use of supplemental bags. The illustration given (Fig. 14) is that of an ordinary Clover's facepiece, with inspiratory (B) and expiratory (A) valves, and a supplemental bag (G) attached.

Administration.—Gas is inhaled by turning the stopcock C, and expired through the valve A. When the patient has taken seven or eight respirations of gas, the tap (E) is turned, and the forefinger placed upon the expiratory valve (A) to prevent its working, the result being that the patient breathes backwards and forwards into the supple-

mental bag (G), alternately emptying and distending it. By releasing the valve at A occasionally, and at the same time applying hand pressure upon the supplemental bag in order to

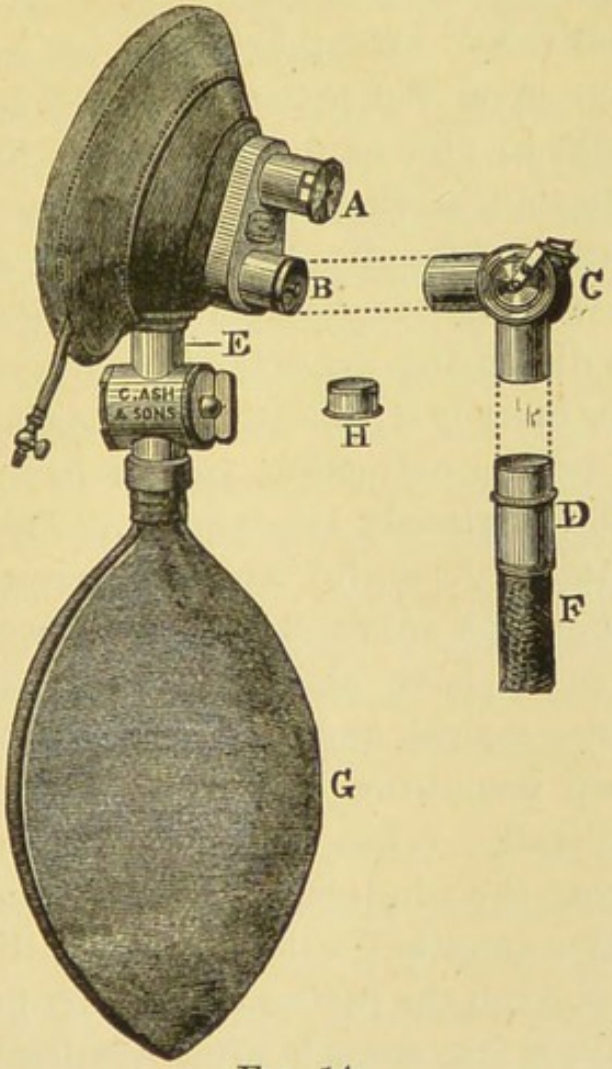


FIG. 14.

empty it, fresh gas can be inhaled through the inspiratory valve (B).

It is stated by some that a longer anæsthesia can be obtained by the use of a supplemental bag. It undoubtedly economises the gas, but it takes longer

to produce anæsthesia, causes more blueness of the countenance than does pure nitrous oxide, and is more apt to be followed by headache, &c.

The person who administers the gas should have nothing else to do during the operation.

His undivided attention must be concentrated throughout upon the patient's condition. No one should talk to him or disturb him. Never under any circumstances should the operator administer the anæsthetic himself; the danger of such a proceeding cannot be exaggerated. A patient has been known to die during the extraction of a tooth *without the operator knowing it;* his attention has been entirely absorbed by the extraction, and he has not noticed that death has already taken place. This reflection becomes terribly painful when we remember that, had a competent administrator been watching the case, he would have stopped the operation, pulled forward the tongue, and forced the patient to take a full deep inspiration, and all would, most likely, have been well. When accidents, dangerous to life, occur during the administration of nitrous oxide gas, or any other anæsthetic, the forcible pulling forward of the tongue and the performance of artificial respiration within a few seconds after unmistakable signs of something unusual in the breathing have appeared, will in almost every case remove the difficulty; but should the only person present be occupied with the tooth, an obstruction to respiration may occur which may easily result in death if not promptly relieved. It is, therefore, a rule never to be broken, that one

person should administer the gas and another extract the tooth, and any one who attempts to perform both operations himself is not only without sufficient excuse, but greatly to blame, should an accident occur.

The administrator should watch with unremitting vigilance the patient's breathing.

He should never trust to the pulse as a source of warning to him of possible danger. The results of innumerable experiments, carefully conducted by various committees and private individuals, point to one all-important fact, namely, that if nitrous oxide gas be administered sufficiently to produce death, respiration ceases many seconds before the heart's action; moreover, that immediately after the cessation of breathing, artificial respiration is generally successful. If, therefore, the pulse only is relied on, the first warning of danger may be the death of the patient, for, unless steps are taken to restore life *before* the pulse has ceased, they will most likely be taken too late.

It is, of course, necessary that the administrator should be familiar both with the phenomena attending normal anæsthesia and with those appearances which are not normal and give cause for uneasiness.

The normal phenomena vary somewhat, but the following description may be taken as more or less typical.

After some nine or ten full respirations the face becomes pale or bluish, and then assumes a slightly darker tint, the fingers often twitch (subsultus tendinum), the conjunctiva may be touched without

any responsive closure of the lids. The last two or three inspirations are accompanied by stertor, not the palatine stertor of the habitual snorer, which in subjects inclined to snoring continues throughout the administration, but the true laryngeal stertor, described by Lister. It is a mixture of choking, gulping and mucous rattling, and exactly resembles the breathing of a person after prolonged immersion under water. This stertor is not always present, but it is so in a very large proportion of cases; it is a very reliable sign that anæsthesia is complete. The facepiece is now removed and the gulping breathing continues, the lips look bluish, the eyes roll, and in a few cases protrude slightly. The respiration then becomes more quiet, the stertor disappears, the natural colour returns, and with it consciousness. This change of colour is sometimes entirely absent, and patients have been known to become completely insensible without any of the bluish tint here spoken of.

There are little trifling peculiarities in almost every case which are not worth attending to, but the above description is fairly generic. The appearances when seen for the first time are very alarming, but they vanish as quickly as they appear, and leave behind them no after-effects such as sickness or headache, while the anæsthesia is amply long enough for dental purposes, except in a few rare cases, when a little ether may be required to prolong it.

We will now examine the anatomical and physiological details of the above phenomena.

The lividity or blueness is not due to venous congestion, but to the blood not being sufficiently oxygenated. The eye-lid does not close when the conjunctiva is touched; this means that reflex action generally is paralysed. It has nothing to do with the patient's power of sensation, which is paralysed at an earlier stage. The patient is not conscious of the touch of the finger, when he winks his eye-lid, but his reflex nervous apparatus being still awake, the stimulus produces the usual reaction. If we were conscious in a higher sense the lid would close before the conjunctiva was touched; and, therefore, there is no danger of unconscious struggling.

The laryngeal stertor is caused by the vibration of the arytæno-epiglottidean folds of mucous membrane, which approach each other and the base of the epiglottis, gradually diminishing the respiratory aperture at this point. The common stertor of snoring is caused by the flapping of the velum palati, and has no signification whatever, but is apt to deceive an inexperienced administrator.

This approximation of the arytæno-epiglottidean folds will, if the anæsthetic be pushed, end in complete obstruction of the air passage, and it is of vital importance that the nature of this obstruction should be thoroughly understood, and that it should not be confused with a blocking up of the upper part of the passage by the falling back of the tongue or the folding back of the epiglottis. It is important to lay stress upon the exact difference between these obstructions, because the life of the patient depends

upon the administrator knowing exactly what to do should such an accident take place, as it will sometimes *without the premonitory stertor.*

The obstruction caused by the falling back of the tongue, and consequent application of the epiglottis to the upper aperture, will be relieved by pulling forward the tongue till the tip protrudes between the teeth; but the obstruction which is due to the approximation of the arytæno-epiglottidean folds is not affected directly by the position of the tongue, for it, as well as the stertor due to the vibration of the folds, may be produced when the tongue is out as far as it will go. If, however, when the tongue is already as far forward as it will go, it be forcibly pulled against the teeth—although the hyoid bone and the epiglottis do not move, having already moved as far as they can — a reflex action, operating through the nervous system, the nature of which, whether inducing muscular relaxation or contraction, is not exactly understood, and does not much matter at present, causes the folds to recede, and allows free passage for the air. It does so by virtue of a stimulus, received by the nervous system, when the tongue is dragged against the teeth to a degree which, if no anæsthetic had been administered, would have caused pain.

When the impediment to respiration, caused by the mutual approach of these membranous folds, passes into complete obstruction, the respiratory heavings of the chest do not necessarily cease, but rather become more jerky and irregular. This is

a source of danger to the unwary in a double manner—1st, because the movements of the chest-wall may delude the administrator into supposing that respiration is continuing. A case is reported by Lister in which the anæsthetist quite overlooked a total obstruction of the larynx, being misled by the heaving of the chest-wall into the supposition that respiration was continuing.* 2ndly, Because a strong respiratory effort, either of inspiration or expiration when the air-passage is obstructed, has a tendency to stop the heart's action,† and this tendency is increased by the fact that the heart's action is slightly enfeebled at this point of the administration. It is of the highest importance, therefore, to assure oneself that breathing is really going on, and should it stop, to discontinue the gas and make forcible traction upon the tongue with a pair of forceps (the slight puncture made by the forceps will probably assist the reflex stimulus).

The next precaution is one of less urgency, and yet of some moment, insomuch as it can be shown that in certain cases a disregard of it has led to fatal results; moreover, it is quite possible that some unexplained deaths under anæsthetics may have been due to negligence in this particular. It is *never to operate upon a patient when only partially anæsthetised;* neither begin before full anæsthesia has been reached, nor go on after the effects have begun to fade. We are indebted to Dr. Lauder

* Holmes, Syst., ed. 3rd. vol. iii. p. 606.

† Huxley explains this in his 'Elements of Physiology.'

Brunton for the physiology of the fact that during incomplete anæsthesia a very slight shock may arrest the heart's action, even if its beat be normal, strong, and its structure perfectly sound, for the following reasons:—

The heart's beat is accelerated by the vasomotor nerves and inhibited by the vagus, the stimulus of a shock to the fifth nerve (as in drawing a tooth), affecting both vagus and vasomotor centres at once and equally when the nervous system is in working order, produces no effect on the beat, because one influence counter-balances the other. When an anæsthetic is administered, however, the vasomotor centre is paralysed before the vagus centre; thus for a short time the inhibitory nerve alone is active and a shock to the fifth would simply produce extreme depression or stoppage of the heart's action. When, however, the anæsthesia is thorough, the reflex sensibility of both centres is abolished, and therefore, no such effect is to be apprehended. The venous condition of the blood, in nitrous oxide anæsthesia, by stimulating the vasomotor nerve, reduces this danger considerably.

But, apart from the subject of danger to life, it is in every sense an unwise proceeding to continue a painful operation during returning consciousness, for it destroys the confidence of the patient in the anæsthetic, and over and over again has the gas been blamed and discredited when the entire fault lay with the excessive zeal of the operator, who, fired by an ambition to do a great deal at one

sitting, has persisted too long and inflicted some well-remembered twinges at the finish, besides running the risk above alluded to.

To summarise the preceding remarks: If the administrator have his whole and undivided attention devoted to the breathing of the patient—and should the breathing stop, take away the facepiece, forcibly pull outwards the tongue with a pair of forceps, and, if necessary, perform artificial respiration—and if the operation be performed during full and perfect anæsthesia, there is no danger whatever in administering nitrous oxide gas for a brief operation such as the extraction of a tooth.

Minor Precautions.

During the administration of nitrous oxide gas there are many points of practical importance to the comfort of the operator and patient which should be observed.

Silence. It is a curious fact recently pointed out by Mr. Braine, that, at a particular time during the administration of the gas, the sense of hearing becomes morbidly acute; the ticking of a watch which is only just audible before the gas is inhaled becomes very distinct and loud during the inhalation the slightest whisper is heard and remembered by the patient while the sense of pain is deadened, and he or she will often repeat afterwards remarks made before the extraction of the last tooth, although insensible to the pain of the tooth itself. This morbid acuteness of hearing may easily explain the

excitement which sometimes attends the earlier inhalation and recovery. There is never any struggling during deep anæsthesia; there is occasionally opisthotonos, which of course is not to be confounded with struggling, although equally inconvenient. When there is struggling, noisy talking, and threatening gestures, it is usually during recovery, and in a very large percentage of cases it occurs in persons addicted to alcohol. "In patients with red faces and dilated capillaries, struggling may be looked for; but that it does not simply depend on the presence of the alcohol is proved by the fact that nitrous oxide gas has been given to partially intoxicated people, without producing the least excitement." *

Undue restraint should be avoided, because it may in itself produce struggling, but it is advisable to be on the alert, and ready to restrain the patient should it become really necessary.

It is, therefore, a wise rule to observe absolute silence, remembering that the patient just before he becomes insensible, instead of getting deafer, is more acutely sensitive to sounds of all sorts; especially is it a foolish thing to talk about either the patient or the operation. Many patients have a dread that the surgeon will begin to operate before they are quite under the influence of the gas, and that they will feel something. Their recollection perhaps of some previous occasion, when the inexperience or timidity of the administrator led him

* Braine, *loc. cit.*

to give an insufficient dose, "and they felt something, and heard everything, but couldn't move" (as they often say); or, perhaps, the account rather coloured and enriched by the imagination of a gossiping friend of some such occurrence, has rendered them apprehensive on this score; in such cases should the clink of an instrument, an observation as to the state of the patient, the difficulties of the case, the mode of operating, or anything of the sort be incautiously allowed, the patient will, in all probability, be terrified half-back to consciousness, will struggle and gesticulate, and afterwards will always imagine the pain to have been felt whatever may be said to the contrary. Indeed, such imaginary troubles have even reached the amusing pitch of a patient declaring that *she felt the pain and saw the tooth extracted*, on an occasion when in reality a sudden slipping of the prop and closure of the mouth had prevented the operator doing anything. Absolute silence should, therefore, be kept in the room until the administrator indicates to the operator that he is about to remove the facepiece. This indication should always be given a second or so beforehand, in order that no time may be wasted.

The removal of artificial teeth, or of anything else that might be swallowed, such as a pivoted tooth, &c. Even such a strange body as a quid of tobacco has from constant habit been entirely overlooked and retained in the mouth. The danger of allowing such a thing to remain is sufficiently obvious, but the accident is unlikely in dental practice, since

the operator is presumably already aware of the presence of any such object. The only point to be observed in this connection is always to *look in the mouth yourself.*

Without regard to previous diet, it is not a matter of much importance when nitrous oxide is used, and will be more fully discussed under the head of chloroform. It is sufficient at present to say that the stomach should not be full, that the patient should not be faint through want, and that stimulants beforehand should be forbidden.

To fulfil these conditions is easy if the time for the operation be wisely chosen, but this often cannot be done in dental practice, and for such brief anæsthesia it really does not matter, but there is no doubt that the after-comfort of the patient would be consulted by observing, when possible, the following rule : to administer the gas at a time when the stomach would be empty in the natural course of events, not to omit a meal, which omission would produce an unaccustomed condition of want not at all desirable, but to choose such a time as before breakfast, or three hours and a-half after. It is not wise to interfere with old habits of food-taking. If a light lunch be taken at 1, 3.30 or 4 o'clock would be a convenient time for the anæsthetic ; but there is no doubt that before breakfast is the most suitable part of the day for the administration of chloroform or ether.

It is better to avoid any admixture of air with the gas during the inhalation, not because the admixture

produces excitement, but because the air weakens the effect of the gas, and may even nullify it altogether. (Mr. Braine has often demonstrated this point by intentionally giving them mixed or alternately, without producing the least excitement.) If the facepiece be a good one, with a perfect air cushion, there is no likelihood of much air entering with the gas, unless the patient wears a beard, in which case the beard should be wetted or rubbed with soap.

It is undoubtedly an advantage to make the patient take a few deep breaths in order that he may understand what deep regular breathing means, and that nothing unusual is required of him. Without some such preliminary instructions, nervous and excitable patients will often occasion a great deal of needless discomfort to themselves and to those assisting by breathing peculiarly; some will puff and blow very fast and excite themselves, others will hold their breath and experience a very unpleasant sense of suffocation, and this generally leads to desperate struggles to get away the facepiece, during which the jerking or shifting of the position of the patient's head renders it impossible to avoid the admixture of air with the gas, and consequent waste of time in producing anæsthesia. It is as well in such cases to allow them to breathe pure air through the inhaler for a few inspirations.

The dress should never be allowed to be tight enough to interfere in the least degree with full and easy breathing.

Some patients complain of unpleasant after-effects from taking gas through an inhaler which has been previously used for ether; to obviate this, a special inhaler should be used when gas alone is required.

Perfect silence should be observed during the recovery from anæsthesia, in order that the patient should neither become excited, nor remember anything about the operation afterwards. It is a most valuable rule to promote the credit of the anæsthetic by not rousing the patient hastily; after the extraction he should be absolutely undisturbed for thirty seconds at least, especially if he has struggled during the operation; the prop need not be removed, nor the patient's head touched, nor a word said. The last few seconds are exactly the time when all the dreams and sensations afterwards described take place. Patients have often struggled and attempted to seize the operator's hand at the end of the extraction, and yet after a few seconds' absolute, undisturbed silence, have come to themselves, remembering nothing; had they been rapidly restored to consciousness they would in all probability have remembered a sense of struggling and restraint, together with the fanciful additions of a half-dreaming state.

We now come to the discussion of the various morbid states which have been supposed to render the administration of gas unadvisable.

This part of the subject may be dealt with by the single general statement that for all minor operations, not lasting more than two or three minutes, it is

almost always better to give the gas, no matter what the condition of the patient; in fact, there are very few states of health or disease which contra-indicate its employment.

Notwithstanding the fact that this general statement covers the case, it will be more satisfactory to refer in detail to a few complications that have been supposed to exercise a baneful influence, and even to contra-indicate the exhibition of an anæsthetic.

Heart disease is no drawback to the administration of nitrous oxide. Very fatty weak hearts have been supposed to expose the patients to some risk, but there has never been a fatal case traceable to this cause; moreover, as this condition is not diagnosable during life, it is futile to consider it. Organic disease does not involve any additional risk whatever to the patient.

Pregnancy. Gas may be given with perfect safety up to the end of the eighth month, but beyond that term it would be advisable to postpone operative measures until after delivery. Under special circumstances, however, it has been successfully administered a few days previous to delivery. Gas is eliminated so quickly from the blood that it probably has no effect on the child. Should the mother struggle she must not be held, and if she cannot be calmed the administration had better be stopped.

Lactation. This function is not affected by the gas, but is liable to be interfered with if such a shock as tooth extraction be endured without it. Mr. Braine relates two cases bearing on this contingency.

"I may here mention the case of two patients who were suckling, and in whom the shock from the extraction of a tooth without the gas, stopped the secretion of milk; subsequently, having to undergo a similar operation under like circumstances, they determined to take the gas, and in neither instance did any derangement of the function of lactation occur."

Menstruation does not interfere in any way with the satisfactory results, and is no reason for postponing the operation.

Erotic sensations are more apt to occur at this period, and for this reason alone, if for no other, the presence of a female attendant in the room is always an advantage.

Aneurism is a condition in which all struggling should be avoided, and the same may be said of *hernia;* that is to say, any symptom of struggling should not be restrained. It would be better to let the patient push away the facepiece and talk than to restrain him by force; it is generally easy to reassure him and begin again.

Kidney complications have no significance in the administration of nitrous oxide.

Apoplectic patients, people with short thick necks and of full-blooded habits, demand a little care. Their necks should be perfectly free from all constriction, and the head should be rather inclined backwards than forwards; if the chin be bent down towards the chest there is a danger of compressing the veins of the neck and preventing the free return

of blood from the head. In such cases again violent struggling involves some risk.

In *phthisical* cases, where the disease is extensive, there is a peculiar source of danger to the unwary administrator. Mr. Braine has pointed out that "The anæsthesia deepens after the removal of the facepiece," so that in such cases less gas must be given, and full insensibility must not be reached.

Chorea, *hemiplegia*, and *epilepsy*. "Children with chorea and people who have had hemiplegia take gas well."

"It is perfectly safe to administer this agent to epileptic patients. I have met with several cases where the extraction of a tooth, without gas, has produced an epileptic attack, but I have never seen one occur when gas has been given. A little time ago I accompanied a surgeon to a case of circumcision, on a boy about $2\frac{1}{2}$ years old. On entering the room, I found the patient lying on the floor, in a very severe epileptic fit. In a short time he became partially awake, and not seeing any good reason for waiting, I anæsthetised him there and then; and, after the operation, he recovered in the usual way."

"*Great age* of the patient is no bar to the administration of nitrous oxide—my oldest patient, a lady, having reached the age of ninety-four. An exception must be made in the case of habitual drunkards, when an atheromatous condition of the vessels may render struggling dangerous, while

the very fact of the alcoholism predisposes to struggling." *

Hysteria.—The dental practitioner when operating with an anæsthetic is not unfrequently puzzled by phenomena that are due to hysteria. Snow mentions a few cases of prolonged inability or disinclination to rouse. Some years ago a girl gave some anxiety to the house surgeon at the Dental Hospital by remaining in a lethargic state, until the late Mr. Clover suggested that it was owing to her having taken too much brandy that morning, when she at once jumped up and indignantly denied the charge, to the amusement and relief of the bystanders.

On one occasion a youth of about eighteen, apparently a foreigner, to whom Mr. Bird had given gas, displayed very curious symptoms of hysteria. He partly recovered from the anæsthetic, and then suddenly had a kind of spurious fit, during which he struggled so violently that three assistants had some trouble to prevent him hurting himself. He half recovered and cried, and said he could not help it, and again relapsed into a fit; this occurred three or four times in succession.

The most common freak of hysterical patients is to pretend that they cannot rouse themselves, and this may well alarm a young practitioner; he may, however, rest assured, if the breathing is regular, that there is no kind of danger, seeing that a minute or two suffices to get rid of every trace of nitrous oxide from the system. This condition may always

* Braine, *Journal of British Dental Association*, Dec. 1884.

be diagnosed by the presence of tremor of the eyelids.

Anæmia.—In patients suffering from anæmia anæsthesia is produced very rapidly, jactitation becomes very marked, and the pupils dilate to an alarming extent. Very little gas having been inhaled, it leaves the blood with great rapidity, and hence the available anæsthesia is short. Such patients require a little air with the gas towards the end of the administration, in order to prolong the inhalation; the movements are not so violent, and the anæsthesia is lengthened.

Asthma.— Patients, the subjects of asthmatic attacks, have been met with who are much distressed upon the application of the facepiece, and who, after taking a few inspirations of gas, cease breathing for what seems to the administrator an alarming period; they necessarily become more or less cyanosed; as long as the conjunctival reflex is present, there is no danger, and the facepiece should not be removed. Very soon the spasm of the bronchial muscles is relaxed, and the respirations become very deep and rapid. It would appear that these patients suffer all the distressing sensations of an attack of asthma early in the administration, and that so soon as the gas which is held in the lung begins to exert its specific action this is relieved.

Accidents which may arise during Anæsthesia, and their Treatment.

Vomiting during the administration is very rarely met with; it may, however, occur in an extremely

nervous patient when gas has been given soon after a meal, or when the stomach is distended with flatus. There is great danger that some of the vomited matter may be drawn into the larynx, and therefore it is of the greatest importance to recognise the state of matters at once. The vomit is, as a rule, fluid, and occurs quietly, with very little or no retching. *Treatment.*— The administration must be at once stopped, and the patient's body be bent forward, with the head slightly down, and the finger passed rapidly round the mouth, to clear it of any solid material.

Teeth, etc., free in the mouth.—Teeth very frequently slip out of the grip of the forceps, especially bicuspids, and are liable to travel backwards into the pharynx, unless special precautions be taken to prevent them. For this purpose, netted spoons, etc., are used; they are passed to the back of the mouth, and fill up the space between the tongue, the roof of the mouth, and the pillars of the fauces. They are cumbrous to introduce, and valuable time is lost in getting them into position. One or two fingers passed diagonally across the mouth and behind the bicuspids will prevent all bicuspids or incisors getting past them, and have the advantage of being able to localise the position of any tooth that has touched them; of course, in this case, the prop must be well back between the molars. Some operators, when they wish to extract the upper incisors, prefer placing a napkin behind these teeth by loosely pushing it into the mouth; it is certainly a very efficient method, and no teeth can pass it when

properly in position. The anæsthetist should see that there is a free air-way on one side. One of the blades of the instrument may fracture during the extraction, and thus become very dangerous. In one case the fragment of the instrument travelled with such great speed across the room, that had it gone backwards instead of forwards it would probably have become impacted in the soft parts of the pharynx. Wooden props may break in two, or split longitudinally. Teeth which are cut off with cutting forceps are also very likely to travel backwards. Of the teeth which are lost during extraction, *i.e.*, those which are extracted from the maxilla, but which are not brought out of the oral orifice, and cannot be found afterwards, by far the majority, fortunately for the patient, are swallowed. They pass through the isthmus of the fauces, probably strike the back of the pharynx, drop into the æsophagus, and are rarely heard of; but it is possible for a tooth to enter the larynx should the patient take a deep inspiration at the moment the tooth is passing over the epiglottis; it might then be drawn in with the current of air as the aperture of the larynx is open and unprotected by the epiglottis.

Treatment.—When there is a tooth free in the mouth, at once stop the operator, bend the patient's body forward and force down the head, then sweep the finger around the mouth and remove the tooth. Should no tooth be found, keep the patient in this position until total recovery, and the probability is that he will spit it out. Never allow a young operator

(for it is only beginners who attempt such a thing) to go on extracting when there is a tooth free in the mouth. If a tooth be seen lying upon the tongue do not endeavour to remove it, or you may promote swallowing, and it will be lost; but bend the patient forward, as explained above, and it will fall out of the mouth by its own weight. When a tooth does enter the larynx it gives rise to symptoms which differ according to the situation of the foreign body; if it is lodged about the opening of the larynx and base of the epiglottis, it causes coughing, dyspnœa, and spasm of the larynx. An attempt should at once be made to dislodge it by feeling round with the finger, getting the patient to cough forcibly, and, if possible, to invert the patient and jolt him (easily done in children). Should these not prove beneficial, and signs of asphyxia threaten, the only remaining treatment is laryngotomy. When the tooth is in the larynx the symptoms are aggravated, there is constant cough, dyspnœa, and spasm of the larynx, and death from asphyxia is imminent. Laryngotomy should at once be performed, and if there be still no relief the incision should be prolonged downwards through the cricoid cartilage (laryngo-tracheotomy), and in all probability the foreign body (unless impacted) will be expelled immediately, or during a fit of coughing. Should the tooth escape the mucous folds of the larynx, and pass on into the trachea, then the symptoms may not be so severe. There will be an irritating cough, perhaps paroxysmal in character, whenever the foreign body is moved; at intervals it

may be coughed up to the vocal chords and cause spasm of the intra-laryngeal muscles, and necessitate tracheotomy. On the other hand it may travel down into the bronchus, and probably into the right bronchus, as the septum between the bronchi is a little to the left of the mesial line, and becoming impacted there, may give rise to remote lung symptoms—bronchitis or pneumonia.

From the above account it will at once be seen how the presence of a tooth in the respiratory tract endangers the life of a patient either immediately through asphyxia, or remotely through secondary pulmonary affections, and therefore the greatest care should be taken to prevent this accident happening by never running any unnecessary risk through going on extracting when there is a free tooth in the mouth.

Syncope.—This occurring during the administration of nitrous oxide is very rarely met with. It can be recognised by the failure of the pulse, the pallor of the face, the dilated pupil, and the cessation of respiration. *Treatment.*—No time must be lost, the patient must be laid upon the floor, or upon a couch with the head low, all clothing loosened that may interfere with free respiratory movements, ammonia applied to the nostrils, face and chest slapped with a wet towel. Nitrate of amyl is very useful; a capsule should be broken and held a few inches from the nostrils, as much fresh air as possible allowed, and all bystanders kept from crowding round. Should respiration have ceased,

the tongue should be drawn forward, and artificial respiration commenced.

Upon recovery do not allow the patient to assume the erect position until there is a good pulse.

Cessation of Respiration.—Breathing sometimes becomes very shallow during the administration and may gradually cease, but it is readily re-established by pressure upon the lower part of the thorax, the object being to cause a forced expiration by pressure upon the thorax and abdomen, in order that, upon relieving the pressure, the diaphragm may descend and the ribs come forward to their previous position, and that air may rush in to fill the expanding lung. The administrator should stand on the left or right front of his patient, place one hand on each side of the lower half of the chest, one forearm being on the abdomen to prevent descent of the diaphragm, and then press sharply inwards and at the same time backwards, then suddenly release the pressure and, if necessary, repeat the manœuvre; one or two such attempts are invariably followed by natural respirations. As the patient is seated in a chair, the tongue is not as a rule the impediment, unless the head be placed very far back, as is usually the case in extracting an upper wisdom; but it must never be forgotten in every case of cessation of breathing the tongue may form a mechanical obstruction to inspiration.

When the tongue has fallen back, it is generally sufficient to place the index finger along the median line of the tongue as far back as it will reach, and

then to flex the finger. This draws the tongue forward, and opens up the air passage freely. This method has been found very useful in many cases, and may always be tried before using tongue forceps.

The general methods of performing artificial respiration, the "Sylvester," and the "Howard," are described in the chapter on Ether.

Supposing the necessity for performing laryngotomy to arise, the operation should be performed as follows:

Laryngotomy.—The patient should be laid upon his back with a cushion under the shoulder, so that the head may fall back and render the surgical landmarks prominent. The object is to make an opening through the crico-thyroid membrane by means of which the patient may breathe until the cause of the dyspnœa can be removed or remedied.

The operator then feels for the thyroid cartilage and passes his left forefinger downwards until he feels the space between the thyroid and cricoid cartilages. He then, holding the scalpel in the right hand, makes an incision of one inch in length strictly in the middle line, its centre being over the depression between the two cartilages. This incision should expose the thyroid and cricoid cartilages, as they are subcutaneous in the middle line. The left forefinger will indicate the crico-thyroid space. The knife is then turned, so that its back will act as a retractor, the right edge of the wound pushed to the operator's left, and then the knife is caused to pierce through the crico-thyroid membrane and

divide it freely with a transverse cut. A laryngotomy tube can then be inserted; but failing this, the wound must be kept open, and artificial respiration employed if needful.

The only vessel that may be wounded is the crico-thyroid artery, but this is usually very small and gives no trouble.

This method is said to be better than performing the operation with one thrust through skin and membrane, as it is less liable to be followed by ærial fistula.

After-Effects of Nitrous Oxide.

These are generally very trivial, and in by far the majority of cases there are none. It is on this account that nitrous oxide as an anæsthetic agent has become so great a favourite.

Vomiting.—This may happen in a nervous patient if the gas has been administered soon after a meal. It is more apt to occur when the same apparatus has been used for the administration of ether previously. Where a separate apparatus is used for gas only, vomiting is exceedingly rare.

Headache is liable to occur when a supplemental bag is used, and the gas is rebreathed and so contaminated with the exhalations from the patient's lungs; it very seldom follows when pure nitrous oxide is given.

Should the gas have to be given twice within a short interval, the patient ought to be cautioned that headache may ensue.

Fainting occurs in a few cases, and is then not unfrequently due to the excessive zeal of the medical man, which leads him to order a long fast beforehand. As has already been said, the danger of faintness is greater than the danger of sickness, and it is always better to time the operation so that the stomach is empty without any special abstinence from food. In fact, throughout the operation much of the success depends upon the absence of *special* conditions altogether, for special instructions, special diet, anxious questions and examinations all tend to create a fluster and to excite and disturb the patient; whereas, on the other hand, the apparent absence of precautions, paraphernalia, anxious enquiring glances, and mysterious hints between the operator and the anæsthetist, suggest to the patient that there is really nothing to make a fuss about. The room should be like an ordinary sitting-room, and the chair as like an ordinary armchair as possible, and there should be no instruments visible. If the patient be a woman or a child, the presence of a woman servant is always pleasant and reassuring, and the absence of the friends of the patient contributes much to the ease of the operator and the success of the operation. People who are given to fainting are liable to do so in the operating-room just as much as elsewhere, but the accident has no significance; it is, however, important that any person in a fainting fit should be promptly laid flat on the back, with the head if possible lower than the shoulders. This position is sufficient as a rule

to restore consciousness in a few seconds. An inclination to faint may, while in the operating chair, be checked by pushing the head forwards and downwards between the knees. A teaspoonful of sal-volatile in water, or better still, if available, a sniff at a capsule of nitrate of amyl, will restore the patient at once. These capsules and instructions how to use them may be obtained at Martindale's, in Cavendish Street, or at Ash's, in Broad Street; but of all restoratives the best is the prostrate position. This fact should, in my opinion, be printed in large letters at the entrance of every church and every theatre, and taught to every child in the nursery. A person with a weak heart in a fainting condition, held up and sometimes hugged tight by well-meaning friends armed with scent and luke-warm water, is within a measurable distance of being fondled lovingly out of this life altogether, yet how frequent a spectacle it is — the anxious friend sedulously stopping the heart's action, the curious and kindly circle shutting off the air, or at any rate rendering it warm, stuffy, and impure, and the officious by-stander, with a handkerchief reeking with scent, poisoning what little air does reach the patient. With such a scene before the mind's eye, one may feel excused for urging this point of the position of a fainting person.

It is sometimes necessary to maintain the prone position for some little time to allow the heart fairly to recover. On one occasion a patient fainted, owing to the heat in the stopping-room at the top

of the Dental Hospital in Leicester Square. She was laid down on her back and instantly recovered, but on attempting to rise, fainted again; this condition of consciousness while lying down, and instant relapse on sitting up, continuing for some time.

In one case of fainting after gas had been given and a tooth extracted, the sight of blood appeared to be the exciting cause. A boy upon recovery fainted, he was restored by the usual methods, but upon rinsing out his mouth he fainted again. This occurred a third time. He was then laid down upon a couch with the head low, the foot end being raised. His mother stated afterwards that the boy always fainted when he saw blood; most probably it was the blood on the napkin and in the mouth-wash that caused these successive faints. When on the sofa, and away from all instruments, soiled napkins, &c., the symptoms ceased.

Nitrous Oxide and Oxygen.

When the first edition of these notes appeared, this mixture was known principally in connection with some very interesting researches pursued by the late M. Paul Bert, which, while they added enormously to our stock of knowledge, were, as far dental surgery at least is concerned, barren of any practical outcome. The apparatus devised by Paul Bert was so cumbersome and elaborate that it could only be employed under special circumstances; but the fact that the combination of oxygen with nitrous oxide profoundly modified the course of the resulting

anæsthesia, was not destined to remain for long without an exponent, who, by great ingenuity and patient scientific experiment, has at length placed its advantages within the reach of dental surgeons. Before discussing Dr. Hewitt's investigations, we must say a word about the work of the older observer.

As long ago as 1871, M. Bert commenced a series of papers, addresssed to the Académie Royale des Sciences, in which he discussed the subject of "the influence exercised by changes in atmospheric pressure upon the phenomena of life." Many curious and interesting facts were thus brought to light concerning the gases contained in the blood and the tissues, their tension, and the exact nature of the gaseous interchanges which take place in the lungs. This series of communications continued until 1875.

In 1879 M. Bert's researches took a somewhat new departure, although the obvious outcome of his previous work, in the form of a note entitled "Sur la possibilité d'obtenir à l'aide du protoxyde d'Azote une insensibilité de longue durée, et sur l'innocuité de cet Anesthésique."

The substance of this paper is as follows:—

Protoxyde of nitrogen is widely employed at the present day to render painless the extraction of teeth, but this anæsthesia cannot be prolonged, for the simple reason that as soon as perfect insensibility is obtained, dangerous phenomena of asphyxia appear. This is because the only way to produce anæsthesia is to administer the nitrous oxide *pure*, unmixed

with air, therefore, of course, asphyxia is induced *pari passu* with anæsthesia. The reason why nitrous oxide must be administered pure is simply this: in order that a sufficient quantity to anæsthetise should enter the economy, the tension of the gas should be equal to one atmosphere, at a normal atmospheric pressure; this means a cent. per cent. proportion of gas; in other words, the lungs must be *full* of gas, and therefore there is no room for any oxygen. This is the case when the pressure of the atmosphere is normal.

But if the patient be placed in a pressure of two atmospheres the required tension can be obtained by causing him to breathe 50 per cent. nitrous oxide and 50 per cent. air. Under such conditions it ought to be possible not only to obtain anæsthesia, but to maintain a normal quantity of oxygen in the blood, and consequently to preserve the conditions necessary to respiration.

In order to analyse this theory experimentally, a dog was caused to breathe *in an increased atmospheric pressure of* $\frac{1}{5}$ *atmosphere*, a mixture of $\frac{5}{6}$ nitrous oxide, and $\frac{1}{6}$ oxygen (the tension of the gas in this mixture equals exactly 1 atmosphere). The dog became anæsthetised in a few minutes, the respiration remained normal, the blood retained its colour, the heart its force, and the temperature its normal degree; in a word, all the phenomena of "la vie végétative" were unaffected, whilst those of "la vie animale" were suspended.

After some time the inhaler was removed, and

after three or four respirations the animal recovered sensibility and volition; and almost immediately afterwards even gaiety and vivacity.

This rapid recovery, so different from what is observed in the case of chloroform, is owing to the fact that the gas does not undergo any chemical combination in the blood, but remains there in a free state, and therefore escapes directly.

M. Bert's practical application of the foregoing facts was an apparatus consisting of a large cast-iron box with a glass roof, inside which the atmospheric pressure was increased to the required amount. All those who were engaged in the operation were inside the box, and the mixture of gas and oxygen was under the operating table ready prepared. The apparatus was of course hopelessly impracticable except for large hospitals, and, moreover, involved much expense to work. This memoir was read on the 11th Nov., 1878. In the July of the following year another note on the same subject appears in the 'Comptes Rendus.' In this second note the results of sundry operations conducted on the human subject are detailed. The apparatus had been contrived by MM. Labbé and Péan. A young woman of twenty was the first subject; the result was all that could be desired, and the anæsthesia was maintained for four minutes. It has since been maintained as long as twenty-six minutes. In 1880 M. Bert, speaking on this subject, claimed for his apparatus that it very nearly attained the ideal perfection of anæsthesia. The complicated and costly nature of the apparatus,

however, presented such obstacles to its universal adoption, that his ingenious mind had again started on a new voyage of discovery with the object of dispensing with it, and arriving at the same safe and prolonged anæsthesia under the normal atmospheric pressure.

Having heard of the method employed in America of giving the gas intermittently, re-administering as often as signs of recovery appeared, M. Bert employed this method on dogs, but was not prepossessed with the plan, the constant approach of asphyxia being a dangerous and unpleasant concomitant, and evidently distressing to the animal.

What took place was as follows:—

As soon as the anæsthesia was perfect, and asphyxia was threatened, the blood of the animal was saturated with the gas, and his lungs were full of it. At this point he was allowed to breathe pure air. Now it takes about ten respirations to fill the lungs with air, and as long, therefore, for the blood to retake all the oxygen it requires, but during this time the gas is escaping from the blood, and impoverishing the lungs' contents of oxygen; thus sensibility returns before the blood has been able to recover enough oxygen.

Therefore M. Bert determined to cause the animal, when anæsthetised, to breathe, not air, but pure oxygen, by this means re-oxygenating the blood before consciousness returned; but the gas was eliminated too quickly, owing to the presence of the pure oxygen, and the results did not come up to M. Bert's hopes.

He next attempted to produce a longer insensibility by administering a mixture of gas and oxygen, after anæsthesia had been obtained by means of pure gas. This was more than sufficient for the re-oxygenation of the blood, because the gas present in the mixture prevented the rapid elimination of the gas that was suspended in the blood. Thus, when pure gas was again given, it was not necessary to push it to the verge of asphyxia. By these means the insensibility of a dog was maintained for half an hour.

During the last few years Dr. Hewitt has devoted himself with unsparing assiduity to the task of bringing the advantages of this mixture within the reach of the minor operations of surgery by doing away with the necessity for an increased atmospheric pressure, and, owing to his careful work, dental surgeons are now able to employ it without having recourse to the ponderous machinery advocated by the French investigator. Dr. Hewitt's researches in their latest form were submitted to the Odontological Society in June, 1892, in a paper on the "Anæsthetic Effects of Nitrous Oxide administered with Oxygen at ordinary Atmospheric Pressure." He said that the ordinary symptoms shown by the person anæsthetised by nitrous oxide were stertor or noisy breathing, jactitation or involuntary muscular movements, and lividity or duskiness. Unless these were present a good anæsthesia could not be ensured. When a certain proportion of oxygen was mixed they did not appear. He thought these phenomena were not part and parcel of the anæsthesia, but

arose from deprivation of air. Stertor and lividity alarmed the friends of patients, jactitation gave rise to inconvenience, especially in children. Dr. Hewitt described the history of the use of this mixture from its first trial by Paul Bert. The description of his own apparatus given in the paper reads as follows :—

"The accompanying drawings show the apparatus with which the cases have been conducted.

"Two india-rubber bags are employed: one for nitrous oxide, the other for oxygen (Fig. 15, ON_2 and O). These, which are fed from cylinders worked by the foot, are attached to two metal tubes T′ and T. Where the tubes join there is an arrangement by which oxygen may be added to the current of nitrous oxide to the desired extent. Above this regulating arrangement with its dial (D), indicating handle (H), and indicator (i), there is a two-way stop-cock, which allows, by the movement of its handle (H′) either of air or of the mixed gases being breathed. In order to permit the free escape of each expiration, two flap-valves, one an expiratory, (EV), and one an inspiratory (IV) are provided. The tubes (T and T′) also possess flap-valves (v and v′) to prevent the contents of one bag passing over to the other. The oxygen tube T is considerably expanded above, so that the nitrous oxide tube may pass up through its middle. Oxygen thus travels along the circular channel left between the tubes, whilst nitrous oxide passes along the inner tube. Fig. 16 shows the central nitrous oxide tube (T′) and the expanded oxygen tube (T). The space left

between the nitrous oxide tube and the expanded oxygen tube is closed in by two circular plates, the

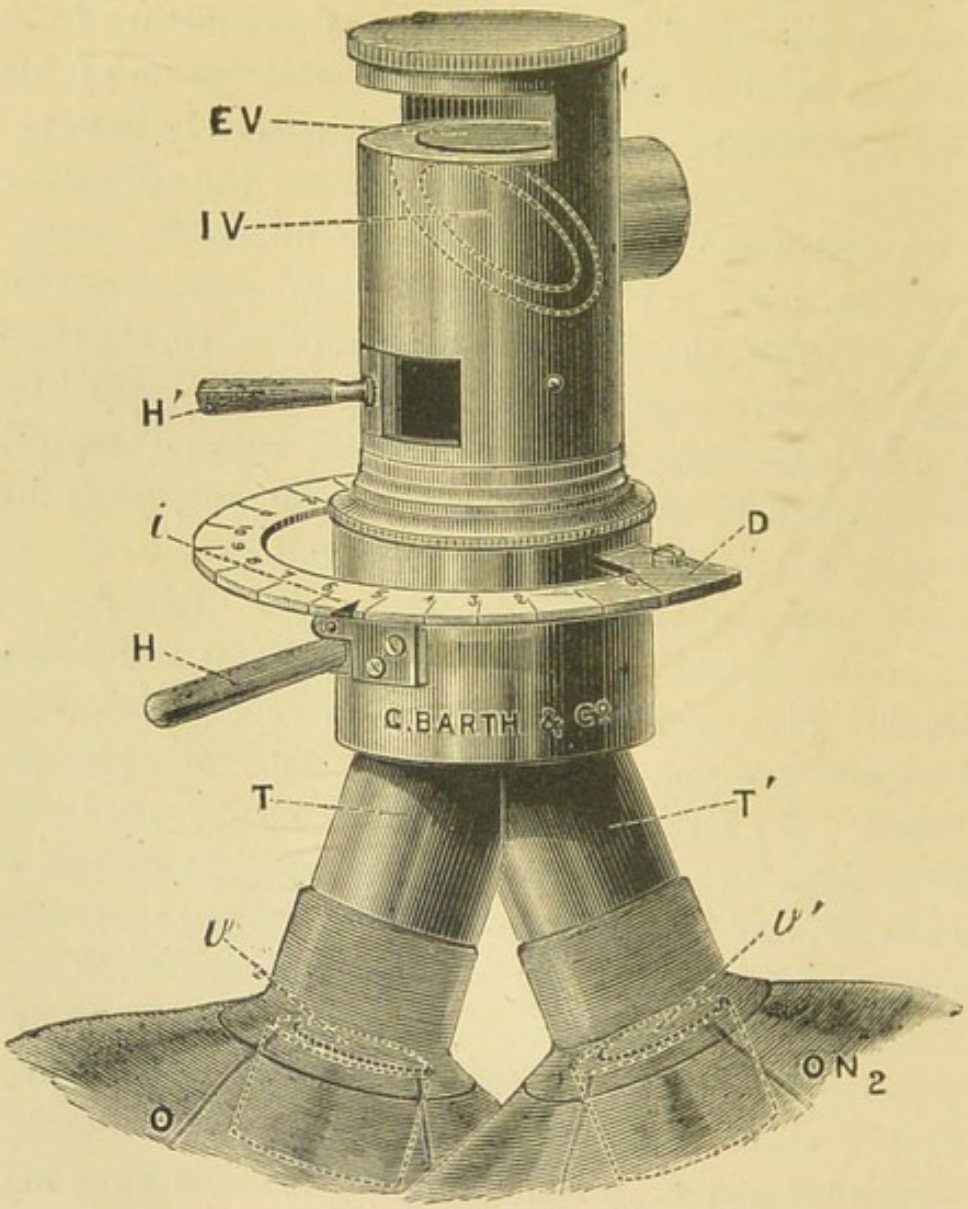


FIG. 15.

upper of which (P) revolves by means of the handle (H) upon the lower, which is fixed. The upper plate has thirteen holes in it. The lower has a long slot

(S) shown in dotted lines. Now when the handle (H) is turned, so that (P) revolves, one or more holes can be brought over the slot in the lower plate, and be thus rendered available for the passage of oxygen. In Fig. 16 the indicator points to "4" on the dial: *i.e.*, four holes are opened for oxygen

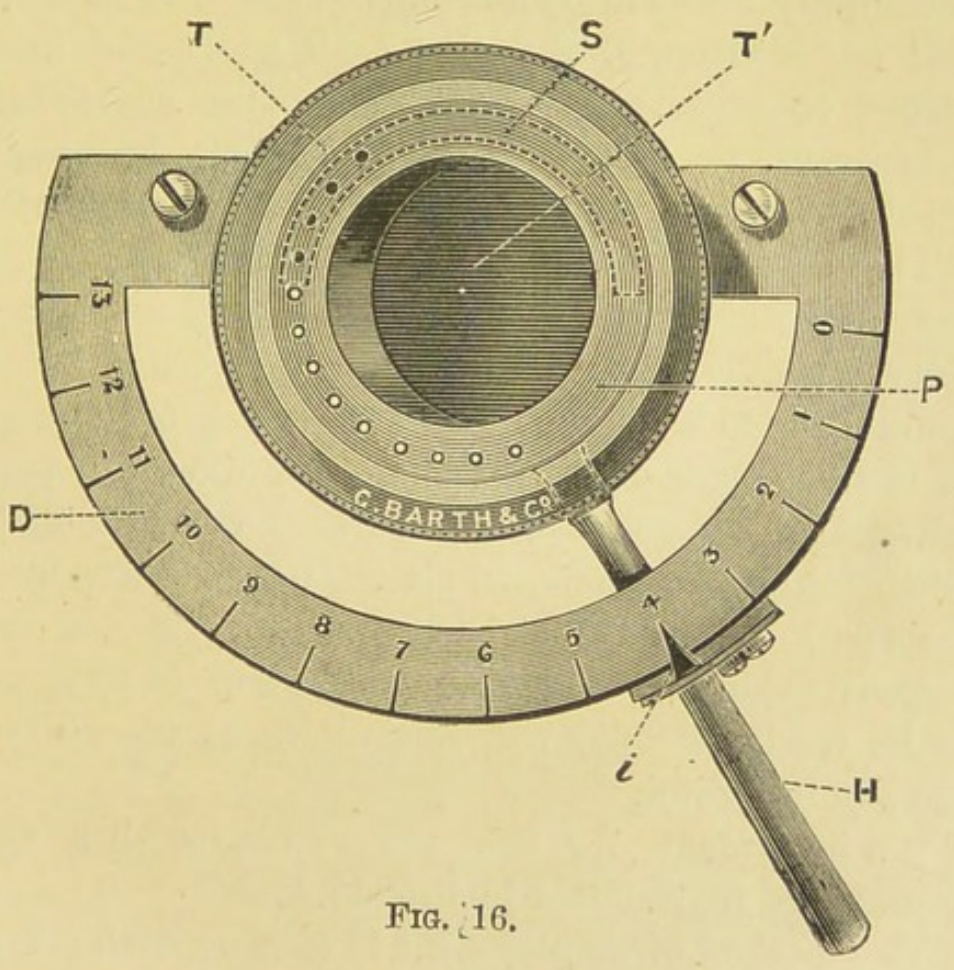


FIG. 16.

and nine are closed. *By this plan a very small increment or decrement in oxygen is represented by a very considerable excursion of the indicator along the dial plate.* Notwithstanding that I have made a large number of experiments with the object of ascertaining what percentages of oxygen pass

through these holes, I find it impossible to give any reliable averages, owing to the variations in pressure which must to some extent occur in the bags during the administration. All that I can say is that when both bags are kept partially distended and one hole is open, a very small percentage (something between 3½ and 6½ per cent.) of oxygen will come through, and that each additional hole turned on represents something like an additional 1 per cent. or 1½ per cent. of oxygen. In actual practice all we require is an apparatus which will allow of very small increments and decrements of oxygen. Should one bag ever be allowed to become fully distended the regulating apparatus will, of course, fail to work as such. If one bag be allowed to become more distended than the other the percentage of its gas will, of course, be higher than when the bags are of equal size. The apparatus here described allows (1) air, (2) nitrous oxide, or (3) nitrous oxide mixed with a proportion of oxygen, to be freely respired through valves at the will of the administrator.

"When ready for use the apparatus has the appearance represented in Fig. 17."

The method of employment is to start with a low percentage of oxygen, and add nitrous oxide as required. Every case required special care in the graduation of the quantity employed. The symptoms shown under this mixture were—the respiration was at first quickened and rendered more deep, subsequently became almost as in sleep: no change

of colour occurred: the circulation was not so hurried as with nitrous oxide: the pupils were not

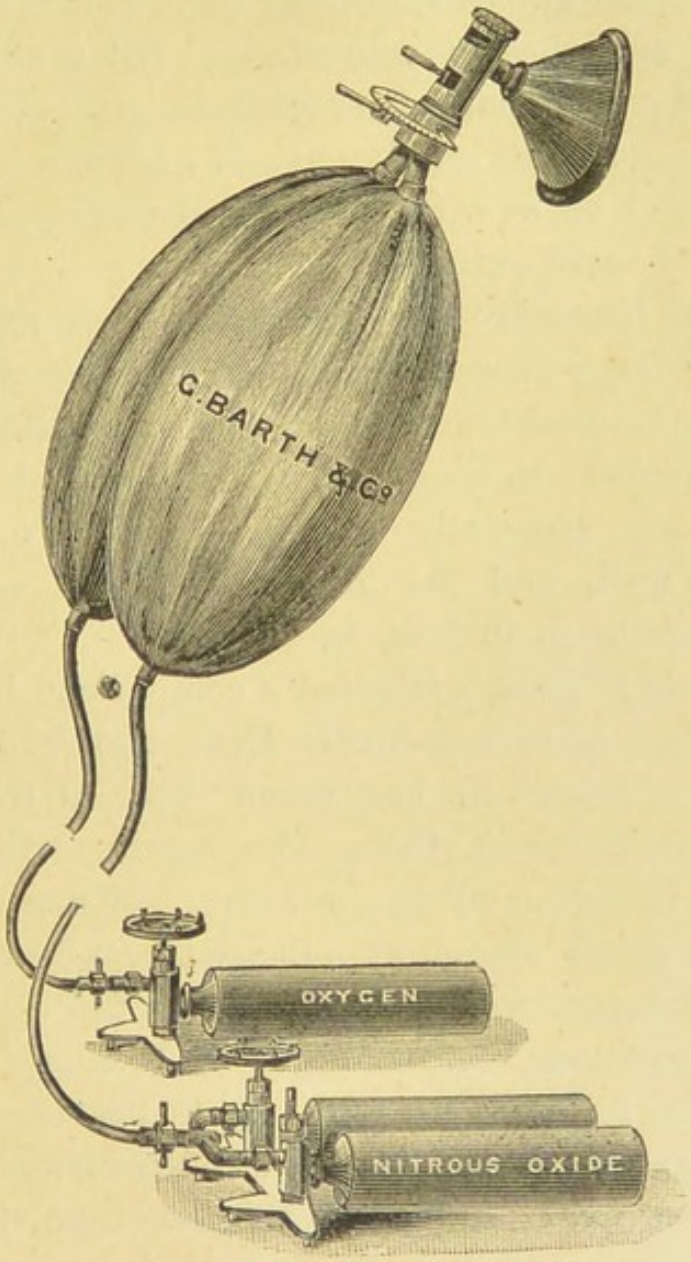


FIG. 17.

dilated: the muscular system was relaxed: jactitation and stertor were absent. Analysis of 153 cases—123 female, 29 male, 1, sex not stated: age

varying from 7 to 61. Of these, 117 were regarded as typical cases, 36 evincing some symptoms of nitrous oxide narcosis, *e.g.*, rigidity, jactitation, &c. Signs of anæsthesia: conjunctival reflex abolished, muscular relaxation, soft snoring breathing, fixation of eyes. Period of inhalation: 110 seconds. Available period of anæsthesia: 44 seconds. Average number of teeth extracted: 2·7.

General Remarks.—In some cases it was necessary to have a large percentage of nitrous oxide, as much oxygen produced excitement and muscular movement, especially in strong vigorous people. Children and feeble — especially anæmic — people took the mixture well, and he regarded it as being of peculiar value in such cases.

Dr. Hewitt then instituted a comparison between the mixture of nitrous oxide alone and with ether in cases in which he had given them to the same patient at different times, the results telling, he thought, in favour of the mixture. Where the airway was partly closed by enlarged tonsils or what not, the mixture was preferable, as it did not cause so much swelling of the tongue or tonsils. It was also useful for persons with weak hearts. After-effects were not so satisfactory as with nitrous oxide, the patient remaining dazed for some time after the administration, while retchings and nausea were more liable to occur than with gas. He thought the mixture most useful for children and young persons of both sexes, for the anæmic and debilitated, for those who are "bad subjects" for nitrous oxide, for

persons experiencing bad dreams under gas, for the aged, for persons suffering from visceral affections. The objections to its use were the great difficulty in manipulating the apparatus, the greater amount of preparation required, the unsightliness of the apparatus, and the length of time of inducing and recovering from the anæsthesia.

CHAPTER IV.

Note on the Use of Air with Nitrous Oxide.

BY GEORGE ROWELL, F.R.C.S.

The increase in the length of anæsthesia, which is in most cases obtainable when small quantities of air are administered with nitrous oxide, has recently been recognised, and the following short account embodies some of the more important practical considerations and details of the process.

The method is useful whenever an extra ten to fifteen seconds' anæsthesia is desirable, always provided that the patient is a suitable subject. The question of the suitability of a particular patient for the exhibition of the method may be best answered by the elimination of those subjects for whom it is not advisable. These are, briefly: (1) Quite robust and strong adult males; (2) Marked alcoholics; and (3) Those patients, occasionally though rarely met with, who invariably struggle or become very rigid under nitrous oxide alone. In all other patients, speaking generally, the method may be practised with advantage. The most favourable patients, and those in whom we see best the benefits derived from

the air, are anæmic girls, weakly persons generally, and children.

The main essential in the giving of air with nitrous oxide appears to be that the patient shall first have several breaths of gas free from air. If some air is admitted from the beginning, the risk of movement, noise, or excitement occurring is much greater than when this precaution is carefully attended to. Any apparatus with an inspiratory valve, which shuts off the gas-bag from the patient's expirations, may be used.

Having decided to give air, and having first administered, as premised above, several breaths of pure gas, the exact manner in which the air is admitted matters little. Mr. Woodhouse Braine admits it by the simple contrivance of pulling aside the india-rubber expiratory valve of the facepiece, which is accomplished by means of a piece of silk attached to the valve. This allows a certain quantity of air to enter with each inspiration that is taken while the silk is pulled upon. Mr. Carter Braine has a number of small holes, covered with an air-tight cap, adjusted to the side of the facepiece. By rotating the cap he is able to uncover any number of the holes, and thus not only to permit of the entrance of air through them when the patient takes a breath, but to vary the quantity admitted.

The plan which I have adopted is to occasionally interpose a complete breath of air between the breaths of gas, by turning the stop-cock of a Hewitt's gas apparatus (Fig. 13) off and on again before and

after an inspiration. This method is easy to work, and is of advantage in that the comparative amount of air given is readily estimated, and that no special apparatus is required.

The first breath of air should be given after about from ten to eighteen breaths of gas; earlier in the weakly, young, and particularly in the anæmic, and later in the more healthy-looking and robust. In children the first breath of air may be given after often only six or eight breaths of gas. When the patient's conjunctival reflex, as not infrequently happens, disappears early, this is a useful guide that air may be given. After the first breath of air, five, six, or seven breaths of gas are given, or a greater number when any movement or phonation is caused by the air, or the patient shows any sign of coming round. Then another breath of air is given, followed by five or more breaths of gas as before. Usually two or three breaths of air, interspersed in this way during the administration, will be found enough to produce the desired result. The administration is brought to a close by a consideration of the same symptoms that are relied upon when nitrous oxide is given free from air.

When air has thus been carefully given, the resulting anæsthesia is practically as deep and good as when nitrous oxide alone is employed, and it is, I believe, always lengthened. Ten to fifteen seconds seems to be the average additional time gained for operating. Occasionally in a favourable subject, such as a weakly, middle-aged, sparely-built person, who is tractable

and not nervous, a much longer anæsthesia than this results. In such a case one minute of good operative anæsthesia is no uncommon event, and I have several times seen ninety seconds' perfect anæsthesia. The reason of this lengthened anæsthesia is obviously that the air given keeps the patient breathing, and so permits of a longer inhalation, and hence the absorption of a greater quantity of gas.

Disadvantages may be urged against any therapeutic procedure. The drawbacks to the use of air with gas are slight, and, after a certain amount of practice in the method, can be to a great extent controlled. Slight excitement, evinced by phonation or moaning and movements of the extremities, may occur during the inhalation. This will generally be found to be due to the too early admission of air. More common is slight noise during the operation, which is certainly more often met with than when air is not used. The after-symptoms appear to be in no way different from those of an ordinary gas-administration.

Gas and air, then, in the majority of cases, is a more serviceable anæsthetic than gas by itself. Furthermore, in many of those cases in which a long anæsthesia is very often required, such as anæmic and weakly girls, young people, and feeble subjects generally, gas and air is particularly easy to give, and it is in just these kinds of patients that its benefits are the most marked.

CHAPTER V.

Ether in Dental Operations.

Although nitrous oxide is the anæsthetic used in by far the majority of dental extractions, yet there are many cases in which the anæsthesia produced by it is not of sufficient length to perform a very difficult extraction, such as a tooth fractured from a previous attempt, or an impacted wisdom in which the jaws are very nearly closed and where valuable time is lost in forcing them open : or, on the other hand, the dentist may desire to extract many teeth at one sitting.

We then are forced to use some agent which will produce a much longer anæsthesia, and those which are most frequently used in such cases are ether, chloroform, or the A. C. E. mixture.

Of these, ether is the anæsthetic most in favour in England, Ireland, and America, whereas in Scotland chloroform has its stronghold. Where the patient is seated in a dental chair, ether is the safest to use, inasmuch as it is a cardial stimulant, whereas chloroform, from its depressant action on the heart, would, from this position alone, be contra-indicated ;

but ether is by no means the easiest of the three to administer. There are three varietes of ether—Æther purus, sp. g. ·720, of the Pharmacopœia; methylated ether, sp. g. ·720; and what is termed compound anæsthetic or freezing ether, sp. g. ·656. Of these the pure ether and methylated ether can be used for inhalation and produce general anæsthesia, but the anæsthetic ether is an ether specially prepared, intended for local anæsthesia only, and is the ether used when a surgeon wishes to freeze a portion of the skin, prior to making an incision; it must not be administered by inhalation under any circumstances, as there are cases on record in which its use has produced the most alarming results. It would save any element of confusion there may be to those unacquainted with the composition of the ethers, if this ether were strictly termed "freezing ether," and the word anæsthetic entirely restricted to the anhydrous and methylated varieties.

The methylated ether is the variety in common use, especially in hospital practice, on account of its price being much less than that of pure ether. It is, perhaps, more likely to cause headache and vomiting as an after-effect in certain cases, but as a rule no difference can be detected when it has happened that the two kinds have been administered to the same patient.

It is of great importance that the patient be prepared for the administration, as ether is more apt to cause vomiting than any other anæsthetic —hence the stomach should be empty. Nothing

causes so much annoyance to the operator and anxiety to the anæsthetist as to administer ether to a patient about one hour or so after a meal. The anæsthetist under these circumstances would be justified in refusing to administer, as there is a risk of partially-digested food entering the larynx, and the chances of having to perform tracheotomy greatly increased.

In this connection Mr. Woodhouse Braine's words are quoted verbatim :—

"Although I am a great advocate for having the stomach entirely empty, the patient must not be allowed to become faint for want of food. Should the operation take place before 9.30 A.M., no food of any kind should be given; but if it be the usual custom of the patient to take a cup of tea or cocoa about 7, this may be allowed, for having become a habit, it will be missed, and faintness be produced by its omission. If the operation be between 11.30 and 2, let a light breakfast be taken about 8, if that be the patient's regular hour; but if no meal be usually taken till 9.30 or 10 o'clock, then let breakfast be omitted altogether, and a small cup of soup or beef-tea three hours before the time of operating. Never allow the breakfast to be given before the usual time, for in this case digestion does not take place, and vomiting always follows the operation. Should the surgeon fix on the afternoon, let an ordinary breakfast be taken, and the soup or beef-tea be given at 12; on no account let the patient become faint; any tendency in this direction should

be combated by the administration of a small quantity of brandy and water."

In spite of all care in dieting, cases are repeatedly met with, where no food has been taken for five or six hours, and yet upon recovering from ether, vomiting of semi-digested material occurs; these are generally patients who have worried themselves greatly about the operation.

Ether may be administered alone, but as it has a very strong pungent odour, which is regarded by most people as very unpleasant, and often causes vomiting, coughing, and struggling on the part of the patient, by far the most pleasant method is to give nitrous oxide first and then to change to ether, as by so doing, the patient is relieved of the unpleasant sensation of inhaling the pungent ether vapour, and is only conscious of inhaling nitrous oxide.

Both methods, however, will now be described.

Methods of administering Ether.

1. The Clover Inhaler.
2. Ormsby Inhaler.
3. The Cone. Folded Towel.

Of these the Clover and Ormsby are most extensively used. In America and in a few places in England the Cone, or a folded towel, is used and ether poured on to them; but the method is so exceedingly disagreeable to the patient, produces such a sense of suffocation, and causes so much struggling,

besides wasting so much ether, that the method can only be condemned as unscientific and barbarous.

Clover's Portable Ether Inhaler.—This ingenious contrivance is so constructed that ether vapour may be given to a patient in a gradually increasing strength; at first he breathes air only, and then a little ether is mixed with it, but so little, that it is scarcely recognisable, and then the administrator

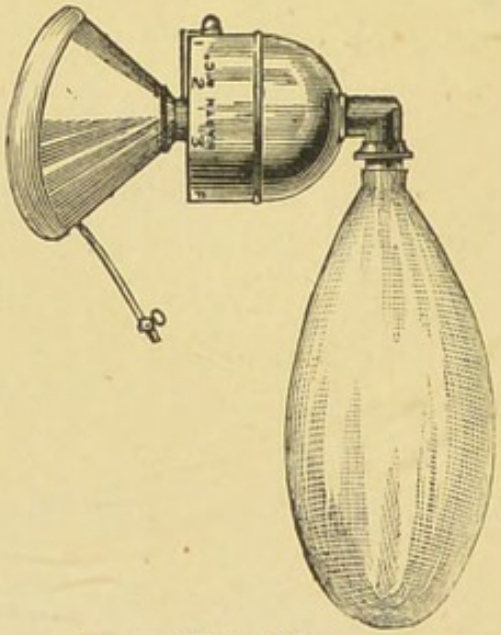


FIG. 18.
CLOVER'S SMALL PORTABLE ETHER INHALER.

goes on increasing the strength of the vapour so long as the patient shows no discomfort, up to the point when he is completely anæsthetised. This is by far the most pleasant way of administering ether alone.

The Inhaler consists of four parts, as shown in Fig. 19:—

1. A facepiece, with the usual air-cushion, to which is fixed—

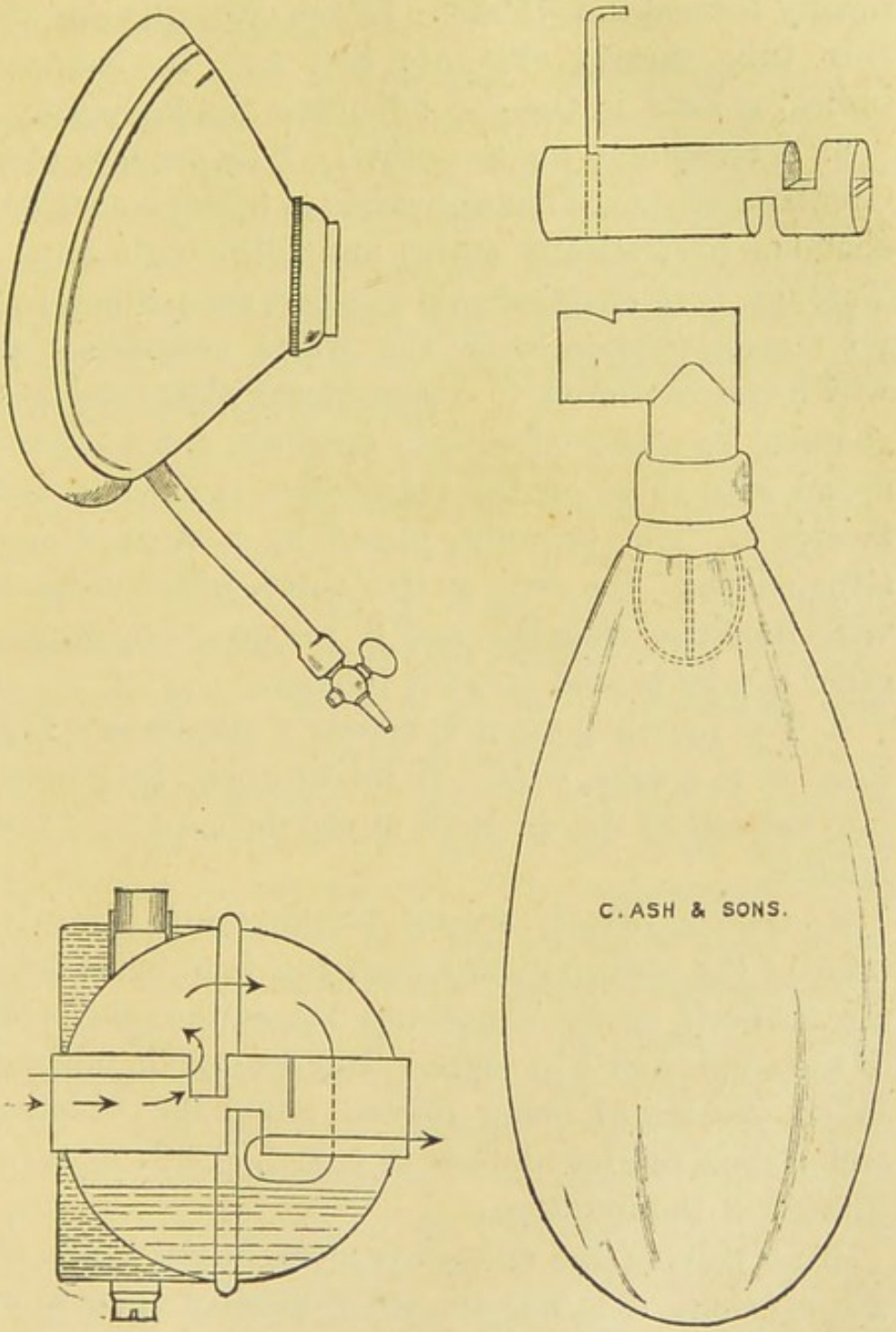


FIG. 19.

2. A metal tube three or four inches long, technically termed the whistle. In the circumference of this tube certain slits are cut, and it has an indicator fixed to the end adjoining the facepiece.

3. A receptacle for the ether. This consists of a circular chamber of metal, outside of which is another chamber hermetically sealed and filled with water. Through both chambers an air-shaft runs which has no communication with the water chamber, but which can be caused to communicate with the ether chamber by means of certain openings cut to correspond with those on the tube which is fixed to the facepiece. The opening, closed by a stopper and situated near the base of the dome, communicates with the ether chamber, and is the means by which ether can be poured into the inhaler.

4. The fourth portion is merely a respiratory bag fixed on to a tube, which, in its turn, can be pushed into the end of the air-shaft at the domed end of the inhaler.

To use the inhaler, fix the facepiece into the tube bearing the indicator, and push the tube home into the air-shaft, fix the respiratory bag to the other end of the shaft, and add ether. The dome will now be found capable of being rotated round the whistle, and certain figures on base 0, 1, 2, 3, F will in turn present at the indicator.

By revolving the dome, the slots on the inside of the air-shaft and whistle are gradually opened or closed, and it is by these means that a gradually increasing ether vapour can be given, the numbers

indicating the amount of air which is passed through the ether chamber.

With indicator at 0 patient breathes through the air-shaft, which, having all slots closed, allows no ether to enter the air-tube; but when the indicator is at 1, 2, 3, then respectively $\frac{1}{4}$ $\frac{2}{4}$ $\frac{3}{4}$ of the air breathed passes indirectly through the ether chamber, the remaining portion going direct into the respiratory bag, and when at F the whole of the respirations pass through the ether chamber.

The shape of the inhaler is ingeniously contrived, to prevent any fluid ether from getting into the face-piece in any position in which it may be placed.

Before administering ether, ℥ iss. – ℥ ij. of the anæsthetic should be poured into the ether chamber, the indicator placed at 0, and respiratory bag removed. The inhaler is applied to the face, and the patient allowed to breathe through it once or twice to gain confidence, and there being no ether turned on, he is reassured. The respiratory bag is now quietly applied, and this should be done at the end of inspiration, so that at the next expiration the bag is filled with air by the patient himself. Some administrators fill the bag with their own expiration; but this should be condemned as being unhygienic and perfectly unnecessary. Be careful not to place the respiratory bag on the inhaler at the end of an expiration, as there will not be sufficient air for the following inspiration, the bag will collapse, and patient feel suffocated.

The patient should be allowed to breathe a few

times into the bag, and then, during expiration, the administrator should turn on a little ether by revolving the dome, then gradually feel his way by increasing the vapour; but should coughing or struggling appear to be imminent, then the vapour is too strong, and he must turn the inhaler back towards O. When 2 has been reached without discomfort he may increase the vapour more rapidly, and turn on up to F until complete anæsthesia is obtained, and then it is not necessary to continue with so strong a vapour; generally the remainder of the operation is completed with the inhaler at 2½ to 3.

The Ormsby Inhaler.—This inhaler, an exceedingly useful one, is very simple in construction, has no parts to get out of order, and is not so liable to be damaged by a struggling patient. It consists of a facepiece, to which is affixed a wire cage bearing an ordinary sponge, and of a respiratory bag drawn over the cage.

Fitted on to the facepiece is a brass cap, covering a funnel-shaped opening leading down to a lead tube, which bifurcates, enclosing the sponge. This tube is punctured with many openings, and is intended to facilitate the pouring on of ether without removing the facepiece.

Most inhalers are sold with bags too small to hold the expiration of a well-developed chest without becoming distended, and hence makers have covered the bag with a net and fixed it to the facepiece, with the object of preventing the bag being

forced off during expiration (see Fig. 20). This breathing into a small bag is a great tax on the respiratory muscles, besides which ether is lost by being forced out all around the facepiece. By using a bag 12 inches in diameter (see Fig. 21), all the above defects are remedied, as it is quite large enough to hold an expiration without any distension of the bag.

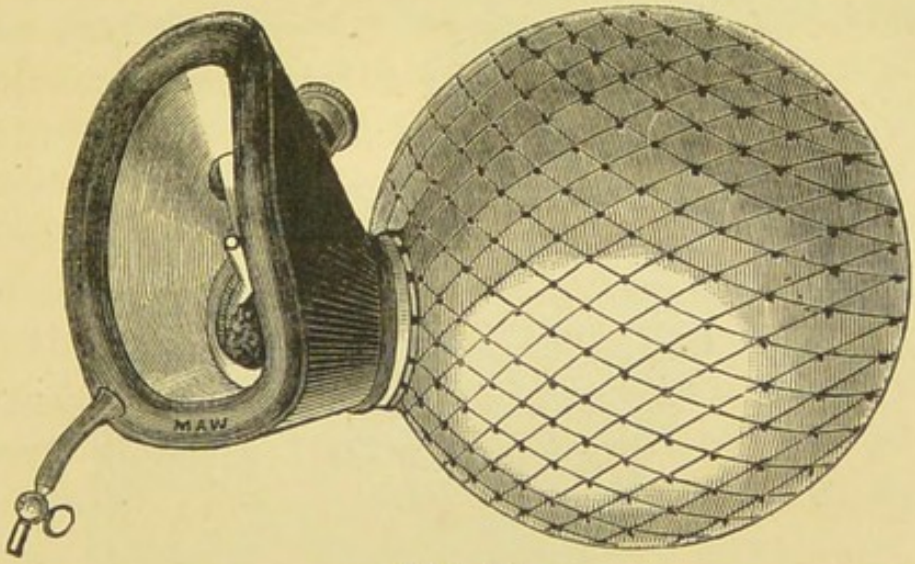


FIG. 20.

DR. ORMSBY'S ETHER INHALER.

Ether cannot be given so gradually by this method as with the Clover, but with care the degree of graduation can be very nearly approached.

To use the inhaler, choose a good open sponge—one that can be breathed through easily—and place it in the cage loosely, entirely filling up the opening at the commencement of the cage. Then pour on ʒ ij. ether, and gradually apply to face. Very soon

ether may be increased by another ʒ ij., and with care the patient can be anæsthetised as quickly and comfortably as with a Clover, and remain a better colour throughout. The Ormsby inhaler has been condemned as unscientific and wasteful of ether;

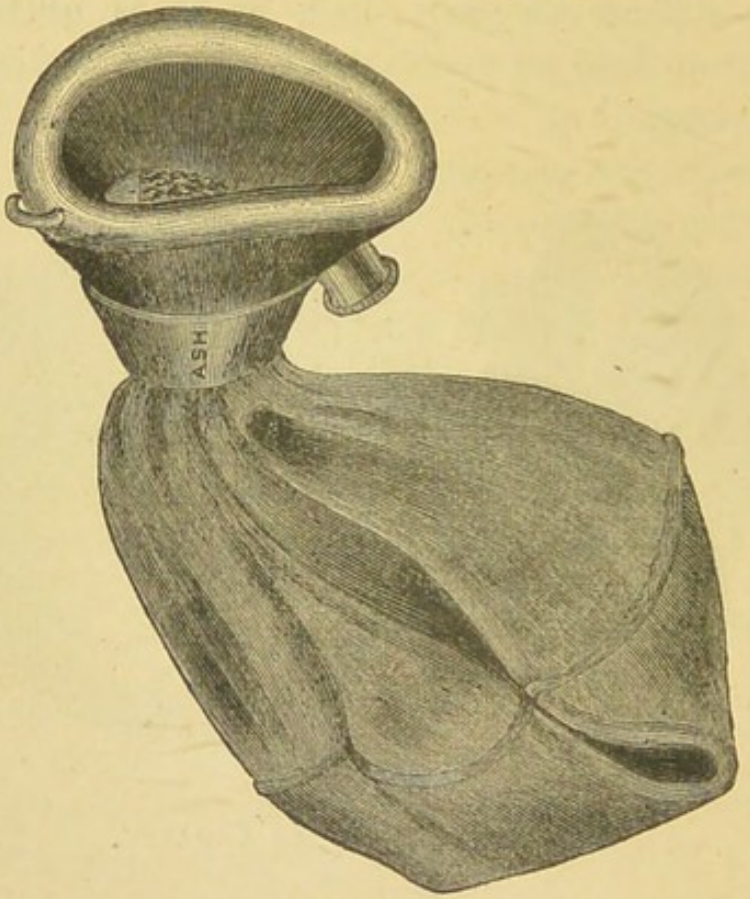


FIG. 21.
MODIFIED FORM OF DR. ORMSBY'S ETHER INHALER.

but when precautions are taken with the size of the bag and kind of sponge used, it should regain favour. A stronger ether vapour can be obtained with this inhaler than with the Clover, and there are fewer after-effects when it has been used.

The Administration of Ether preceded by Nitrous Oxide.

It frequently happens that cases occur in dental practice in which the anæsthesia produced by inhaling nitrous oxide is not quite of sufficient duration for the necessary extractions to be effected; in such cases a few respirations of ether administered when the patient is under gas prolongs the anæsthesia, and so small an amount of ether is used that the patient is not aware that he has inhaled anything but nitrous oxide.

Sometimes so many teeth, stumps, etc., have to be removed, that to administer nitrous oxide and ether in the manner described above would simply be to court utter failure. There are a great number of cases in which the inhalation of ether has to be pushed to its full surgical degree, then as many teeth as possible extracted without any hurry on the part of the operator, and should the patient be recovering consciousness before all are extracted, the inhaler must be reapplied and more ether administered. By this method a patient has been kept anæsthetised for over half an hour, before all the teeth, etc., could be extracted.

The methods of administering nitrous oxide and ether in combination or succession, in general use are the following:—

1. With Clover's inhaler, of which there are many slight modifications.

The diagram (Fig. 22) shows a Clover's Portable Inhaler, with the nitrous oxide bag attached; it will be seen that the nitrous oxide bag merely takes the place of the respiratory bag in the ordinary Clover's inhaler.

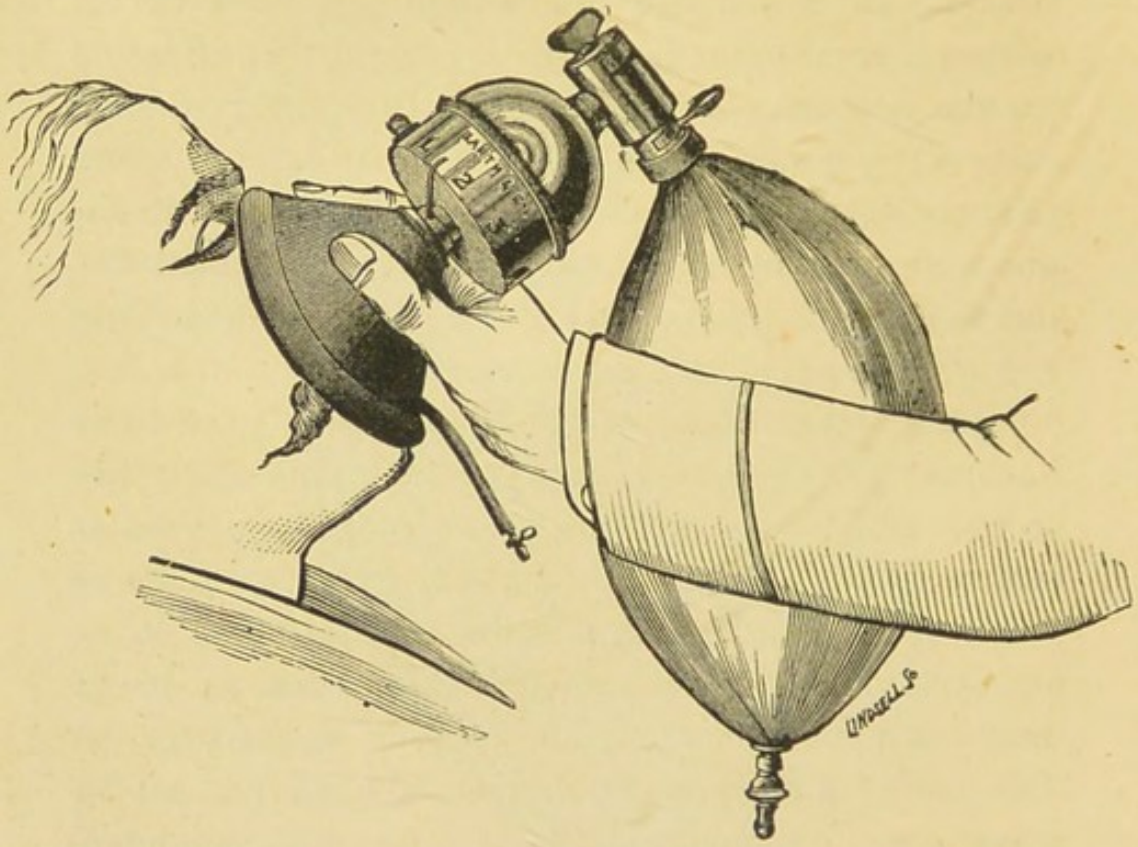


FIG. 22.

SMALL PORTABLE CLOVER INHALER WITH GAS BAG ATTACHED.—(HEWITT.)

The Administration.—Pour ʒ ij. ether into the inhaler. Place indicator at O, and apply the inhaler to the patient's face, being careful that the air-cushion fits accurately. Allow patient to breathe air only for a few respirations. Then attach the bag contain-

ing the gas to the dome. By turning the stop-cock to the left, the patient will commence inhaling nitrous oxide, and expiring it through the expiratory valve. The amount of ether, or rather the duration of the anæsthesia required must now be judged by the anæsthetist, if there are only two or three teeth to extract, very little ether will be required; if there are many, the anæsthesia must be prolonged.

Firstly.—We will suppose that there are only two or three teeth at most, then nitrous oxide can be administered alone until the patient is unconscious, and then by rapidly rotating the ether dome to 2 or 3, one or two respirations of ether can be given, the inhaler quickly removed, and the teeth extracted. Recovery is very quick, and the fact that ether has been inhaled may not even be suspected by the patient; he may complain that the inhaler smells of ether. The patient should always be told that ether has been administered, and should be compelled to remain quiet in the chair longer than if he had only taken nitrous oxide, as upon getting up too soon and going out into the open, he is frequently rendered giddy and sick through seeing the moving traffic of the streets.

Secondly.—Let a case be taken in which a large number of teeth have to be extracted, say ten or twelve. The inhaler is charged with ether as before, and the bag containing N_2O affixed to the inhaler, and the gas administered. After seven or eight respirations the expiratory valve is thrown out of action, and the gas bag being thus converted into a

supplemental bag, and ether is gradually turned on by moving the dome round to 1. At this point patient may become a little cyanosed, and a slight jactitation may commence; it is then advisable to give a little air, turning the stop-cock to the right for one or two respirations at most, and then closing it again. Then more and more ether is given by gradually turning the dome until it reaches its limit, viz., F. Slight cyanosis is not of much moment during the earlier part of the administration, but when anæsthesia is produced more air can be given and the colour improved. Too much air must not be given when changing from gas to ether, or the patient will cough or struggle, and take a much longer time to become unconscious. For convenience the gas bag is usually detached and the smaller ether bag used in its place when patient is under ether. When patient is completely narcotised, the inhaler is removed and the extractions commenced. The inhaler should be placed handy so as to be ready to continue giving ether if necessary.

2. By anæsthetising patient with nitrous oxide and rapidly changing to the Ormsby inhaler.

In this method the apparatus for giving gas is kept quite distinct from that for administering ether, so that there cannot possibly be any smell of ether about the gas tackle, and patients are never conscious of inhaling anything but N_2O, and do not complain that your apparatus smells of "that nasty ether."

Many authorities pass ether and gas through the

same facepiece, as is the case in using the Clover inhaler; but there is an objection to this practice, namely, the facepiece becomes so impregnated with ether that the whole apparatus reeks of it; and afterwards, when nitrous oxide alone is administered, patients frequently complain of the taste and smell, and even in some cases of headache and malaise; thus, nitrous oxide, which is distinguished for its freedom from taste and after effects, is sometimes unfairly charged with producing these symptoms. Eau de Cologne and other scents are used to disguise the smell of ether about the facepiece, not always with success; many patients, especially ladies, detect the smell of ether at once, although the administrator himself is unable to do so from daily being in an atmosphere of ether. It is with the greatest possible diffidence, however, that mention is made of this objection, seeing that many administrators of the greatest experience and ability adopt this combined method.

The way this inhaler is used is as follows :—

Wring out the sponge in hot water and place it loosely in the wire cage, the best way to do this being to take hold of the sponge with the tongue forceps, push the sponge well into the wire cage, and then to draw it forward until it completely fills the opening into the bag. Placing the sponge in this manner compels the patient to breathe through it, and not by the side of it, and a few seconds spent in carefully arranging the sponge adds materially to the success of the administration. Now put the

end of a towel in hot water and wring it fairly dry, and pack it into the Ormsby. This is intended to warm the inhaler itself, and to prevent freezing of the sponge when the ether is poured upon it.

The gas apparatus is now got ready. Pour ʒ i. of ether on to sponge, and replace the towel to prevent it evaporating into the room. Nitrous oxide is now administered, and when the patient is fully under its influence, the towel is shaken out of the Ormsby and the inhaler applied to the face.

In thus changing rapidly from nitrous oxide to a strong ether vapour a little skill is required; if it be done haphazard, without any relation to the rhythm of respiration, the chances are that it will be an utter failure, and that the patient will struggle fiercely. It is of the greatest importance not to allow an inspiration of air during the change, but to watch the breathing; and, when the patient has taken an inspiration of gas, to rapidly change the inhalers, so that the next expiration distends the bag of the Ormsby. In the bag there now is air, ether vapour, and an expiration of gas from the patient's lungs.

It requires some practice to manage this changing of inhalers nicely, and beginners often allow the patient to get one or two inspirations of air before applying the Ormsby, the result being that the patient feels suffocated by the strong ether vapour, and struggles or fights wildly, but does not recollect anything if the ether is continued.

Supposing that the Ormsby has been applied at

the correct moment, there is almost always a cessation of breathing for a few seconds, the larynx being very sensitive to ether vapour; but, after a very short interval, a deep gasping inspiration is taken, and then respiration proceeds regularly. An inspiration of air should be allowed occasionally if there is any cyanosis.

It takes about two and a half to three minutes to produce anæsthesia; some patients become deeply anæsthetised in two minutes, while others, again, require four to five minutes. The more quickly a patient is got under the influence of ether, the less of it is inhaled, the quicker is recovery, and the less likelihood is there of after effects. Patients who are slowly anæsthetised take much more ether, and remain in a drowsy condition, with headache and vomiting, upon recovering.

"Those practitioners are the most successful ones who succeed in getting their patients insensible the most quickly; and I consider two minutes and forty-five seconds rather over than under the average time it should take to produce complete insensibility.

"There is no fear of giving ether vapour too rapidly, or of the ether vapour being too pungent, so long as the patient breathes easily.

"Occasionally a patient breathes very slowly, and holds his breath, apparently, for a long time; but if you breathe synchronously with him, and do not feel any discomfort, you need be under no anxiety regarding him, no matter how long the time appears."—*Braine.*

The cold produced by the rapid evaporation of ether is often so great that the sponge on which it is poured becomes frozen into a hard solid mass; and when in this condition it only gives off a very small quantity of ether vapour. This is best prevented by warming the inhaler as described above; but occasionally we meet with a patient who does not become anæsthetised beyond a certain stage, insufficient for operative purposes; more ether is poured on without any result, and then it is discovered that the sponge is hard to the touch and white with a kind of hoar frost; under such circumstances a sufficient strength of ether vapour is not obtained. This is easily remedied by wrapping a napkin, wrung out in hot water, around the inhaler; in a very short time the sponge thaws and the patient becomes deeply anæsthetised. Care must be exercised when using the warm napkin, or the patient will become too deeply narcotised.

A safer way, for one who is not an expert in administering ether, is to remove the sponge, squeeze it out in tepid water, and then insert it in the Ormsby and pour on a fresh dose of ether, as one is then aware of the quantity of ether he is working with.

The signs of insensibility are :—

1. Insensitiveness of the conjunctiva. No contraction of the orbicularis palpebrarum muscle when the conjunctiva is touched. The pupils are, as a rule, of medium size, and re-act to light.

2. Flaccidity of the muscles. An arm when

raised offers no resistance, and upon releasing it falls limp and heavily.

3. Deep regular breathing accompanied by snoring. The anæsthetic should then be discontinued, and the necessary teeth extracted.

Should, however, an inexperienced administrator continue with the anæsthetic, then the patient becomes anæsthetised more deeply than is necessary and the following symptoms, those of overdosage, appear :—

(1) Insensitive conjunctiva, with widely dilated pupils, not reacting to light.

(2) Stertorous breathing.

(3) Marked cyanosis.

(4) Relaxation of the sphincters. Micturition and defæcation may occur, followed in a short time by the cessation of respiration and circulation.

Complications and After-effects.

Dyspnœa occasionally arises from some thick tenacious mucus hanging about the fauces and epiglottis; and this is most easily got rid of by changing the position of the patient's head from one side to the other, or raising the head somewhat. If, however, the breathing do not improve, then open the mouth wide by means of the tongue forceps, and this, producing the act of swallowing, may put matters straight. If it do not succeed, then pull the tongue well out of the mouth, and cause the patient to make a forcible expiration, by sudden firm pressure on his thorax with your left hand and fore-

arm. If this pressure be applied sharply, quite at the end of a natural expiration, such a full inspiration follows, that the mucus is forced from its position, and is either coughed up or swallowed.

The after-effects are not, as a rule, so distressing to the patient as those met with in general surgery; the anæsthesia required for dental operations is comparatively short, from five to fifteen minutes' duration, in marked contrast to surgery, where the patient is frequently under the influence of ether for two hours and more. In the majority of cases very little ether is administered. Headache, giddiness, vomiting, and general malaise are frequently met with, but require little, if any, treatment.

It should not be forgotten that the swallowing of the blood is very apt to initiate vomiting.

It has been suggested that the administration of ether has been frequently followed by bronchitis, which has more than once proved fatal. There is no doubt that such was the case in the earlier days of ether administration, when it was given by the open method. It certainly does produce an irritation of the bronchial tract and an increased secretion of mucus. Perhaps the bronchitis is due to the direct irritation of the vapour, or the cold following its evaporation; or, as suggested by Mr. Braine, to the excess of perspiration damping the under-clothing, and draughts caused by the incautious flinging open of windows by the attendant (the latter seemed a sufficient explanation of the only case quoted by him). At any rate, after ether has

been administered, the patient should be wrapped up warmly as a precaution.

The struggling and subsequent headache common in alcoholic patients after an anæsthetic are much aggravated if ether be given. The arterial tension is increased, so that the bleeding is much more considerable; this is a protection in major operations from secondary hæmorrhage, as more vessels require to be tied, but it increases the danger of tiresome bleeding after tooth extractions, and in cases with a hæmorrhagic history some consider it wiser to abstain from the use of ether.

Dislocations of the Jaw.—Unilateral is by far the most common, but bilateral is occasionally seen. A great number of these would never occur, were the anæsthetist to support the lower jaw, and prevent it being driven so far downwards towards the sternum. When it does occur it should be reduced at once, before the patient recovers consciousness, and it is surprising how easily this can be done whilst the patient is under an anæsthetic.

Syncope.—This is very rare under the influence of ether; should it threaten, at once lower the dental chair to a horizontal position, or place the patient supine on the floor, and take measures to prevent the blood trickling down the pharynx.

Hæmorrhage.—When a number of teeth have to be extracted, especially stumps, there is always pretty free bleeding, and this blood, if swallowed, is certain to cause after-vomiting; it is important, therefore, to endeavour as much as possible to get it to trickle

out of the mouth, by depressing the angle of the mouth with your finger, or to check it by direct pressure on the gums.

Loose Teeth.—Be very careful to note whether there are any loose teeth on that side of the mouth on which it is proposed to use a Mason's gag, so as to avoid dislodging them.

Cessation of Respiration.—When a patient ceases breathing under the influence of ether, the administrator must at once satisfy himself of the cause of the stoppage. It may be *voluntary* in origin, *i.e.* the patient himself holds his breath, the ether vapour being too pungent for him to inhale with comfort; on the other hand, it may be *involuntary*, due to some mechanical impediment, such as the falling back of the tongue, etc., or due to an overdose of the anæsthetic. Touch the conjunctiva with the finger, and if there be a reflex movement of the eyelid, there need be no alarm; while this is the case it is safe to conclude that it is a voluntary cessation of breathing; all that is necessary is to keep the inhaler applied and in a few seconds breathing will recommence. On the other hand, should there be no response to the touch on the conjunctiva, the anæsthetic must at once be discontinued; a finger should be swept round the mouth to ascertain if there is any foreign body present; and the tongue should be forcibly drawn forwards, and the jaw protruded by placing the thumb behind the angle of the jaw and driving it forwards.

The above manipulations only occupy about three

seconds' time, and should breathing not be established, then artificial respiration must be resorted to.

First try the method described under nitrous oxide complications on page 56, and, if not successful, at once place the patient on the floor and perform the "Sylvester," or "Howard," method of respiration.

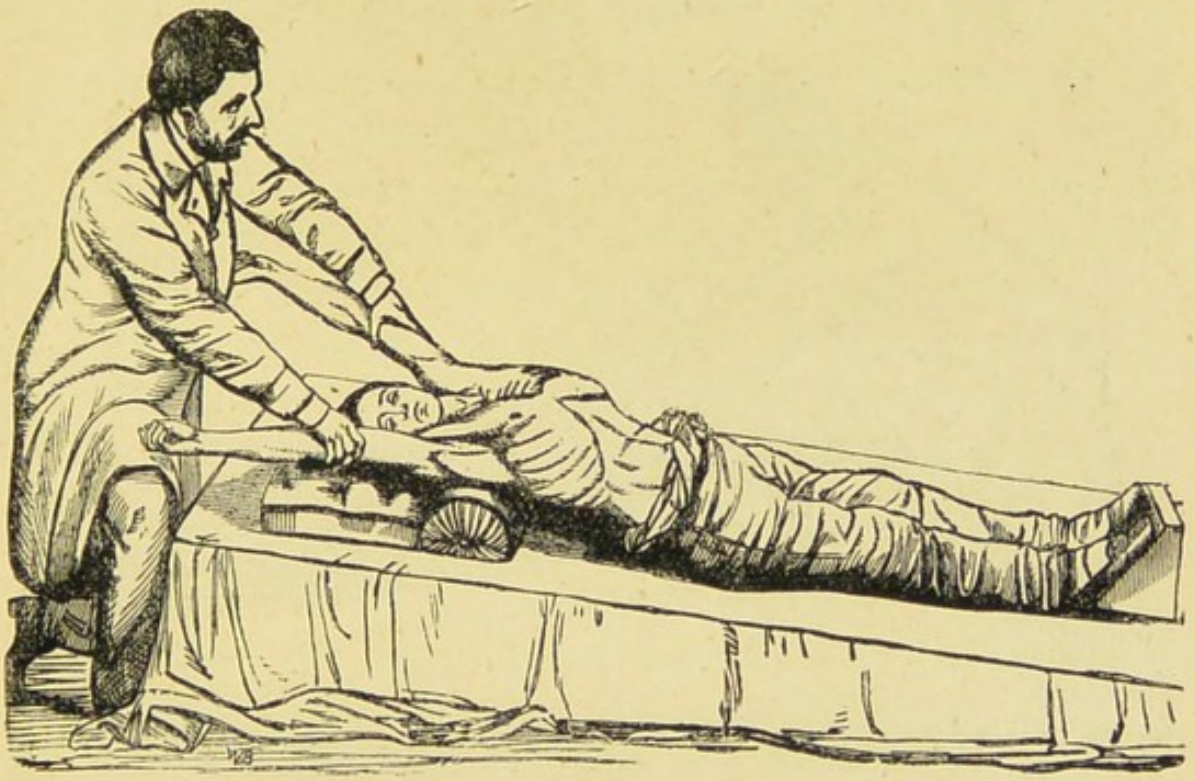


FIG. 23.

INSPIRATION.—SYLVESTER'S METHOD.

The following account of the "Sylvester" method is taken from Holmes' 'System of Surgery,' vol. iii., from the excellent article by Mr. Harley:—

"Manual pressure equal to about thirty pounds may be with perfect safety applied to a healthy adult human thorax.

"In making the pressure, care is to be taken to

observe if any food is forced out of the stomach, which may happen if that viscus is full; and, if so, it is necessary to prevent it getting into the wind-pipe. This may be readily done by placing the patient for a few seconds on his face and forcibly expelling the food by pressure on the back.

"The manual pressure ought to be made on the

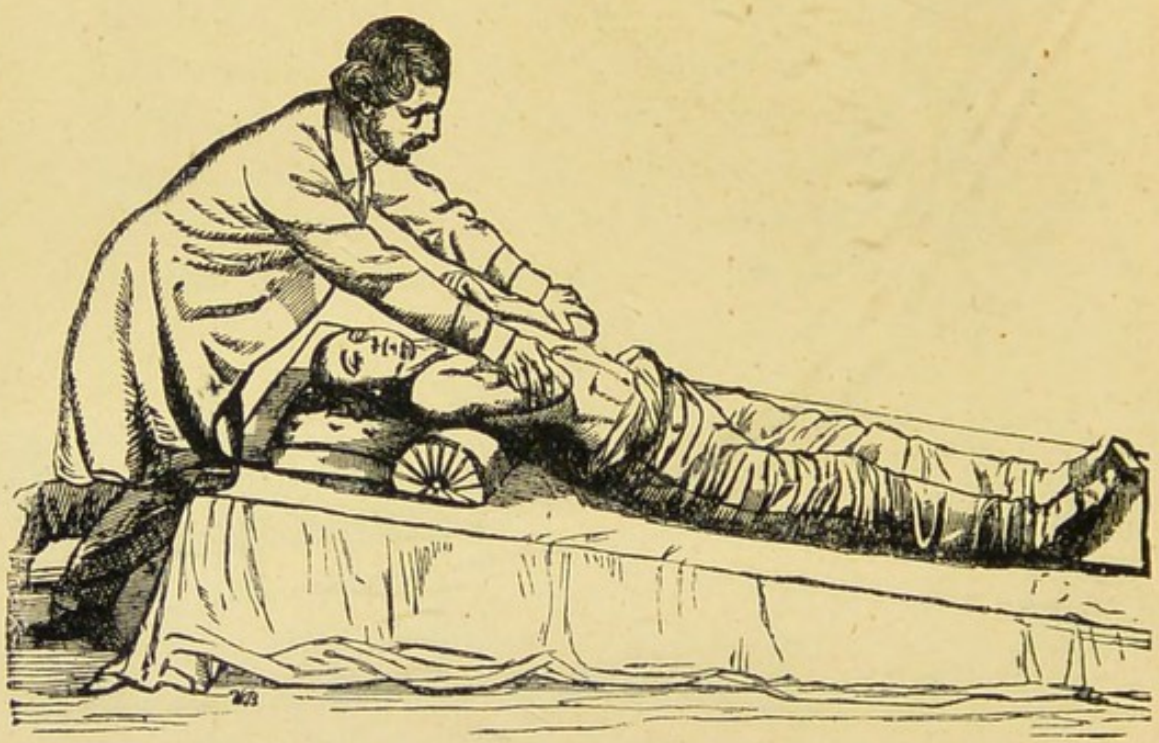


FIG. 24.

EXPIRATION.—SYLVESTER'S METHOD.

lower part of the sternum, for the resilience of the thoracic walls is there greatest; and pressure on the abdomen at the same time is not to be omitted, or the diaphragm will descend and counteract the benefits derived from the pressure made on the lower part of the chest.

"*The Sylvester method of artificial respiration*, which

is by far the most effectual mode of obtaining an interchange of the pulmonary gases, is performed by alternately raising and depressing the arms, as exemplified in Figs. 23, 24 on pages 101 and 102, which themselves describe the mode of procedure more plainly than words can. As is observed in the figure, the patient's shoulders are not only well raised, but his head (as Dr. Howard suggested) thrown well back. On bringing down the patient's arms they should be gently and firmly pressed against the sides of the chest, so as still further to diminish the cavity of the thorax. This pressure can be exercised with greater facility and equal effect by pressing the arms on the lower third of the sternum. By alternating the movements of the arms and pressure of this kind, a regular exchange of air can be produced, varying in quantity from thirty to fifty cubic inches, an amount more than is requisite for the purposes of resuscitation.

"If there be sufficient assistance at hand, the Sylvester method ought to be employed in all cases in which artificial respiration is considered necessary. This process is performed about twenty times in the minute, until natural respiration is returning, when simple manual pressure will be sufficient to aid the expirations. It should be persevered in until there is absolutely no hope remaining.

"The Howard method of artificial respiration differs from the preceding inasmuch as the object is to force air out of the chest by direct pressure applied to the thorax, whereas in the Sylvester

method the air is forcibly inhaled and expelled by raising and depressing the ribs.

"The patient is laid upon his back with a cushion under his loins, this throws the head back and makes the lower ribs prominent. The arms are then drawn up over the head, crossed, and held in that position by an assistant, who also takes charge of the tongue and keeps it well forward. The anæsthetist then kneels on the ground with the

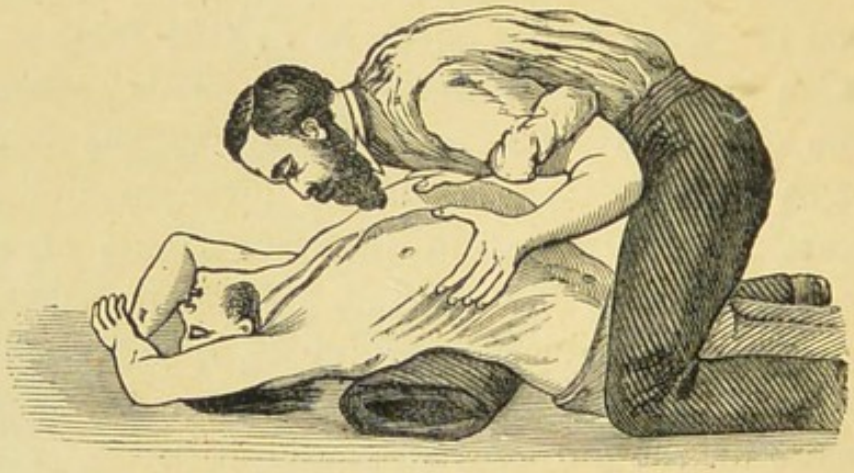


FIG. 25.

EXPIRATION—HOWARD'S METHOD.

patient's thighs between his two knees. The hands are then placed spread out widely on either side of the lower part of the chest, the thumbs being upon the epigastrium. He then bends forwards with all his weight upon the ribs and attempts to squeeze his hands together, and remains in this position whilst he slowly counts one, two, three; he then, with a sudden push away from the thorax, resumes his kneeling position; he then counts one, two, slowly

to himself, and reapplies the pressure. These movements are repeated until either the breathing is re-established, or there is no hope left.

Should no air enter the thorax upon trying either of these methods, it must not be forgotton that a foreign body, such as a tooth, clot of blood, etc., may

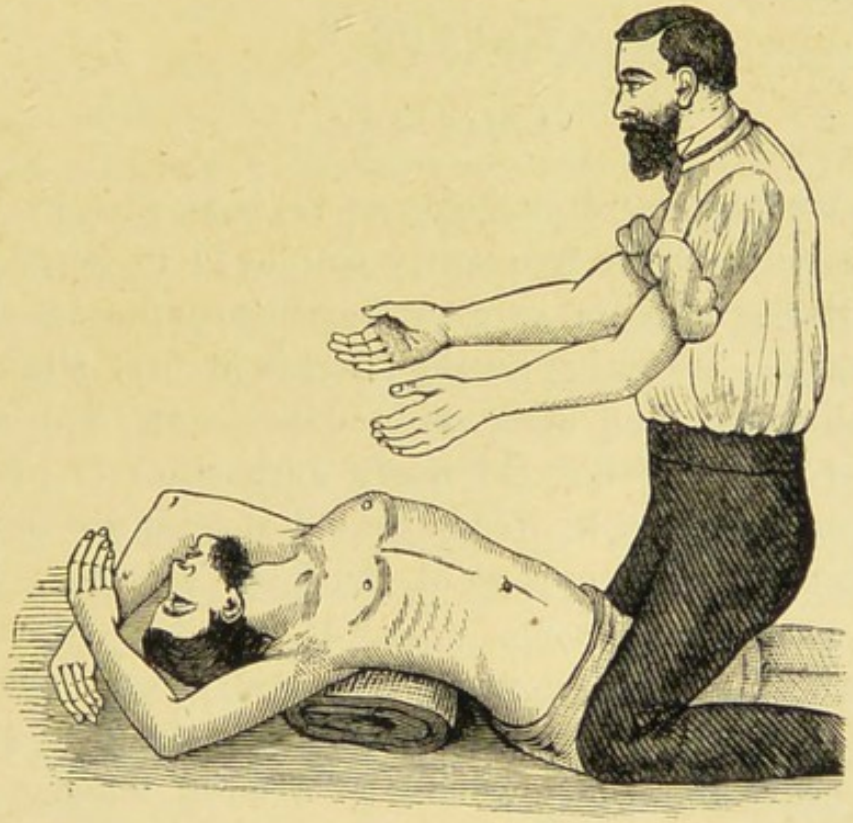


FIG. 26.
INSPIRATION—HOWARD'S METHOD.

have become impacted in the larynx, or that there may be spasm of the larynx. The administrator must be prepared to do tracheotomy the moment he finds that no air can be got into the chest, and therefore should never give an anæsthetic without having tracheotomy instruments at hand.

CHAPTER VI.

Chloroform.

For lengthy operations chloroform is at present the anæsthetic most frequently employed in Scotland, and its use in dental surgery is almost confined to that country. Its action on the heart is at first slightly stimulating, but afterwards depressant, and this latter influence has led many authorities to prefer the use of ether, in order to avoid at least one source of danger, the stoppage of the heart's action. On the other hand, some contend that few cases of death under chloroform have really been traced directly to the depressing influence of the drug upon the heart and the lowering of arterial tension, but rather to certain defects in the manner of administration. Death has occurred more frequently under chloroform than under ether. This is true, but it must be remembered that it has very rarely occurred when administered in the manner advocated by Sir Joseph Lister and the Scotch school.

The argument in favour of chloroform, as urged by Lister, is that the danger incurred is not due to any effect of the drug upon the heart, but rather to

certain radical errors in the mode of administration. An illustration of the nature of these errors is afforded in the report of the committee on anæsthetics appointed by the British Medical Association. In this report it is stated that to test the effect of chloroform upon the heart, air *saturated* with the vapour was passed through a tube into the trachea. Now, the essential element of safety during inhalation of chloroform is, as will be presently seen, that it should *never be administered above a certain strength*, fixed by Clover at 5 per cent., and by Paul Bert at 8 *grammes of chloroform to* 100 *litres of air.* To experiment, therefore, with a saturated atmosphere is simply to experiment with a poisonous dose.

Methods of Administration.

The methods in use for the administration of chloroform are numerous, from the piece of lint and drop bottle, the simplest of all contrivances, up to the chloroform inhaler elaborately constructed to render the inhalation safer; but no inhaler, however perfect it may be, can do away with the constant care and watchfulness necessary on the part of the anæsthetist. To trust to an inhaler permitting only a certain percentage of chloroform vapour to be breathed, to the working of valves, or indicators to register the respirations, is certain, sooner or later, to be followed by disaster. It may be broadly stated that the method of administering chloroform in dental surgery should be as simple as possible.

The Open Method.—Under this heading we find

several varieties, the most notable being, perhaps, the Scotch method, which is as follows: a towel is so folded that it forms a square of six folds, and a piece about the size of a hand is kept wet with chloroform, the quantity of chloroform poured on being immaterial. The towel is gradually approximated to the patient's face as he becomes accustomed to the vapour, but there should always be a free air space between the towel and the face. The strength of the vapour thus obtained is said by Sir Joseph Lister, not to exceed 4·5 per cent. by weight. When the towel is removed for more chloroform to be added the towel should not at once be replaced close to the face, but gradually approximated as stated above; the reason being, that when the towel is taken away, the patient inspires more deeply because air only is inhaled, and should the towel with fresh chloroform be immediately replaced close to the face, more of the anæsthetic may be inhaled than is necessary and an overdose administered.

Sir Joseph Lister's Method.—A towel is taken, and one edge folded back for an inch or so—it is then gathered up in the shape of a hood, and fixed behind with a safety pin; this pin should be so placed that when the front of the turned-up edge is at the point of the chin, the safety pin is opposite the root of the nose. The administrator holds the towel with the safety pin over the root of the nose, and pours the chloroform on to the convex upper surface of the hood.

At St. Bartholomew's Hospital a piece of lint is taken 12 × 6 inches, and folded in half, making it 6 × 6 inches, as shown in Fig. 27. This is held in the left hand, with the middle finger behind the lint, and the index and ring fingers in front of it. This is laid upon the patient's face, covering the mouth and nose, the middle finger raises the lint somewhat over the nose, allowing passage for air, and the escape of

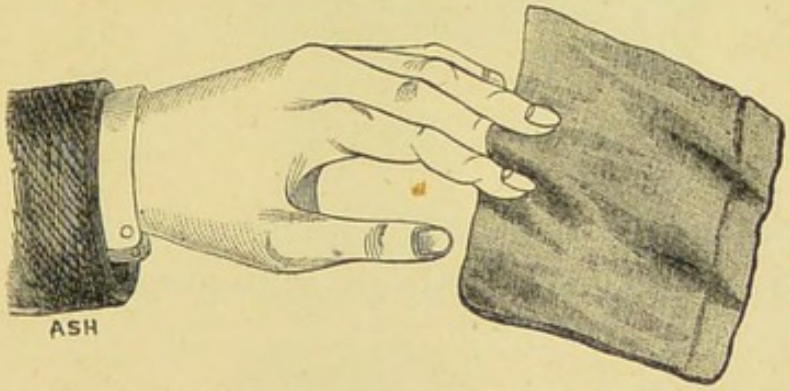


Fig. 27.

exhaled vapour—upon removing the fingers, the lint will remain arched forwards over the nose. Chloroform is dropped upon the lint over the mouth, and then the lint is reversed so that the wet side is downwards. When more chloroform is dropped on, the lint is again reversed, and so on, the lint being reversed by holding it in the manner illustrated. When fresh chloroform is added the lint should be gradually approximated to the face.

At St. Thomas's Hospital two squares of flannel are taken and folded longitudinally—they are then stitched at one end and spread out like a fan at the

other, as in Fig. 28. Chloroform is then dropped on from a drop bottle.

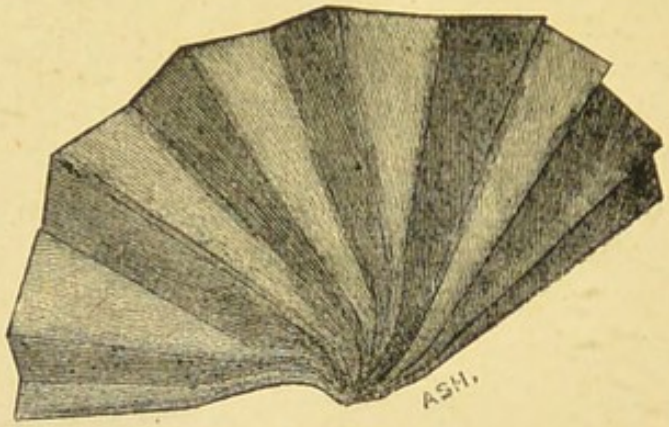


FIG. 28.

Skinner's Mask (Fig. 29).—This consists of an oval framework of wire with an arrangement by which

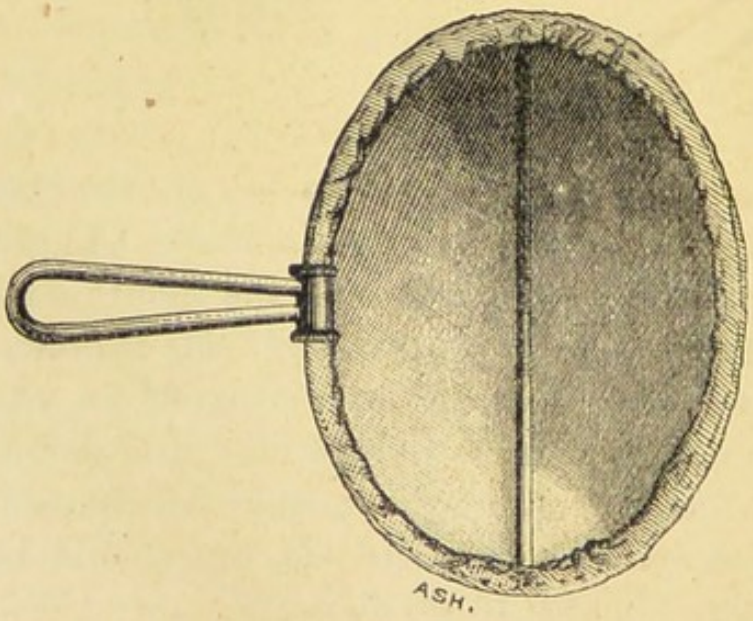


FIG. 29.

the flannel is raised from the patient's face and at the same time rendered tense. A wire handle is

fixed on to the frame to hold it by when in use. Chloroform is dropped on to the flannel from a drop bottle. This inhaler folds up into a very small compass, and can conveniently be carried in the coat pocket.

Murray's Inhaler (Fig. 30).—This consists also of a wire framework, bearing flannel stretched over it, at the summit of which there is generally a small piece of sponge fixed in situ by means of a

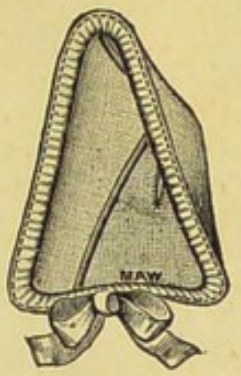


FIG. 30.

pin. The chloroform is poured upon this sponge and the inhaler applied to the patient's face; it should not quite touch it, however, as the flannel around the margins may become wet with chloroform, and so blister the patient's face wherever it may rest.

The Cone.—A simple cone made out of lint is preferred by some administrators, the chloroform being sprinkled either inside or outside the cone.

The Drop Bottle.—Two very convenient forms, out of a large number, are illustrated. Fig. 31 is provided with a bayonet catch and so arranged that chloroform may be carried about in the bottle with-

out any of it being spilt, should the bottle be upset or laid on its side; when it is desired to use it, the catch is freed and then chloroform can be dropped out of the small spout on to the lint, etc. This drop bottle, together with a Skinner's Mask, can be carried about in the coat pocket, making a very

Fig. 31.

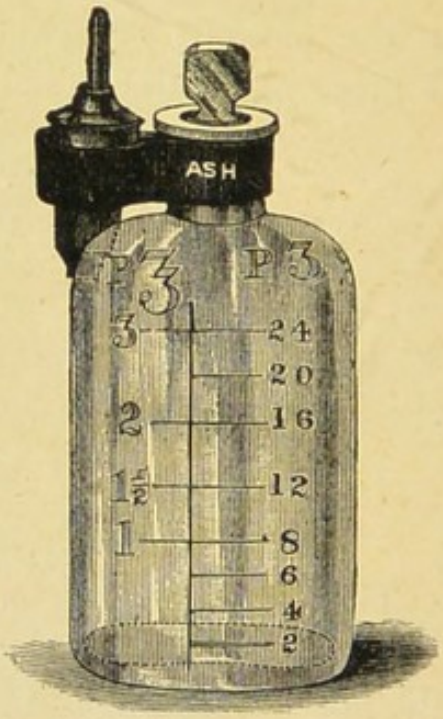


Fig. 32.

efficient chloroform apparatus. Fig. 32 is a much larger bottle, containing three ounces of anæsthetic fluid, and is fitted with a cork containing the dropper. It is made by Messrs. Krohne & Co. A stopper takes the place of the dropper when not in use. It is used in the same way as an ordinary pepper castor. It is very useful for the administration of chloroform and the A. C. E. mixture; in the latter case the dropper may be dispensed with early

in the administration, the stopper used instead and a drachm or so of the A. C. E. mixture poured out as required.

Hyderabad Inhaler (Fig. 33).—Messrs. Krohne & Sesemann are the inventors of a cone inhaler similar to that used by the Hyderabad Commission, but bearing a breathing indicator. It consists of a wire network, covered inside and out with flannel—at

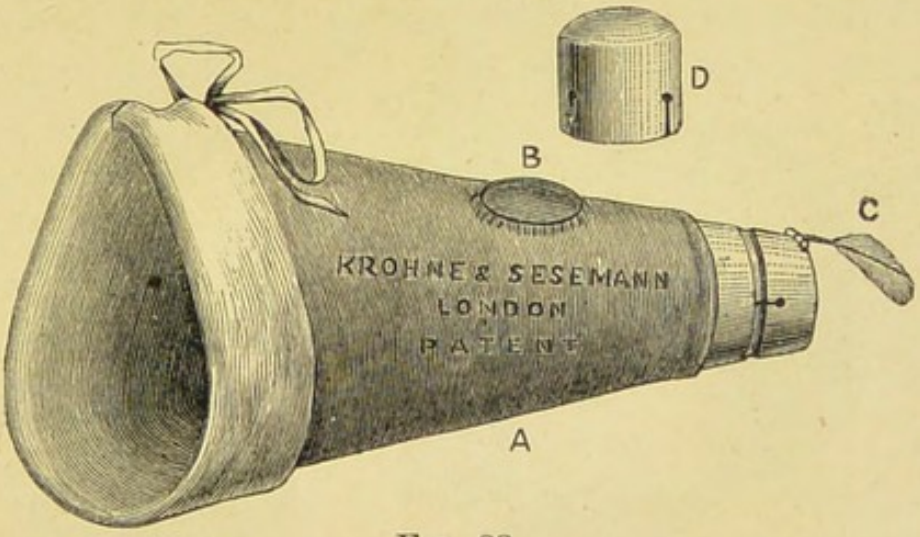


FIG. 33.

the small end of the cone a feather is suspended, and, being very delicately balanced, it shows by its movement that the respirations are continuing. Chloroform is poured on to the inner flannel covering, through an opening for that purpose, situated on the top of the inhaler. During expiration the feather is blown away from the cone, returning again during inspiration. Although this breathing indicator is very useful in those cases where the respirations are too shallow, even to be heard by the administrator, reassuring him by its movements

that air is entering the thorax, yet he should not trust to this sign alone to guide him as to the condition of his patient, but keep also a careful watch over the state of the pupils, the conjunctival reflex, and the colour of the face.

The Junker Inhaler.—An illustration of this useful

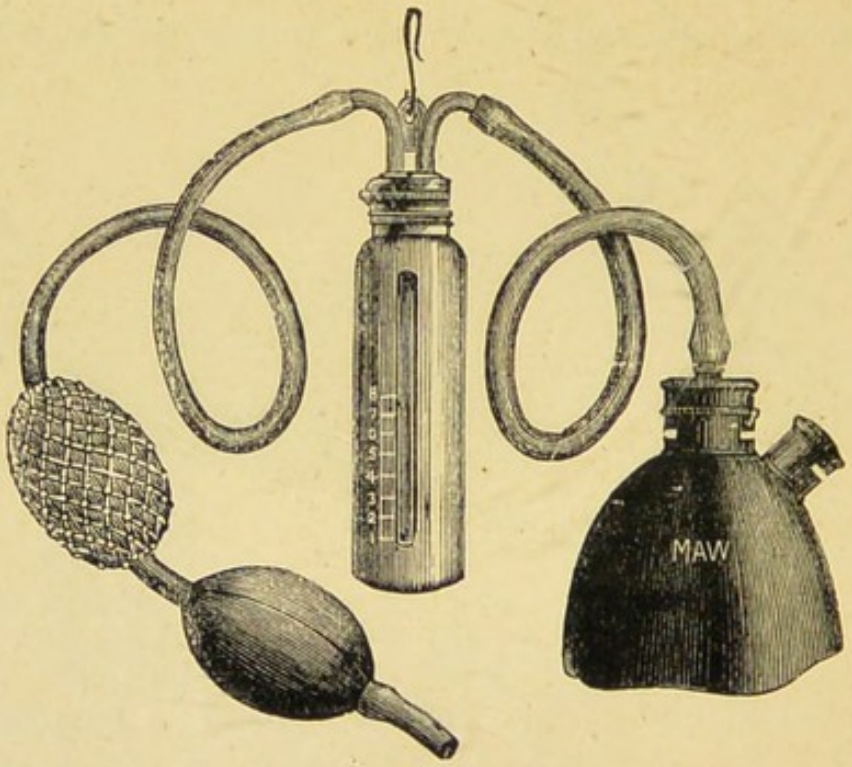


Fig. 34.
Junker's Chloroform Inhaler.

inhaler is given, together with a greatly improved modification of it by Mr. Carter Braine.

The Junker inhaler consists of a cylindrical bottle, graduated in drachms up to one ounce, an apparatus for pumping air into the bottle, and a face-piece. The ingress tube passes nearly to the bottom of the bottle, and the egress tube for chloroform vapour

commences close to the screw stopper. Although the bottle is graduated up to one ounce, yet only four drachms should be poured into it. Air is driven through the chloroform by compression of the hand-bellows, and it then escapes laden with the vapour of chloroform through the tube leading to the face-piece. This face-piece is made of vulcanite and of a convenient shape to fit the face. It should be noticed that there is a mechanism for the admission of air between the face-piece and the fixture of the india-rubber tube leading from the bottle; this valve should be open during the administration, or chloroform may be pumped in until the limit of safety is passed; there is also an expiratory valve fixed to this face-piece, and this must be in working order also before administering.

The objections to this inhaler are :—

1. The tubes are interchangeable, the tube from the bellows may be put on the wrong side of the bottle, and then the compression of the bellows drives fluid chloroform out of the bottle into the face-piece, thereby directly endangering the life of the patient.

2. Should the bottle be tilted on its side during the administration, then again fluid chloroform may be driven into the face-piece or along a nasal tube.

3. That the bottle must always be kept upright when it contains chloroform.

4. Should more than four drachms of chloroform be poured into the bottle, then splashing may occur,

and a spray of chloroform enter the egress tube, instead of air laden with chloroform vapour.

In the modification by Mr. Carter Braine, all these defects are remedied. The tubes cannot be reversed,

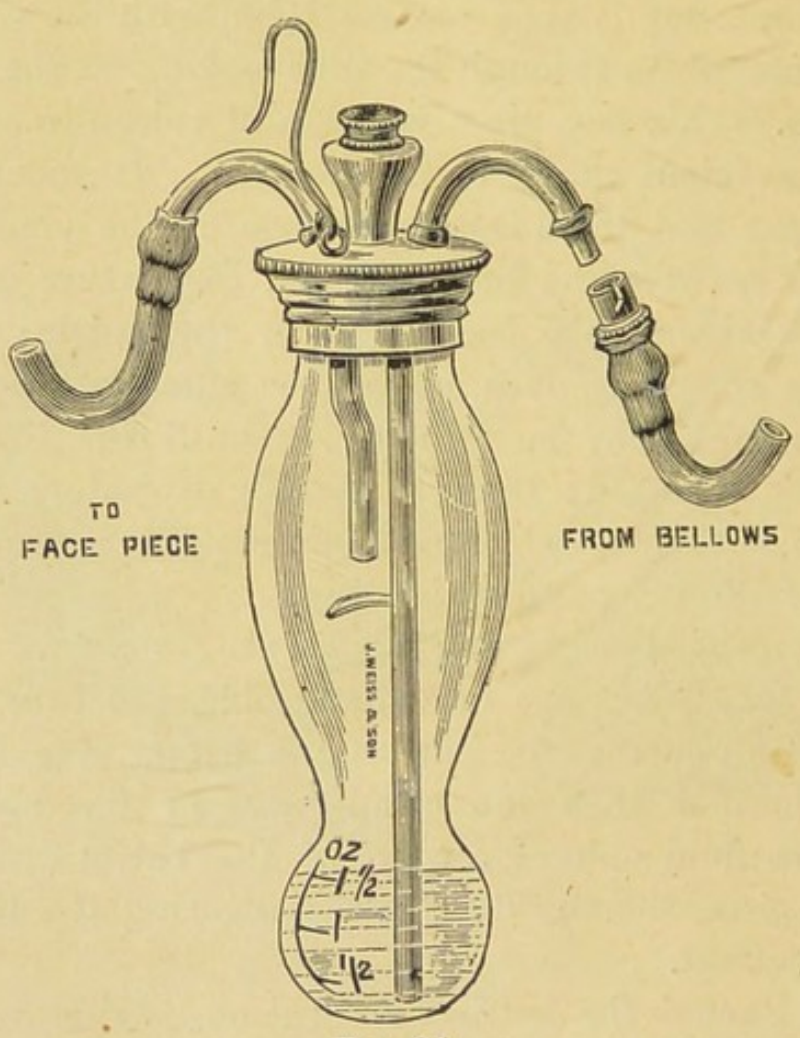


FIG. 35.

JUNKER'S CHLOROFORM INHALER AS MODIFIED BY MR. CARTER BRAINE.

as one is plain and the other is fitted with a bayonet catch; in any position of the inhaler, on its side or completely reversed, no fluid chloroform can be driven out of it, neither can any splashing enter the

egress tube, the convex plate fitted below the shorter tube effectually preventing this catastrophe. Chloroform may be poured in to the amount of one ounce and a half, but never above the constriction between the bulbs; the inhaler may be laid aside until wanted, with perfect safety, as no chloroform can run into the egress tube. It can be placed in the coat pocket or suspended from the button-hole,

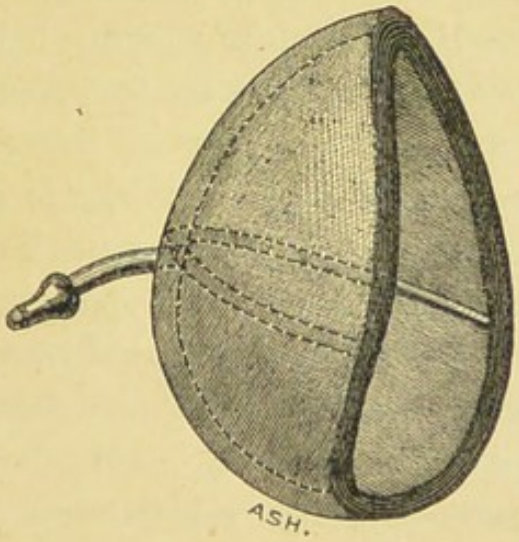


FIG. 36.

operating table or bed. The following face-piece (Fig. 36) made by Krohne & Sesemann is recommended for use with this inhaler.

It consists of a wire framework covered with flannel, the centre wire of which is hollow, and perforated with many small holes, so that upon compressing the hand bellows, the vapour of chloroform escapes through these holes in many directions into the mask, getting well mixed with the air, and avoiding the single large puff of chloroform at every

compression; it also does away with all necessity for valves, as the patient can breathe readily through the flannel.

General Precautions.

When, in a special case, it has been decided that chloroform is the anæsthetic to be administered in preference to ether, either on account of the expressed wish of the patient himself, or by the advice of his medical attendant, who, being aware of any tendency there may be to bronchitis, the presence of an aneurism, or marked degeneration of the vessels, does not desire his patient to be exposed to the irritating vapour of ether, or to the increased arterial tension present when it is administered, then the following precautions should be taken:—

The anæsthetic should be administered at the house of the patient; it is far more comfortable, and a safer proceeding for all parties concerned, when the preparations are made as if for a surgical operation, and the patient is either in bed, or on a sofa, clad only in sleeping apparel and dressing-gown.

The recumbent posture cannot be too earnestly insisted upon; to administer chloroform to a patient seated upright in a chair is to disregard his welfare and imperil his existence.

The chloroform used must be the best of its kind, and obtained from one of the well-known makers; it should be kept in a well-stoppered bottle in a cool place, and not exposed to light (to prevent its decomposing into hydrochloric acid and chlorine).

The time necessary to produce anæsthesia varies greatly, but from five to eight minutes may be taken as the average; it is not safe to render the patient insensible within the period of two and a half minutes, the average time taken when nitrous oxide and ether are administered.

The preparation of the patient with regard to abstinence from food is the same as for ether administration, to the chapter on which the reader is referred.

Strict silence should be observed during the earlier part of the administration; there should be no talking about the operation, its difficulties, etc., nor even upon matters quite foreign to the case, and all moving about of instruments must be postponed until the patient is unconscious.

The inhalation of chloroform is more pleasant for the patient when it is administered gradually; a few drops upon the lint are quite sufficient to commence with, and the quantity of chloroform increased by successive drops so long as breathing is free and regular. Upon the occurrence of coughing, the chloroform should be lifted a little from the face, and more air allowed, as the vapour is probably of greater strength than the patient can breathe comfortably or with safety. In a couple of minutes or so, the second stage of anæsthesia is produced, and the patient no longer knows what is taking place around him, and is apt, on the occurrence of any noise or talking in the room, to become excited and call out; an officer, for instance, may shout out

words of command, and an auctioneer commence selling goods. Struggling may also take place, and then the administration must be carried on with great caution; a young and well-built adult will often take several rapid and deep inspirations and then hold his breath whilst he struggles, and thereby a large quantity of chloroform is drawn into his lungs and its elimination prevented. This of itself is a source of danger, but the really critical moment is just after the struggle, when a forced expiration, followed by a very deep inspiration, results in a very large quantity of the drug entering the lungs, at the termination of which another forced expiration, followed by a very deep inspiration, occurs, and again a large quantity of chloroform taken; under such circumstances if the inhaler is not removed an overdose is very apt to be taken.

According to Dr. Snow's investigations, eighteen minims of chloroform in the blood produces anæsthesia sufficient for surgical purposes, and double this quantity, viz., thirty-six minims, paralyses the respiratory and circulatory centres in the medulla.

In the third stage of anæsthesia, the excitement and struggling fade away and there is a tendency for the voluntary muscles to become rigid; the pupils are as a rule of medium size and react to light; the muscles then gradually relax, the patient enters a deep sleep, and there is no response to sensory stimuli.

The conjunctival reflex persists until late in this stage; this third stage of anæsthesia is termed the

surgical stage, and is that in which almost all operations take place. In the fourth stage of anæsthesia stertorous breathing is present, a widely dilated pupil not reacting to light, an insensitive conjunctiva followed by relaxation of the sphincters; this stage of anæsthesia should never be approached in dental surgery, but be regarded when it does occur as overdosage, and means taken to remedy it.

The fitness of the patient for operation may be ascertained by—

1. Deep regular breathing with stertor.
2. Flaccidity of the muscles.
3. Loss of conjunctival reflex.

As a rule the stertorous breathing, and the flaccidity of the muscles are sufficient signs that the operation may be commenced, and it is not necessary to abolish the conjunctival reflex. It may be stated as a cardinal rule, that when the conjunctival reflex is lost, the chloroform should be withdrawn until its reappearance.

Never permit the operation to be commenced before the patient is well under the influence of the anæsthetic. This is of the utmost importance, because upon examination of the recorded deaths from chloroform, it is found that the vast majority have happened early in the administration, and when the operation has been a comparative trivial one, such as teeth extraction, opening abscesses, dressing of wounds, amputation of finger, etc.; and that no sooner had the operation commenced than cardiac failure ensued. Sometimes it is stated that the

patient moved the moment the knife pierced the skin, so that there is no doubt that some of these cases were not sufficiently anæsthetised, and that death resulted not from chloroform but from want of its proper administration. The following cases may be quoted verbatim as illustrating the above statements:—

"A peculiar and interesting fact, and one that I am inclined to think may account for many deaths, is, that in some individuals when fully under the influence of chloroform the pulse suddenly fails at the moment the first incision is made by the surgeon, and this, too, when the respiration is altogether natural. The first time I observed this peculiarity was in Oct. 1851; the subject was a sickly, emaciated boy about nine, requiring amputation of the thigh on account of an exhaustive disease of the tibia. He was quickly brought under the influence of chloroform, and was breathing well when Mr. Syme transfixed the limb. I had my hand on the pulse, and was carefully watching it. At the moment the knife entered it suddenly ceased, and remained imperceptible for a period of four or five pulsations, the countenance at the same time becoming deadly pale. As it returned it was at first very feeble, but in a few seconds it regained its usual strength. The breathing at the same time was very soft and quiet. Anæsthesia was maintained, and no further untoward event occurred."

"The next case was that of a young lady about eighteen or twenty years of age, whose thigh

Mr. Syme amputated in November last. Dr. Simpson administered the chloroform, and after the operation remarked that the pulse had stopped suddenly just as the knife was piercing the thigh, and had recovered itself with a flutter almost immediately."

"A third instance occurred soon afterwards on the 10th of December, 1851. A woman about forty, of pale, emaciated appearance and nervous, excitable temperament, was placed upon the operating table and inhaled chloroform. She inhaled it well, and was soon insensible, breathing stertorously; then the operation (amputation of the thigh) was begun, and at the same instant the pulse stopped, and did not return for eight or ten seconds, when it was again felt as very faint and indistinct. It rapidly regained its force, and before another minute had elapsed, was as strong as before the operation. During this occasion the breathing did not flag at all, and had it not been for a slightly-increased pallor of the countenance, no visible change might have been observed." . . . .

Citing another case, the same author says, quoting Mr. Stanley, of St. Bartholomew's Hospital: "A few minutes afterwards I commenced the operation by an elliptical incision through the skin, circumscribing the portion of the cheek which I intended to remove. Directly this was done my assistants, who were watching the pulse at the wrist, reported that it could not be felt." In this case it returned, and with its return the patient recovered.

A man, twenty-three years of age, inhaled

chloroform, and in a few minutes insensibility was produced (after some struggling). "The operation was then commenced, but no sooner had Mr. Lloyd cut through the skin than it was stated that the pulse had suddenly ceased." *

Mr. Bickersteth concludes very rightly that this stoppage of the heart was due to shock and not to chloroform; but he is puzzled by these two facts: first, that in the case of Mr. Stanley, no syncope had taken place during a previous severe operation without chloroform; and secondly, that in Mr. Lloyd's case, a more serious operation under chloroform was performed upon the patient without syncope. Dr. Lauder Brunton's observations show the reason why these are not difficulties; in both cases, no doubt, only enough chloroform had been given to paralyse the acceleratory cardiac nerves, leaving the inhibitory open to stimulus.

In the following paragraph Mr. Bickersteth very strongly enunciates the doctrine, so much insisted upon by Lister in later years, that the pulse is no safe guide :—

"But the pulse should not be taken as any guide during the administration of chloroform. It should be wholly disregarded, except under certain circumstances when syncope is feared from loss of blood during the performance of capital operations. The pulse is only affected secondarily in consequence of the failure of the respiration. It follows, therefore, that our attention should be mainly directed to the

* Bickersteth, Ed. *Monthly Journal*, 1853, vol. xvii. p. 220.

latter, while the former may be altogether neglected, or at any rate regarded as only of secondary importance. By carefully watching the pulse the attention must in a measure be taken away from the respiration, and exactly to such a degree it is productive of evil; for in order to guard against mishaps, and at the same time conduct the inhalation with confidence, the breathing must be observed with the greatest care and attention."

The respirations must be carefully watched, and directly they become irregular or hampered, the chloroform must be discontinued and the cause of the impediment found and remedied; in all probability this will be due to the falling back of the tongue, or to the approximation of the aryteno-epiglottidean folds and the falling back of the epiglottis—the forcible drawing forwards of the tongue with forceps will at once re-establish regular breathing.

The rhythmical upheaving of the chest is not an infallible sign that breathing is normal, as it continues even when no air is entering the thorax, and, therefore, the administrator when in doubt must assure himself, either by listening for the respirations or by feeling the warm expiratory puff on his hand or cheek, that respiration is really continuing.

Lister (*loc. cit.*) quotes two cases of great interest as illustrating this point:—

1. "As an example of the risk that is run by want of close attention to the respiration, I may mention the following case. A surgeon of considerable experience was giving chloroform to a patient, on

whom an operation was being performed, of which I was a mere spectator; but I noticed that stertorous breathing came on and gradually passed into complete obstruction at a time when the administrator was gazing with interest upon the proceedings of the operator. Seeing that the patient was in danger, I suggested to the giver of the chloroform the propriety of pulling forward the tongue. He replied that this was uncalled for, and pointed to the heavings of the chest as evidence that breathing was proceeding freely. Knowing from what had gone before that those efforts were doing nothing for the respiratory function, and feeling that there was no time for discussion, I stepped out of my province so far as to seize the tongue myself and draw it forward, when a long and loudly stertorous inspiration demonstrated the necessity for the interference. Had the delusive movements of the chest been trusted, it is probable that they might have continued till the heart had become so enfeebled by the asphyxial state as to cause no perceptible pulse at the wrist; and had death occurred under these circumstances, the case would have been set down as one in which the circulation failed before the respiration. The administrator would thus have been absolved from all blame; and the fatal event would have been attributed to idiosyncrasy, or to any heart disease which might have been discovered on post-mortem inspection."

2. "An incident which occurred during my Glasgow incumbency illustrates so strikingly both the

value of drawing forward the tongue and the relations of the circulation and respiration to chloroform, that it seems right to place it on record. One of my colleagues in the infirmary had been making an attempt to reduce a dislocation by means of the pulleys, chloroform having been given very fully by the house surgeon, who at the close of the performance removed the cloth from the patient, and proceeded to attend to other matters. Happening to be present, and observing that the respiration was deeply stertorous, I watched it carefully and noticed that it passed almost immediately into complete obstruction, though still accompanied by the movements of the thorax, the face meanwhile becoming markedly livid. Unwilling to interfere, and seeing the carotid pulsation conspicuous in the neck, I waited awhile, hoping that the obstacle to the breathing would disappear spontaneously. But instead of this I soon saw, to my horror, the lividity give place to what I knew physiologically to be identical with *post-mortem pallor*. I now rushed forward and drew the tongue out firmly with the artery forceps; air at once passed into the chest, and the man was rescued."

Besides keeping watch over the respirations, the colour of the face should be noted, extreme pallor of the face and mucous membranes indicating cardiac failure, and cyanosis indicating the want of more air. The sensitiveness of the conjunctiva must be tested occasionally, and chloroform discontinued when the reflex is lost. The pupils also are a

valuable guide to the administrator: in the early part of the inhalation they generally dilate a little, probably from excitement; in the surgical stage of anæsthesia they are, as a rule, of medium size and react to light, and they become widely dilated when an overdose is administered, or syncope is imminent.

The pupils will also dilate when pain is felt or sickness is threatening, but in such a case the light reflex is present, together with the conjunctival reflex; they then indicate that more chloroform is necessary.

Syncope.—The advent of this alarming complication under chloroform calls for prompt treatment. The symptoms are marked pallor of the countenance, widely-dilated pupils, shallow respirations, a scarcely perceptible pulse and clamminess of the surface. The onset of these symptoms frequently give no warning to the administrator, occurring with great suddenness.

Treatment.—Stop the administration, and lower the head to facilitate the blood-current to the centres in the brain. When a patient is upon a table this can readily be done by pulling him or her down by the feet until the ham is over the end of the table, then flex the legs and let an assistant hold them, and tilt the table up till it stands on end, and perform artificial respiration by Sylvester's method (see pages 101, 102). In the case of the patient being in bed or upon a couch, then it is better to place him at once upon the floor and commence artificial respiration, as in this position the administrator can work more

effectively. It must not be forgotten in the excitement of the moment to draw the tongue forward. The omission of this precaution might render the other proceedings useless. The chest may be slapped with a wet towel. Mouth-to-mouth inflation has been of service in some cases. A capsule of nitrite of amyl may be broken and held close to the face, and a hot enema containing brandy administered. Brandy, ether, and whiskey have all been injected hypodermically, being stimulants almost invariably at hand. Professor Wood, Philadelphia, has recently (at the Berlin Congress) advocated the hypodermic injection of the tincture of digitalis combined with spir. ammon. aromatici. Great care must be exercised that none of the teeth or stumps fall back into the pharynx, the precautions mentioned in a previous chapter being taken to prevent this mishap, which is the more likely to occur in the recumbent position. The oral spoon is of great advantage in such a case.

The trickling of blood into the pharynx should, during the operation, be prevented by pressure with a sponge on the oozing sockets, and, after the completion of the necessary extractions, by turning the patient on to his side, with the face slightly downwards, so that it may escape from the angle of the mouth. This position can be secured by standing behind the patient and drawing the pillow away from under the head until the edge furthest from the administrator is just under the cheek. The patient should be allowed to sleep off the effects of

the inhalation if there is any tendency to do so; the kindly attention of friends endeavouring to arouse him by talking to him and shaking him should at once be stopped; they may be calmed by being told that sleep is the most natural way of recovery, and that after-effects are absent when it occurs, whereas sickness and headache will ensue if the patient is disturbed. The administrator should not leave his patient until he has shown by some definite sign of consciousness, such as opening the eyes when told to do so, that he is not under the influence of the anæsthetic, nor before there is a fairly good pulse.

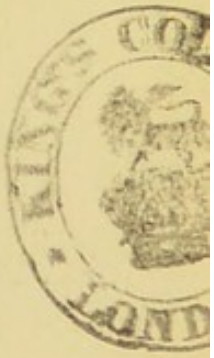
When a patient is anæsthetised in bed, and has to be carried to the operating table and back again to bed upon completion of the operation, the head must always be kept low whilst in transit.

Cessation of Respiration.—It is only necessary here to recapitulate the causes which may account for the embarrassment or the complete stoppage of respiration, as the symptoms and the treatment thereof are fully discussed in the chapter on Ether. They are the falling back of the tongue, approximation of the aryteno-epiglottidean folds of mucous membrane, spasm of the intra-laryngeal muscles, the presence of foreign bodies in the respiratory tract, such as teeth, blood, artificial plates, as well as the more obvious causes occasioned by the fracture of an instrument or prop, and the impaction of the broken-off piece either within the larynx, or in its vicinity.

The much-disputed point as to whether, in cases of death occurring whilst under the influence of chloro-

form, the heart or the function of respiration was primarily affected, cannot be sufficiently discussed, for want of space, in this small work; and, therefore, only the main features of the question will be mentioned.

The Edinburgh School are the staunch advocates for the employment of chloroform as an anæsthetic, and state that, when administered after the plan of Professor Syme, plenty of air and plenty of chloroform, the whole attention devoted to respiration, and the pulse entirely neglected, that then the administration of chloroform is perfectly safe. They deny that there is any such thing as primary cardiac syncope whilst the respirations are normal, maintaining that the function of respiration is the first to give warning of danger, and ceases before the heart's action. They can certainly point to a brilliant record of cases in Scotland.



The Hyderabad Commission, experimenting upon the behaviour of animals under the influence of chloroform, deny the presence of primary cardiac failure, and state that the respirations always ceased first, and that the heart went on beating for a few minutes after.

Surgeon-Major Lawrie, who has had vast experience in the administration of chloroform in India, maintains that this is true in the case of human beings as well as in the lower animals; he denies the existence of any such thing as primary cardiac failure; maintaining that heart failure is always secondary to the failure of respiration.

Unfortunately this is not the experience of the English anæsthetists, men who devote their time purely to the administration of anæsthetics, and through whose hands a considerable number of patients pass annually; they maintain that, although in by far the greater number of cases where complications arise, the function of respiration is alone implicated, yet cases occasionally occur in which cardiac failure and respiratory failure takes place almost simultaneously; but there is a third class, in which primary cardiac failure, irrespective of previous respiratory trouble, is possible.

After-Effects.

Vomiting.—Chloroform owes its popularity with many to the belief that the after-effects are as a rule entirely absent, and that there is not the annoyance and discomfort of nausea and vomiting frequently met with after the administration of ether.

Nevertheless vomiting does occur, and in some cases persists longer than does the vomiting after ether, and cases are met with where retching and vomiting have lasted for two days.

To render vomiting less liable to happen, the rules regarding the preparation of the patient, mentioned under the chapter on Ether, should be attended to; after the operation the patient must be kept quiet and not disturbed. It is useful to darken the room in order to promote sleep, as well as to prevent the eyes resting upon objects in the room, which to a person recovering from anæsthesia frequently appear to be

on the move, and so cause giddiness and faintness. No food should be allowed for at least three hours, and not then, unless the patient desires it; a little beef-tea may afterwards be taken, but no solid food should be given until the next day.

To relieve vomiting, ice may be sucked, or a teaspoonful of hot water swallowed occasionally.

In two cases of severe vomiting, when no drug could be retained by the stomach, the administration of an enema containing bromide of potassium (gr. x.) gave almost instant relief.

A. C. E. Mixture.

This is the only anæsthetic mixture, out of the many in existence, which comes within the scope of this work; all the mixtures contain a certain percentage of chloroform, together with ether or alcohol, or with both of these agents. The idea of mixing alcohol and ether with chloroform would appear to be an attempt to combat the depressing action of chloroform upon the circulation, by administering at the same time with it other anæsthetic drugs, known to be cardiac stimulants; or, in other words, to render the administration of chloroform safer.

The A. C. E. mixture consists of absolute alcohol sp. gr. ·795 one part, chloroform sp. gr. 1·498 two parts, pure ether sp. gr. ·720 three parts (Martindale). The great objection to anæsthetic mixtures is that the ingredients evaporate at different rates, the ether in the above mixture volatilises first, so that when more of the mixture is poured upon the inhaler,

the administrator is working with a greater percentage of chloroform than that with which he commenced; and this fact must always be borne in mind, although drugs of the specific gravities mentioned above are said to evaporate equally.

This mixture is pleasant to inhale, as the ether forms only one half the volume of the mixture, and on account of its containing chloroform also, very little is poured on the inhaler at a time, and so the pungency of the ether vapour is not noticed. A few patients, those who have a horror of the close-fitting facepiece associated with nitrous oxide administration, prefer to inhale this mixture previous to etherisation, as it does away with the feeling of suffocation they experience, when the gas facepiece is applied.

The mixture should be freshly made up as required, and not kept in bulk, in order to prevent alteration of its composition by evaporation through a faulty stopper, &c.

Administration.—The A.C.E. mixture may be given in the same way as chloroform, by the open method, or upon the Skinner's Inhaler, the supply of the anæsthetic being kept up by means of an ordinary drop bottle; by these methods the admission of plenty of air is assured.

Some administrators prefer the ordinary felt cone. The body of the cone is made of felt, covered externally with mackintosh, outside which is a covering of silk. The mackintosh prevents the anæsthetic soaking through the cone. The apex of the cone should contain an opening large enough to admit the

administrator's thumb. A small piece of sponge is placed in the cone close to the apex.

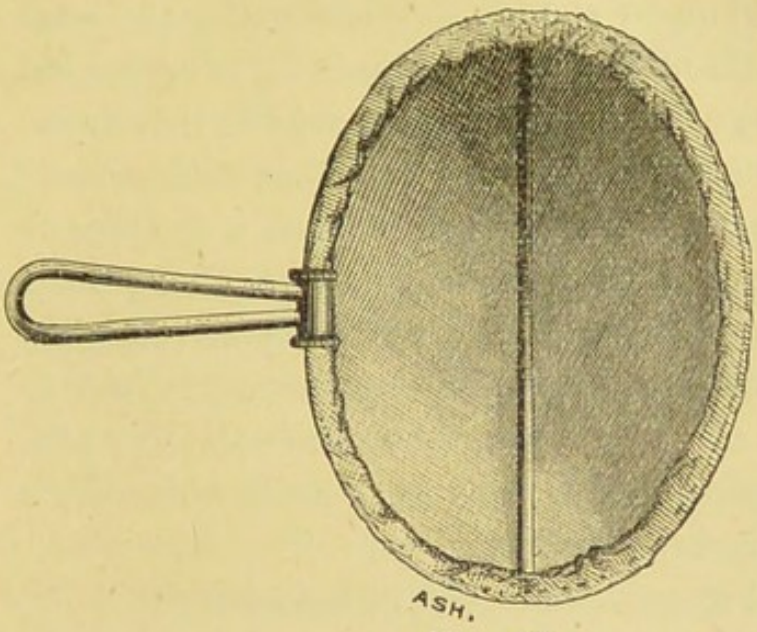


FIG. 37.
SKINNER'S INHALER.

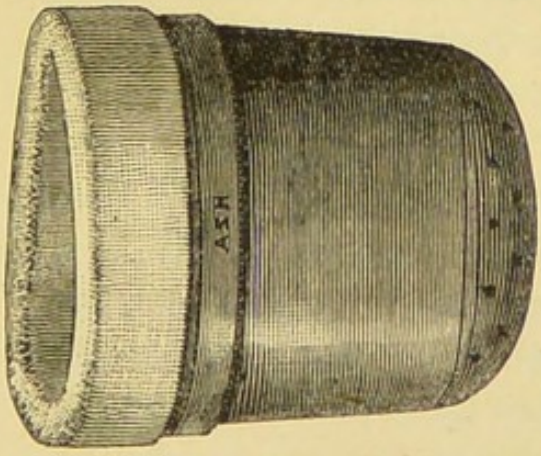


FIG. 39.
RUNDLE'S MASK.

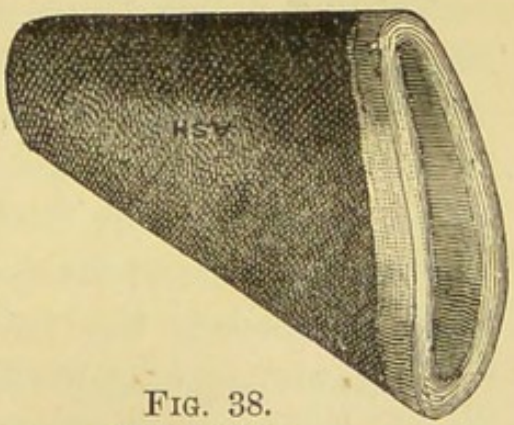


FIG. 38.
FELT CONE.

Rundle's Mask is a very useful contrivance. It consists of a leather mask, one end being shaped to fit

the face, and the other being perforated with numerous holes. Inside this is a flannel lining containing a good open sponge. When using the cone or mask, a little of the anæsthetic fluid is sprinkled upon the sponge and surrounding part of the inhaler, and the inhalation commenced. When the patient has become accustomed to the vapour, a drachm or so may be poured on the sponge at a time, until consciousness is lost. As the mixture contains chloroform, the cone must be occasionally lifted to enable fresh air to be breathed, and all the precautions taken and care exercised as if chloroform were being administered.

The patient should be in the prone position.

Local Anæsthesia.

Nothing seems more tempting in minor surgery than the notion of producing anæsthesia of the part to be operated upon, while the patient's intelligence is unaffected. A large percentage of extractions could be performed with greater certainty if the patient could assist the operator with his intelligence without feeling the pain. Moreover, there is a feeling, unreasoning perhaps, but undoubtedly existing in the minds of many people, that they "hate to be rendered insensible." As a consequence substances are perpetually being brought out for which the power of producing local anæsthesia is claimed. As a rule their fate is to prosper awhile and then sink into disuse. Many years ago we all were wrought up to a great pitch of excitement by the announce-

ment that an electric shock administered at the moment of extraction abolished the sense of pain, and this idea has recently been revived; but nothing came of it, one dental surgeon having recently declared as his personal experience that the pain of the shock was simply so appalling that no extraction could have been worse.

The ether spray, which effected its purpose by freezing the surface and benumbing it with cold, was open to the same objection—the cure was worse than the disease.

Cocaine a few years back became the rage; papers were read by the score, beginning with "The leaves of the *Erythroxylon Coca*," &c., &c., and ending with a list of great marvels. Painted on the gum, it worked great things, but injected it simply annihilated any known pain for a certain time. Then came a few cases of a somewhat alarming character. Its physiological effects were such every now and then that people grew afraid; heart failure, dyspnæa, loss of memory, convulsions, and catalepsy, with many more evils, followed the injection of comparatively mild doses. So that in the end cocaine has been mainly restricted to ophthalmic, aural, nasal, and pharyngeal surgery, in fact to those departments of surgery where the parts are susceptible of the desired effect without injection.

A new preparation has lately been introduced, viz., chloride of ethyl, which is used as a spray; it undoubtedly lowers the sensibility of the parts considerably, and though it does not abolish sensation,

it very materially minimises the pain felt in a fairly brief operation. The brass cap on the end of the glass tube should be removed after the gum surface has been thoroughly dried with chloroform, and the

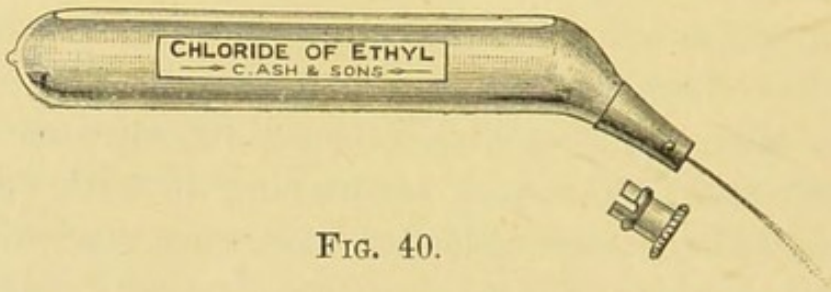


FIG. 40.

thin spray (which the warmth of the hand will soon cause to issue from the tube as soon as the nozzle is lower down than the body of the tube) allowed to play upon the surface of the gum until it becomes white, when the extraction should be performed.

There are many other modes of producing local anæsthesia, but on the whole none have ever come into such general favour as cocaine, and in view of the fact that cocaine has declined in favour (for use during the extraction of teeth), it is hardly an exaggeration to say that there is at present no local agent in very general use. Death has followed the mildest applications of cocaine. Dr. Buxton mentions one case where wool steeped in the drug was inserted in a carious tooth, and another where a one-per cent. solution was used to swab out the larynx, in both cases with a fatal result. It is no wonder that patients and practitioners alike have grown shy of so capricious and dangerous a drug.

CHAPTER VII.

Physiology of Anæsthesia.

The condition of an individual under the full influence of an anæsthetic, that is, the real state of his faculties and the phenomena that he himself experiences during the operation, affords some interesting problems for our consideration, that will well repay a careful investigation. It has been suggested that an anæsthetised person is aware *at the moment* of the pain inflicted, but forgets it instantly, and it is very important to demonstrate the obvious untenability of this proposition. The dread of suffering while unable to protest or explain might well terrify bolder people than the average patient; it cannot, therefore, be labour lost to demonstrate beyond the possibility of doubt, that the power of appreciating pain is one of the very first faculties to be overpowered by the anæsthetic, and that the mental condition of a person fully anæsthetised is one of total absence of thought and feeling. During the induction of anæsthesia, while the faculties are being stupefied one by one, in regular order, and again during recovery, as one by one the great nervous centres awake and resume

their sway, there may be dreams and blunted sensations, and very definite struggles, but these do not take place while the anæsthesia is complete.

Not only is this inquiry into the mental state of the patient easily prosecuted, but it is a matter of primary importance, that the exact nature of the suspension of the faculties induced by the use of anæsthetics should be understood, and, moreover, that the exact order in which the functional activity of the nervous centres is abrogated, should be fully and clearly established. A slight preliminary sketch of the functions of certain nervous centres, in order that the phenomena attending the temporary sleep of any, or all of them, may be better described, will therefore, it is hoped, not be considered unnecessary.

The characteristic functions of the central nervous organs are threefold.

1. *Reflex acts*, or the transmission of the effects of stimulation from afferent to efferent nerve fibres, that is the excitement of some motor fibres in response to a stimulus received by some sensory fibres; as, for instance, when the surface of the body is pricked with a pin, information of the fact is conveyed to the sensory nerve centre by sensory (afferent) fibres, then passed on to the motor centre, and there translated into a stimulus which induces the motor (efferent) fibres to cause certain muscles to contract and remove the injured part from the danger; this is illustrated by the closing of the eyelids when the conjunctiva is touched. It is important to remember that the central organ where this

reflection of the stimulus takes place is not in most cases situated in the brain proper, for reflex actions may be perfectly performed when the great centres of volition and thought are paralysed and even removed; thus a frog after his head is cut off has presumably lost the power of appreciating or avoiding pain, yet if a drop of acid be placed on one leg, he will rub it off with the other because the action has become habitual, and is performed by the spinal tract without any reference to the brain. Again, the act of winking was originally performed deliberately to protect the eye, but it has become so habitual an act that it takes place without the interference of the cerebral centres; in fact, before our higher senses are conscious of the approach of danger a reflex act has already protected the eye from its consequences; the instantaneous wink takes place without the sanction of our brain proper, and even in defiance of a determination to prevent it. When it is known that there is no danger, a friendly hand rapidly approaching the face will cause most people to wink in spite of a firm resolution to keep the eye wide open. Professor Darwin tried to keep his face still in front of the glass cage of a puff-adder while the reptile struck at him, but as soon as it did strike, he involuntarily jumped away, notwithstanding his resolution to remain still.

The movement of the limbs in walking is continued while the brain is quite occupied with other matters, and has even been continued during sleep, for soldiers have been known to fall asleep while

marching. Trousseau relates some very complicated acts performed during a complete epileptic suspension of brain influence. It is plain, then, that when the powers of consciousness, volition, and thought are in abeyance, complicated acts, apparently requiring their guidance, may, if habitual, be perfectly performed by reflex action, although if not habitual they cannot be so performed; secondly, that such acts are continually performed while the intellectual faculties are fully occupied with something else; thirdly, that such reflex acts, being often more rapid and powerful than designed acts, may literally take the intelligence by surprise, and perform themselves in defiance of the strongest efforts of the brain power to prevent them (*cf.* the act of starting, winking, &c.); and fourthly, that in the lower animals they can be performed after removal of the brain proper.

These facts, therefore, clearly demonstrate that although a patient may move, or even struggle slightly during an operation, this movement is not any proof that pain is felt.

Reflex actions are orderly up to a certain point, and are directed to the removal of some definite irritation, or at any rate in response to some definite stimulus; if, however, the stimulus be exaggerated, the reflex action may become disorderly or convulsive, and result in spasm of all the muscles. The great point of importance to the present subject, established by experiment with regard to reflex action, is this, that movements of a definite kind in direct response to stimuli, do not show that the

individual is conscious of the stimulus, but only that the reflex functions are not yet paralysed.

2. *Automatic acts*, which depend on an excitation of the efferent nerve, without any previous stimulus conveyed by an afferent nerve, the whole thing originating at the nerve centre.

3. *Psychical acts*, acts devised by the intelligence.

The principal functions of the nerve centres are the following:—

The functions of the spinal cord, which are chiefly reflex and conducting. All impressions reaching the sensorium from the limbs must travel *viâ* the spinal cord; if, therefore, its functional activity be suspended, reflex action of the limbs and the conduction of impressions from the limbs to the brain are abolished.

The functions of the medulla oblongata, which are of a fourfold nature.

(1.) *The first is that it contains the centre of involuntary respiratory movements*, the so-called "vital spot" or "nœud vital," a limited portion of the floor of the fourth ventricle at the apex of the calamus scriptorius. It is on both sides of the middle line, and injury to either side arrests respiration on that side, while injury to both sides abruptly stops the function, and death ensues.

The activity of this centre depends upon certain essentials.

(*a.*) The presence of oxygenated blood, without which its irritability disappears.

(*b.*) A certain relationship among the gases of the

blood, which relationship acts as a stimulus to the centre. The less oxygen there is in the blood and the more carbonic acid gas, the more intense becomes the action of this centre, until breathing becomes rapid and gasping; the extraordinary muscles of respiration are stimulated, and at last an absolute convulsion takes place, owing to general muscular spasm. These phenomena are called dyspnœa. On the other hand, if the supply of carbonic acid gas be reduced below a certain point, the activity of the centre diminishes, and death from apnœa results.

(2.) *The second is the control of the heart's action.* The centre for the vagus, the inhibitory nerve of the heart (and some think the sympathetic or accelerator centre as well) is in the medulla, as also the vasomotor centre by which the calibre of the small arteries is controlled, also the centre for dilatation of the pupil (the radiating fibres of the iris being supplied by the sympathetic).

(3.) *The third is that it contains the centre for deglutition.* If during the deepest anæsthesia the back of the fauces be touched, deglutition at once takes place.

(4.) *And the fourth is that it contains the centre for mastication and sucking.*

The functions of the cerebellum. This has long been a field of dispute among physiologists and is still far from cleared up. It has, however, been supposed that the principal one is that of co-ordinating the action of the two sides of the body. Paralysis of the cerebellum produces a condition

very like drunkenness; the two halves of the body do not work together, but act independently of each other, and the result is that the legs produce an unsteady gait, the eyes present a double image, and the tongue utters an indistinct speech.

The functions of the ganglia at the base of the brain are generally stated to be of a twofold character.

(1.) *The first is to inhibit reflex action.* When this restraining influence is removed, reflex action becomes much more powerful and violent.

(2.) *The second is to adjust equilibrium.* If the ganglia on one side be injured or removed, unusual and uncontrollable movements are executed, such as rapid rotation of the body, which is possibly due to a sensation of vertigo and a consequent delusion as to the movements of surrounding objects. The true position of objects is appreciated by means of eyesight, and if we alter our position the object appears to do so too; thus, if the object seem to move we move also, under the impression that we are thereby keeping still, hence a movement in the opposite direction, either of the head and body, or of the eyes alone. Now, if an electric current be passed through the base of the brain from left to right, the poles being placed on the mastoid processes, the objects within the field of vision appear to revolve in the direction of the hands of a clock, and therefore an attempt is made to counteract the imaginary movement by an actual movement of the eyes and even of the body in the opposite direction.

The functions of the cortex of the brain. The cortex is generally supposed to be the seat of thought, consciousness, and volition; in short, of all the higher attributes of the animal.

These facts have been demonstrated mainly by—

(*a.*) Comparisons of the attributes of various animals, and the development of their nerve centres.

(*b.*) Investigations of the attributes of animals congenitally defective in portions of the nervous system.

(*c.*) Observations of the losses inflicted by definite lesions of injury or disease upon the nerve centres.

(*d.*) Artificial infliction of cerebral imperfections, such as the experimental removal of portions of the brain substance.

By these and other means the foregoing facts have been demonstrated to be highly probable.

A reflex act, however orderly, must immediately follow the stimulus that causes it. A psychical act, on the contrary, may be the result of stimulus received long before. The storage of this stimulus is "memory." In all probability no stimulus is ever lost, nothing is ever really forgotten, and the most trifling incidents of the distant past are often faithfully revived in dreams, while the repetition at another time and place of some associated stimulus, such as a peculiar scent or sound, will often reproduce faces and words and scenes of long ago that we fancied had faded altogether from our minds. These revivals are very capricious. So much so that it is not the things most familiar to the mind which are

the easiest to revive, but, on the contrary, those that cause a strong impression by their strangeness. Thus it has happened that during delirium the ravings of innocent, pure-minded persons have taken the form of expressions quite foreign to their nature, not because they were in any way familiar, but because heard accidentally, the very strange and unfamiliar sounds had, without their knowing it, made a strong impression upon their brain, unknown to themselves.

It is very important to recollect that the higher centres of the brain exercise a restraining and controlling influence over the reflex actions, for, as we shall see, there is a brief period during anæsthesia when these controlling centres are paralysed, but the reflex power remains active, and under these circumstances the struggles and muscular efforts of a reflex nature are more powerful than they would be were the senses unimpaired and the effort or struggle performed deliberately.

At such a moment a little child will sometimes effect movements that strong men will find a difficulty in restraining, and the convulsions of an adult, whose cerebral control is suspended either by delirium or during incipient anæsthesia, often display an amount of force altogether disproportionate to the apparent physique of the individual.

It is, therefore, to be expected that, as each of the nervous functions becomes overpowered by the anæsthetic, the individual will behave as if he did not possess that particular portion of his nervous system.

The first function paralysed is that of the ganglia of the base of the brain; objects seem to swim round and round, and giddiness supervenes. Then the cerebellum and the cortex of the cerebrum are involved, and co-ordination is lost, and the faculties of will, memory, consciousness, and thought are stupefied. At this stage reflex power is still perfect, and though the patient will make definite struggles, and even cry out if hurt, he is not conscious of the injury, nor will he remember it; his lids still wink when his conjunctiva is touched, but he does not know that it has been touched; a step further and the sensory centres are involved, he no longer possesses reflex but only automatic action, that is, he may struggle and shout, but his movements have no connection with injuries inflicted, or he may struggle when they are not inflicted, and remain passive when they are, because no message of injury is conveyed from the sensory nerve endings to the centres; if the conjunctiva is touched, the lids do not move in consequence, though they may wink, and any other movement may be performed independently of any injury received. Next in order the motor centres are affected, and there is no power of movement save such as may have its origin in the medulla (respiration, deglutition, and the action of the heart are still in full reflex working order); if asphyxia be induced, the extraordinary muscles of respiration will be called into play; if the fauces be tickled, deglutition will be performed. Suppose the anæs-

thetic be pushed, respiration and the heart's beat will continue, but they will not be affected by external stimuli; a stage further and the motor centres of the medulla will be paralysed and death will ensue. The order of recovery is the exact inverse of the order of paralysis, and during recovery there is a stage when the reflex actions of the system have revived, and definite struggles follow definite injuries. If the pain produced by the operation be prolonged till the awakening of the powers of memory, the patient's dreams will be affected, and the patient, who will probably think he has felt the whole operation, will find himself struggling, while the rapid energies of fancy will fill up the picture. On one occasion in which the gag slipped, and nothing was done save an ineffectual attempt to open the mouth, the patient awoke, thinking she had felt the whole operation, *although no operation had taken place.*

On another occasion the well-directed efforts of the patient to seize the forceps caused the operator to desist, and after a few moments' silence, the patient awoke, utterly ignorant of the fact that he had struggled at all.

During the few brief moments of recovery of cerebral power, very exact dreams may be formed from very small exciting causes. The prepossession just before becoming unconscious, that something is about to happen, say the extraction of a tooth, or even a casual word during recovery, coupled with the removal of the gag, is quite sufficient for the

patient's fancy to build upon. It has been abundantly proved that hardly any time is requisite for long and circumstantial waking dreams to be elaborated, and the only secret for avoiding this is not to interfere at all with the patient during the interval between the recovery of reflex power and the awakening of the intelligence. It is during this interval that the patient's "recollections" of the operation are formed, and it is partly upon the operator's abstinence from interference at this juncture that the comfort of the patient greatly depends.

The stages of anæsthesia may be tabulated thus:

1. *Stage of giddiness.* The ganglia of the base partly affected, volition and thought deranged, hearing acute, reflex action perfect, innervation of heart complete (inhibitory "vagus" and accelerator "sympathetic" unaffected); pain inflicted now will produce violent struggles, cause excited fancies, and arouse the patient.

2. *Stage of incipient anæsthesia.* Cortex, ganglia, at the base, and cerebellum paralysed, *i.e.* volition, thought, consciousness, and co-ordination lost, sympathetic (acceleratory) nerve to heart paralysed, inhibitory vagus intact, reflex action intact; an injury now may stop the heart's action, and will probably produce very violent struggles; but if desisted from, the patient will not remember the struggle on recovering.

3. *Stage of sensory paralysis.* Reflex action is lost because the sensory system can no longer convey

the stimulus, and as the injury will not, therefore, be communicated to the vagus, the heart will not be affected. There may be struggles, twitchings of the extremities, rhythmical movements, noises, &c., but these are not in any relation to injury inflicted, but are independent of it.

4. *Stage of total paralysis*, of everything except the essential centres of the medulla. The only movements now are those of respiration and of the heart's action. Beyond this stage death ensues.

The process of recovery is a simple reversal of these four stages; the struggles and twitchings re-commence; the vagus and sympathetic nerves recover their powers; one by one the faculties of life awake, until the whole animal economy is restored to perfect working order. During this revival the several stages, with their special conditions of the nervous system, are precisely similar to those into which the production of anæsthesia has been subdivided (save that they occur in the reverse order), and the same precautions must be observed in each stage.

It remains to be stated, in this connection, that our knowledge of the physiological action of anæsthetics is sadly deficient in one important direction. We have only very imperfect data to go upon, as regards the condition of the cerebral vessels, during the exhibition of various anæsthetic agents. For instance, in the case of chloroform and ether, the vascular condition has been observed to differ to such an extent, that our choice of these

agents, for particular cases, would be very seriously modified were we practically acquainted with the true cause.

The facts at present in our possession are, briefly stated, the following :—

1. If the supply of blood to the brain be arrested, from whatever cause, anæsthesia will be one of the results (anæsthesia due to anæmia).

2. If, on the other hand, the escape of blood from the brain be in any way impeded anæsthesia will be a consequence of this condition (anæsthesia due to hyperæmia).

3. If the quantity of the blood supplied to the brain remain unchanged, but its nature be so altered that it is no longer capable of nutrifying the brain tissue, anæsthesia will ensue.

4. Any considerable alteration in the vascular condition of the brain is attended by anæsthesia.

5. Lastly, it has been possible in many cases to observe the vascular condition of the brain during sleep, during anæsthesia arising from shock, and during anæsthesia produced by the inhalation of anæsthetics, in individuals whose brain surface has been accidentally exposed to view; and the result of these observations has been to show that a vascular change always accompanies such anæsthesia. Professor Carpenter, in his 'Mental Physiology,' 1876, p. 572, strongly inclines to the view that the anæsthesia accompanying sleep is dependent upon "a reduction of the enormous blood supply which is essential to the functional activity of the brain, and

that this reduction is affected by the control which the vaso-motor system of nerves has over the calibre of the arteries." On the same page he quotes an experiment in which Dr. A. Fleming produced a condition closely resembling sleep by compression of the carotid.

Sleep, which is the most natural and free from risk of all the anæsthetic states, is attended with (and probably caused by) a diminution of blood pressure in the brain, consequent on a contraction of the small arterioles under the influence of the vaso-motor or sympathetic nerves.

Let us now consider an experiment quoted by Dr. Carpenter from 'Guy's Hospital Reports,' 1860, p. 153:—

"In the experimental inquiries of Mr. A. Durham, made by removing (under chloroform) a portion of the skull of a dog, so as to expose the cortical layer of the cerebrum, it was observed that as the effects of the chloroform passed off, and the animal sank into a natural sleep, the surface of the brain, which had previously been tinged with blood and inclined to rise into the opening through the bone, became pale, and sank below its level. On the animal being roused after a time a blush seemed to start over the surface of the brain, which again rose into the opening through the bone. And as the animal was more and more excited, the brain surface became more and more tinged with blood, numerous vessels which were invisible during the sleep being now conspicuous, and those before visible being greatly

distended. After a short time the animal was fed; and when it again sank into repose these vessels contracted again, and the surface of the brain became as pale as before."

Here, then, two anæsthetic states are observed, the one due to chloroform accompanied by cerebral hyperæmia, the other that of sleep, an anæmic state; but we do not know how the chloroform was given, what strength, what quantity, and the absence of these facts robs the statement of much of its value.

Note on the Effects of Shock.

Just as we were going to press with the last pages of this book, a case came under our observation which seemed so full of useful warning, to practitioners as well as anæsthetists, that it has been inserted at the risk of appearing a somewhat irregular and even irrelevant addition to these notes.

It is stated that irritation of the fifth nerve is especially liable to be followed by shock, and that after the extraction of many teeth at one sitting alarming symptoms are sometimes met with.

A lady, about thirty-five years of age, requiring a number of teeth extracting, and wishing it all to be effected at one administration, decided to take N_2O and Ether. The anæsthetic was borne very well, and the operation was very protracted, the time occupied from the commencement of inhalation to the completion of the operation being forty-five minutes. The patient recovered and vomited a

quantity of blood that had been swallowed. She then relapsed into a semi-conscious condition, the hands and ears became bluish and the pulse scarcely perceptible, pupils not re-acting to light, surface cold. She was then laid upon a sofa with the foot end raised, and covered with rugs, &c.; in this position she gradually recovered, but was not allowed to sit up for one hour.

The upper jaw was cleared of stumps and teeth, and four were removed from the lower.

The moral of this somewhat alarming sequence of events seems to point against such a prolonged series of shocks to the fifth nerve.

With this case our second edition must close. We trust that it may prove of practical service to many of our *confrères.*

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