Anaesthetics : their uses and administration.

ANÆSTHETICS

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THEIR

USES AND ADMINISTRATION

BY

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PREFACE TO SECOND EDITION.

In the present edition the bulk of the matter has been recast, and materially added to, with a view to increase its utility. The uniformly kind and suggestive criticisms of the first edition have aided me, and I have in many cases adopted improvements proposed by correspondents and reviewers, notably by supplying woodcuts of most of the apparatus described. In my former edition, the descriptions were given almost in the *ipsissima verba* of the inventors, as it appeared to me that they, if anyone, should know how to describe their own ideas. In the present edition these descriptions have, however, been altered to render them it is hoped more plain.

When opinions are at variance about the action of an anæsthetic, or the value of a method, I have endeavoured to present the arguments fairly, but as

the book is intended rather as a practical manual than as a disputatious treatise, all discussions have necessarily been curtailed. While many of the illustrations are original, some are lent by the courtesy of the firms who make the apparatus they depict, or are placed at my disposal by the kindness of professional colleagues, and to all of these I tender my thanks.

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Cavendish Square, W.

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PREFACE TO FIRST EDITION.

The introduction of anæsthetics, which has done so much to rob surgery of its horrors, alike for the patient and the operator, has created a great demand for persons capable of administering these pain-destroying agents, without unfortunately exciting, as a rule, so great a sense of responsibility in the administrator as his difficult and dangerous duties should render obligatory.

It is surprising that surgeons who have witnessed the attempts of novices to give anæsthetics, should hold any view save that no one is capable of safely giving any anæsthetic unless he has been carefully taught and has obtained considerable experience.

Personally, I do not believe that the perusal of any book will enable a medical man to do more than learn the rudiments of anæsthetising; but a book may be of

undoubted service to the thoughtful student or practitioner, in enabling him to appreciate the dangers incident to, the caution necessary in anæsthetising, and to grasp the rationale of the various methods of procedure.

Unfortunately, the subject of anæsthetics has for some years escaped the notice of the scientific side of the profession, and has as a natural result been relegated to the domain of routine.

In this book, which has been written purely from the stand-point of every day practice, I have attempted to indicate that the matter dealt with has a scientific as well as a work-a-day aspect, and that he who desires to be more than a mechanical (and hence dangerous) administrator of anæsthetics, must be scientifically, as well as practically, educated in his art.

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ANÆSTHETICS.

CHAPTER I.

Historical.

Means for producing surgical anæsthesia were practically unknown until Wells introduced nitrous oxide, Morton employed ether, and Simpson chloroform. With the first employment of these three agents commences the history of artificial anæsthesia, although from very early times attempts were made to attain painlessness during surgical operations.

Nepenthes or sedative draughts to relieve severe pain are mentioned in the Odyssey—Helen seeks to "drown all sense of woe" and assuage the sufferings of Menelaus. In Egypt, Cannabis Indica, the modern Haschish, and other drugs, were similarly used. The Assyrians and ancient Chinese seem to have employed various drugs with a view of relieving the pain of wounds and such rough surgery as was practised among them. Opium, Cannabis Indica, carbonic dioxide, and deadly nightshade, were advocated in various forms to achieve this object. Pliny and Dioscorides describe several methods in vogue among the Romans and other nations for benumbing parts subjected to incision and cauterisation. Memphis marble, for example, was finely powdered and applied to the part, while on the addition of vinegar a gas was given off (carbonic

dioxide) which rendered the part slightly anæsthetic. Various members of the Euphorbiaceæ, Mandragora, and Solanaceous plants, were also employed as infusions, which being drunk induced some narcotism. Attempts at anæsthesia by inhalation were very early practised. The Scythians burned Cannabis Indica and inhaled its fumes, to alleviate pain.

In more modern times little advance was made until the present century. Most surgeons were contented to put their patients deeply under opium. In 1661, Greatrakes, a professional "stroker," also practised anæsthetic mesmerism. He performed before Charles II. In a M.S. dated twenty years later, one, Denis Papin, wrote that he possessed the means whereby he could abrogate all painful sensations during a surgical operation, but what his method was, is left unexplained.

In the 16th and 17th centuries Valverdi and others operated upon patients stupefied by compression of the carotid arteries, so depriving the brain of blood. In this practice they seem to have been anticipated by the Assyrians, who are reported to have compressed the vessels of the neck to render painless the operation of circumcision. James Moore, an English surgeon, in 1784 revived a suggestion, originally made by Ambroise Paré, that compression of the nerve-trunks should be practised before cutting the areas supplied by them, and John Hunter actually took advantage of the plan, and amputated a leg in St. George's Hospital after firmly compressing the crural and sciatic nerves. Mr. Moore expressed himself satisfied with the result.

A departure in an entirely new direction was made by Mesmer and his followers, who averred that patients thrown into the "magnetic state" (*i.e.* hypnotised)

could be surgically treated without any pain or inconvenience. Long before Mesmer lived, a belief had been current that the natural magnet possessed powers which were both curative of disease and capable of establishing anæsthesia. Thus Cardan (1584) recounts how the magnet could be employed to abrogate pain. The germs of the facts now known and accepted under the terms animal magnetism or hypnotism bore a fruitful harvest of windy words, Paracelsus, Glocenius, Burgrave, and others, contributing largely thereto. By Anthony Mesmer (born 1734) however, the matter was advanced from theory to practice, and although we may carp at Mesmer as a charlatan and quack, we must accord to him a meed of gratitude for establishing upon a practical basis a science which before his age was lost in useless verbiage. In 1766, Mesmer published his work, "The Influence of the Planets in the Cure of Disease," which maintained that the celestial orbs exercised, by means of "animal magnetism"—an all-pervading fluid, an influence benign or malign on human beings. Fourteen years later, in conjunction with a Jesuit called Father Hell, Mesmer undertook the cure of disease by means at first of the magnet and steel tractors, but finally of manual passes. The plaudits which at first greeted him in Vienna were ere long changed for the most hostile treatment, the learned bodies of his own and other countries treating his writings with contempt and himself with contumely. Leaving Vienna, Mesmer exploited Paris, where he founded the widely famed hospital whereat were treated a great number of patients. In 1785 a royal commission was appointed to enquire into Mesmer's pretentions, but this and subsequent commissions unfortunately con-

fused the issues in question, and while they decided that Mesmer and his immediate adherents were unworthy of credence, they failed to discriminate the substratum of truth underlying their teaching and practice. After Mesmer's downfall the subject was kept before the world by the practice of the Marquis de Puységur and the somnambulists. In 1829, Cloquet amputated a breast, the patient being rendered insensible through having been thrown into the hypnotic state. Elliotson, a firm believer in the practical uses of animal magnetism in surgery, employed it on several occasions with success. Braid, of Manchester, in 1841 made considerable trial of what he called the neurhypnotic trance as a means of producing surgical anæsthesia. Similar experiments were carried out in India by Dr. Esdaile, who performed no less than three hundred operations upon patients in the hypnotic state. Spasmodic attempts have from time to time been made to revive the practice of hypnotism for the induction of anæsthesia with but partial success. It has been found that while only a certain number of persons are capable of being completely hypnotised, even these as a rule require several séances under the hands of the magnetiser before the requisite degree of insensibility to pain is attained. Again, the mental state thus called into existence is in a large number of cases highly prejudicial to physical and moral well-being, and hence the consensus of opinion at present goes rather adversely to the employment of hypnotism in anæsthetic practice, save in very exceptional circumstances and under carefully guarded conditions.

In the 18th century the history of discoveries concerning anæsthetic methods becomes merged in that

of the progress of chemical research. Hales, Lavoisier, Priestley, and Cavendish, opened up rich stores of knowledge by their discoveries among the gases. Oxygen, nitrogen, nitric oxide, were prepared and closely studied, and, in 1772, Priestley added nitrous oxide gas to the list. Pneumatic chemistry, till then unknown, became the absorbing theme among chemists, while physicians sought to bring the recent discoveries to account by pressing these gases into the service of medicine. Dr. Beddoes in 1798, assisted with finances by Wedgwood the renowned potter, inaugurated his Pneumatic Institution at Clifton, where he proposed to treat phthisis and many other diseases by inhalations of various gases.

The Pneumatic Institute is interesting mainly because its first superintendent was Humphry Davy, who prosecuted therein his researches concerning nitrous oxide and other gases. In 1799, Davy discovered that "as nitrous oxide, in its extensive operation, appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Davy substantiated his statements by most careful experiments upon the lower animals, extending Hales' research, which had been confined to mice, and demonstrating many facts the practical uses of which were not appreciated for more than forty years later. But his philosophic mind did not content itself with limiting his experiments here; he actually inhaled the gas and found its influence to assuage the pains of toothache, and in his "Researches" are recorded his own sensations and the behaviour of others after inhaling nitrous oxide gas. Early in the nineteenth century Dr. Hickmann sug-

gested that a painless mode of operating might be achieved by the patients' inhaling carbonic acid gas, but his proposal met with scant favour.

The discovery made by Davy was not brought within the field of practical application until Horace Wells, a dentist of Hartford, Connecticut, conceived the idea of using nitrous oxide gas as an anæsthetic for tooth extraction. Wells went to a popular lecture delivered before the inhabitants of Hartford by a Mr. Colton, an itinerant lecturer on chemistry. During the performance one of the audience inhaled an impure sample of gas and became very excited. In the course of his gyrations this individual wounded his leg but felt no pain, a circumstance of which Wells was not slow to take notice. The following day, Dec. 11th, 1844, Mr. Colton at the request of Wells administered gas to him, and during the ensuing unconsciousness, a Mr. Riggs, another dentist, extracted a molar from Wells' jaw. After successfully employing gas as an anæsthetic among his own patients, Wells essayed a public demonstration in the operating theatre of the Boston General Hospital. The individual upon whom this experiment was tried was not rendered completely unconscious, and gave unequivocal signs of having felt pain. This failure not only ruined Wells, who died in great poverty not long afterwards, but discredited nitrous oxide as an anæsthetic.

Colton subsequently induced various dentists to experiment, and in 1867 he was able to give a record of 20,000 successful cases. In 1868* the anæsthetic pro-

* Colton while in Paris met with a well-known dentist, Dr. Evans, mainly to whose energy and munificence Colton's apparatus travelled to London, where the merits of nitrous oxide gas were brought before the English faculty.

perties of nitrous oxide gas were successfully demonstrated at the Dental Hospital of London, and a committee of the leading English dentists was formed. The two reports published by these gentlemen, and read before the Odontological Society of Great Britain, spoke in warmest praise of the agent, and practically established its claims as a safe and efficient anæsthetic for short operations, in spite of considerable opposition on the part of certain members of the medical profession, who denounced nitrous oxide as dangerous and unsatisfactory.

Ether is said to have been discovered by an Arabian chemist, Djabar Yeber, and its method of manufacture by Dr. Michael Morris. As an anæsthetic, however, it is commonly held to be due to American enterprise. It was fairly well known, and its properties recognised, as early as 1785, when Dr. Pearson, of Birmingham, employed it as an inhalation for asthma, and early in the present century it was used in the treatment of phthisis. In 1818 a paragraph appeared in the *Journal of Science and the Arts*, which although unsigned is generally supposed to have emanated from the pen of Faraday; it runs:—"When the vapour of ether is mixed with common air and inhaled, it produces effects very similar to those occasioned by nitrous oxide." Then follows an account of an experience with ether; a gentleman who inhaled became "lethargic," and so remained for thirty hours. Facts about the narcotic properties of ether were rapidly brought to light, and the writings of Orfila, Brodie, Giacomini, and Christison, all give more or less accurate accounts of the stupefying effects of ether. About the year 1840 it was a common trick at lectures and among medical students to inhale ether-vapour in

order to induce exhilaration. A number of lads were indulging in this pastime in the outskirts of Anderson, S. C., and to stimulate further their mirth seized upon a negro boy and forced him to inhale ether, pressing the vapour upon him until he became deeply narcotised and apparently dead. In an hour, however, to the delight of his tormentors, the negro resumed consciousness. This scene impressed itself so deeply upon one of the lads, named Wilhite, that when three years subsequently he became the pupil of a Dr. Long, of Jefferson, Jackson County, U. S. A., he narrated to him his experiences of ether. As a result Dr. Long in 1842 administered ether to a patient, and while he was narcotised removed a small tumour. The same surgeon employed ether as an anæsthetic on several subsequent occasions with a like success, but somehow the matter did not attract any particular notice. Other medical men also about this time employed ether for surgical anæsthesia. A student named William Clarke, in 1842, administered ether at Rochester, New York, to a patient for tooth extraction, and Dr. Marcy, an American, operated upon an etherised patient in 1844.

However, the employment of ether as an anæsthetic is more usually associated with the name of Morton, a dentist of Boston. William T. G. Morton was a pupil of Horace Wells, and from his master he gathered his first impressions concerning artificial anæsthesia. It would subserve no useful purpose to open up the miserable quarrels and recriminations which have been connected with Morton and his share in the introduction of ether as an anæsthetic. I will, therefore, merely state the facts as far as I can do so without bias, and after reading both sides of the controversy.

Wells made Morton his partner in a dental practice he proposed to start in Boston. The removal from Hartford to Boston was consequent upon a discovery Horace Wells had made of some solder with which he hoped to achieve great things. To confirm his own estimate of the value of this solder he called in a Dr. Jackson, a scientific chemist, who expressed a favourable opinion. However, the partners soon fell out, and Wells returned to Hartford, leaving Morton in Boston. The latter asked Wells for information as to the production of nitrous oxide, and was by him referred to Dr. Jackson. It was suggested by the chemist that trial should be made of sulphuric ether instead of laughing-gas, since it was more easily obtained. Acting upon the suggestion, ether was given and teeth were extracted without pain. This success was followed by a public demonstration, October 17th, 1846, in the Massachusetts General Hospital, when Morton administered ether, and Dr. Warren, a well known surgeon, proceeded to operate. The experiment was repeated, and each time proved a remarkable success.

In England, the first administration of ether took place in Gower Street, London, close to University College Hospital, when Mr. Robertson, a dentist, gave ether and removed some teeth. This took place Dec. 19th, 1846, at the house of Dr. Boot.

On December 21st, Liston amputated through the thigh in University College Hospital, the patient being etherised. Dr. Snow, early in 1847, commenced the successful administration of ether in St. George's Hospital, but upon the introduction of chloroform he gave up ether for its more savoury but less safe rival. On January 19th, 1847, Dr. (afterwards Sir James

Young) Simpson administered ether to a woman in childbirth. Notwithstanding favourable experiences of many, ether was not rendered popular for some years subsequently. The methods in vogue for its administration were far from satisfactory; many patients never got beyond the stage of exhilaration and wild excitement, and their struggles and bacchanalian shouts were pronounced highly embarrassing to the presiding surgeon. These considerations led Liston and other eminent surgeons to regard ether with suspicion, and made them diffident in invoking its aid to their assistance. However, up to the time of Simpson's world-famed pamphlet, *Notice of a new anæsthetic agent as a substitute for sulphuric ether in surgery and midwifery*, November, 1847, ether was slowly but surely winning its way as a safe and trusty anæsthetic. With, however, the introduction of chloroform, came the *coup de grâce* to ether. With an almost incredible rapidity chloroform supplanted her elder sister, not only in Great Britain but almost throughout the world; in America, however, many surgeons still clung to ether. The story of the introduction of chloroform is soon told. Sir James Y. Simpson, not wholly satisfied with ether, in obstetric practice, asked Mr. Waldie, the Master of the Apothecaries' Hall of Liverpool, if he, as a practical pharmacist, knew a substance likely to be of service in producing anæsthesia. Mr. Waldie being acquainted with the composition of "chloric ether," suggested that its "active principle," chloroform, should be prepared from it and used. He never carried out his promise to prepare some, and so the desired substance was obtained in Edinburgh, and Simpson experimenting found its use perfectly satisfactory. This

favourable opinion he expressed in his paper read before the Medico-Chirurgical Society of Edinburgh, Nov. 10th, 1847. On Nov. 15th, 1847, Simpson performed at Edinburgh his first operation, the patient being under the influence of chloroform. It is curious to note how narrowly several persons escaped discovering the value of chloroform as an anæsthetic. Thus, chloric ether, a twelve per cent. solution of chloroform (by volume) in spirits of wine, was employed by Dr. Bigelow, of Boston, but without success. Jacob Bell, of London, however, actually produced insensibility by its use as an inhalation, and Sir William Lawrence the surgeon employed it with some success alike in private and hospital practice. Chloric ether was also used at St. Bartholomew's and the Middlesex Hospitals, but the great uncertainty of its action and the expense of procuring large supplies effectually prevented chloric ether from gaining ground as an anæsthetic. Chloroform was experimentally studied by Flourens in 1847, but no practical uses were made of his work. For some while chloroform was believed to be a "safe anæsthetic," an impression to which the language of Simpson's pamphlet rather lent itself, although certainly no explicit statement to that effect can be found. Unhappily this belief received a rude shock when on January 28th, 1848, a death from chloroform was reported at a place near Newcastle-on-Tyne. This untoward occurrence was soon followed by other deaths, and men's minds became anxious. At this pass Snow, with that earnestness and acumen which characterised all he undertook, commenced his researches into the subject.

In 1848, Snow published his "Experimental papers on narcotic vapours."

Although he improved upon the methods in vogue for the exhibition of ether by the invention of his inhaler, Snow did not advocate at all strongly the merits of that vapour over other narcotics. In 1847 he perfected his chloroform inhaler, being actuated by the belief that this anæsthetic kills through being used in too concentrated a vapour. Snow's experience, like that of most others, made him regard chloroform as dangerous, and so in 1856 he was tempted to investigate amylene, which he found to deserve his good opinion. A Committee appointed by the Royal Medical Chirurgical Society of Great Britain tendered their report in 1864, which strongly insisted upon the danger of chloroform and the inconvenience of ether as then administered. Therein were embodied many suggestions, some of which Clover, who had then achieved a high reputation as an anæsthetist, was not slow in carrying to a practical issue. In 1862 he had constructed and published an account of his chloroform apparatus by which he regulated the percentage of vapour administered. Pollock and Warrington Haward in this country were keenly alive to the dangers of chloroform, and they lost no opportunity of urging the use of ether, an advocacy for which we must always feel grateful. But as time went on Clover was less and less inclined to use chloroform. For minor operations he found nitrous oxide gas given by his apparatus to answer best, and he was led to seek some means of prolonging anæsthesia so obtained. This he achieved by the employment of gas in combination with ether, for which he soon devised an admirable apparatus, described in the *British Medical Journal* in 1876. Subsequently his portable regulating ether inhaler was introduced, and it was

mainly by the compactness and efficiency of this instrument that the practical question, how to give ether rapidly and safely, became answered. In 1879 the British Medical Association undertook to re-investigate the question of the relative safety of the various anæsthetics, and appointed a committee to carry out experiments. The conclusions to which this, the "Glasgow Committee," arrived were in favour of ether, as they found chloroform lowered the blood tension and depressed the action of the heart. In 1889 the Nizam of Hyderabad, at the suggestion of Surgeon-Major Laurie, granted a considerable sum of money to re-investigate the question, and the first Hyderabad Commission, working upon small mammals in India, came to conclusions more favourable to chloroform. As these investigations were not held convincing by English experts, a second Hyderabad Commission, in which Dr. Lauder Brunton assisted, went over the ground again, and corroborated the results before obtained. These experiments are considered at length in the chapter dealing with chloroform.

It is undesirable to enter further into detail. The subsequent history of anæsthetics is mainly that of attempts to introduce fresh substances or to modify the modes of administering the old ones. But few noteworthy advances can be mentioned: Snow, Clover, Richardson, in this country, Claude Bernard, Paul Bert, in France, with others, have devoted much time and labour to the scientific questions connected with anæsthesia, but any account of such labours, to be intelligible, would occupy more space than can here be devoted to the subject.

CHAPTER II.

Preparation of a Patient and Choice of an Anæsthetic.

Although the anæsthetist seldom has the choice of time given to him, the selection of a suitable hour for the operation is not a matter of indifference in administering an anæsthetic. The effect of anæsthetisation upon the robust may be considered trifling and transient, yet when the person anæsthetised is an invalid, and either weakly or highly neurotic, it is certainly not so. Individuals are more liable to after-effects of an unpleasant character when their bodily condition is one of nervous exhaustion and lowered vitality. It is then inadvisable, unless over-riding circumstances should exist, to give an anæsthetic after a prolonged fast—for instance, in the early morning before food has been taken. Similarly, it is inadvisable to select an advanced hour of the evening when the body will be spent with a day of activity or suffering. Further, an anæsthetic should not be given within three hours after a meal of solids, as a full stomach impedes the production of narcosis and leads to vomiting. This last occurring during partial narcosis may occasion fatal accidents through solids being drawn into the trachea. It is well, therefore, to select the period of greatest vital activity, and this is found in most persons in the morning or early afternoon. Arrange for a light meal of soft and easily digested matters to be taken three

hours* before the surgeon should arrive. This may consist of milk foods, strong beef-tea, or jellies, etc., varying with the time of the day and the choice of the patient. Weakly persons with feeble heart-action will certainly do well to take a little good brandy or whisky (one or two table-spoonfuls in an equal quantity of milk or water) half an hour or so prior to the operation, though it is not wise to make the administration of stimulants before an anæsthetic a matter of routine. In every instance it is recommended that the bowels be cleared overnight with a purge.

The following is a condensed form of a useful regimen to be adopted at the time of an operation :—

Operation at 9 a.m.

Beef-tea or thin corn flour to be given at 6 a.m.

Operation at 9 a.m., completed by 10; if sickness occur very hot water may be given in sips from a feeder or porcelain spoon. At 2 p.m. Brand's or Edge's essence of beef in jelly; if much thirst ice may be sucked, or iced soda and milk taken.

If very prostrate from vomiting, iced brandy and soda water.

At 6 p.m. a light meal of fish.

Operation at 2 p.m.

Breakfast at 8, tea, coffee or cocoa, bread and milk, fish, no meat.

Beef-tea, if desired, at 10.30.

Operation at 2, over at 3.

Bread and milk or biscuit and tea or cocoa at 7 p.m.

* It is well, unless the patient be in a very feeble state of health, to adopt Clover's rule, and give the last meal five or six hours before the operation.

When nitrous oxide alone is given, these elaborate details may be omitted, though even then it is well, with children especially, to see that they pass water before being anæsthetised, as urination is often performed unconsciously whilst under the influence of gas.

A patient about to be anæsthetised should be placed in the recumbent position, excepting cases of dental operations under nitrous oxide. The clothing should be carefully loosened, corsets quite undone, neck bands left open, and waist belts and strings removed. It is important that the patient be as comfortably posed as circumstances will permit, for while tranquillity of mind and body go far to assist in the production of narcosis, anxiety and uneasiness will greatly retard its accomplishment. He should now be asked to open his mouth, and a quick glance given to ascertain if any artificial dentures or an obturator, etc., be worn. Such, if present, must be removed with as little annoyance to the patient as possible. A further step may be taken in reassuring him by a few cheery words, and if necessary, directions as to how he is to take the anæsthetic. Such instructions are often of real service by giving him something about which to think.

When, however, the anæsthetic is once well on the way, quietness and silence must be maintained; noise —especially in the case of nitrous oxide—militates considerably against easy and tranquil anæsthetisation.

The choice* of an Anæsthetic must depend on

1. The condition of the patient.
2. The necessities of the operation.

* The question with whom lies the choice of the anæsthetic is considered in detail in Chapter XII.

Ether, either in succession to nitrous oxide according to Clover's method, or given by itself, is the best and safest anæsthetic for general purposes, and should be adopted as the routine method of producing unconsciousness before operations. There are, however, conditions which are often held as justifying a deviation from this routine, and these are noticed below. It may be pointed out, however, that, although apparently a long list, these conditions really represent a very small minority of cases when compared with the great number of instances in which ether should unhesitatingly be adopted.

Children.—Infants and young children bear chloroform well, and resent having their mouth and nose covered by a face piece, an objection, although by no means an insuperable one, to the use of ether. In many instances also ether produces much bronchial trouble, so that a better anæsthetic in these cases is the A. C. E. mixture, or one of chloroform and alcohol. Children about five or six years of age should be given gas and ether, unless they are notably the subjects of respiratory trouble. They will probably strongly rebel against having the face piece applied, so that if it be desirable to avoid "a scene," the mixtures of chloroform, alcohol, and ether, may be substituted and given by the open method. Ethydene dichloride is advocated for children by some, but experience proves that it is not taken more readily and does not appear to be in any way safer in its action than chloroform. Although the use of chloroform is unquestionably attended with happy results in the case of children, it must be remembered that deaths from this agent are by no means con-

fined to adults. It cannot, therefore, be too strongly impressed upon the mind that children run a risk, and probably as great a risk, in chloroform narcosis as do adults.

Pulmonary Disease.—Persons of early adult and adult life should have ether given to them, provided always they are free from pronounced pulmonary affections and renal diseases. With regard to asthmatics, and those suffering from chronic cough, dyspnœa, or emphysema, the A. C. E. mixture should be tried, but if the ether in this still gives distress, its quantity may be decreased, or the Vienna compound used instead. And should the patient suffer greatly from the exclusion of air, through the employment of an inhaler, chloroform can be given by the open method, as that substance will not only produce anæsthesia but will obviate asthmatic seizures. For the subject of chronic bronchial disease the choice of an anæsthetic should be made solely by consideration of his symptoms. In the presence of much dyspnœa, diluted chloroform will be found far preferable to ether. Emphysematous individuals with large (bullock's) hearts are always anxious cases requiring great nicety of treatment. On the one hand lies the possible danger of ether producing a water-logged condition of the rigid chest, and on the other a more than probable danger of syncope through the depressant action of chloroform on the enfeebled, dilated heart. In this dilemma I have found the A. C. E. mixture to answer well, though it needs careful watching, as many and grave symptoms may occur during its use. Among persons who have but one available working lung—as when the other is bound by pleuritic adhesions subse-

quent to effusion, or when one is compressed by an effusion or empyema—the choice of an anæsthetic becomes one of difficulty. In such cases ether is badly borne, and chloroform diluted with alcohol is preferable. And again, the heart, in these cases being often so pressed upon or displaced, is intolerant of further depressing effects;* hence extreme caution will be found necessary.

Renal Disease.—Where the kidneys are much damaged and there is considerable danger of suppression of urine, ether is by many held to be contra-indicated. Certainly in many instances no such untoward result has been brought about; still, perhaps it is well to substitute the A. C. E. mixture for ether, for those patients who are the subjects of pronounced renal disease.

Arterial disease, if present in any grave degree, whether fibroid or due to senile change when far advanced, is a contra-indication for the giving of pure ether. The blood pressure would be increased by this substance, the heart's work augmented, and considerable strain imposed upon the diseased arterial walls by which they become in danger of rupture—a result liable to occur in the brain and leading there to the gravest consequences.

For the aged, that is for those over 60 years of age, chloroform is commonly held to be preferable to ether and in many instances this is true. It is, however, true only because persons past middle life are often the subjects of chronic bronchial trouble; they are also frequently diseased in their vascular systems, and upon

* Any sudden change in the posture of the patient is dangerous and must be avoided. On this subject see the article on etherisation by the rectum Chapter IV.

that account liable to be injuriously affected by ether. Old persons too, like infants, are susceptible to a bronchial and laryngeal irritability which ether excites, producing in some distressing cough, dyspnœa, and exhaustion. However, for aged and feeble subjects with weak hearts and depressed vitality, ether, notwithstanding the drawbacks alluded to above, is beyond doubt the best anæsthetic.

In CONDITIONS OF COLLAPSE, *e.g.*, railway smashes, gunshot wounds, strangulated herniæ, ruptured viscera, or conditions when the vitality has sunk very low, as in the case of carcinoma affecting the œsophagus, pylorus, and causing chronic starvation; also in collapse due to severe hæmorrhages or other causes, or provoked by high temperatures, it may be necessary to perform an operation, and it will usually be desirable to administer an anæsthetic. Ether if properly administered is, I am sure, the best and safest anæsthetic for these cases. It should be given from a Clover's inhaler, as when that apparatus is properly handled there need be no dyspnœa or impediment to respiration. Very little anæsthetic is required, and the mask may be taken off during inspiration every three or four respirations. When there is very considerable respiratory trouble complicating the case, the A. C. E. mixture may be substituted for ether and given either by means of an Allis' inhaler, a cone, or upon lint. Still, ether is *par excellence* the anæsthetic, as it not only produces narcosis, but stimulates the heart and aids the circulation.

In MORBUS CORDIS.—It often becomes a question as to what anæsthetic should be employed in cases of organic heart disease. To answer this question we have to con-

sider firstly, the various forms of valvular disease, and secondly, the conditions of hypertrophy, atrophy, and muscular degeneration, as well as the pericardial conditions which interfere with cardiac function.

VALVULAR DISEASE OF THE HEART, except when incompetency at the aortic orifice occurs, does not, *per se*, greatly affect the prognosis about the safety or danger of giving an anæsthetic, although the changes brought about in the vessels, tissues, and organs of the body in general through such lesions will possibly do so. Indeed, it is a fact that in but few cases of deaths from an anæsthetic have the valves of the heart been found diseased at the necropsy.

DEGENERATIONS OF THE MYOCARDIUM.—When the heart muscle has undergone structural changes, the danger in producing anæsthesia is greatly increased. Any alteration in the respiratory or vascular systems induced by anæsthetics imposes an extra strain upon the already weakened and diseased heart—one which it is unable to sustain; hence supervenes syncope. When the heart trouble is not complicated by pulmonary engorgement, œdema or hydrothorax,—is in short largely compensated,—ether should be given and a Clover's inhaler employed. It has been suggested that a cone or towel is safer in these cases, but I cannot think this to be the case, since with a Clover's inhaler you can, by frequently removing the mask or refilling the inhaler bag, give any degree of dilution of ether you require.

When pronounced pulmonary trouble exists and ether cannot be borne, the A. C. E. mixture should be given. Should nitrous oxide be administered in MORBUS CORDIS? I think yes, but if the case is one of advanced disease and the organ is working feebly, it is wise to

supplement the nitrous oxide by allowing it to pass over ether-vapour. This plan has in my hands answered most admirably. Chloroform, whether pure or diluted, cannot be given to persons having diseased hearts without increasing the risk of syncope, which under any circumstances they must run.

Hypertrophied hearts are in practice usually *dilated* hearts, and being so are muscularly at a disadvantage. The same rules given for guidance above will serve here.

Some highly nervous, excitable persons are much terrified by the application of a face piece, and indeed in some few cases the mental distress and terror thus excited may be sufficient to occasion serious indisposition. In cases such as these it is especially useful to employ the A. C. E. mixture upon lint, replacing it by ether from Clover's inhaler so soon as the patient is sufficiently dazed as not to perceive the alteration.

Pregnant women take all forms of anæsthetics well, but if excitable and nervous as they are apt to be, it is better to avoid the coughing and straining which may follow the employment of ether. It will be found, however, that unless very nervous, women in this condition take nitrous oxide followed by ether well—nor are they more liable to after trouble than at other times—in all such instances, as little of the anæsthetic should be given as is consistent with true anæsthesia, since it is manifestly important to avoid vomiting.

From the surgeon's point of view—to decide upon the choice of an anæsthetic is difficult, as it is impossible to lay down hard and fast rules where there will be always conflicting considerations.

Operations about the Head, Face, Trachea and Respiratory Tract.

Brief operations about **the mouth, nose,** or **pharynx,** such as the extraction of teeth, excision of tonsils, opening of abscesses, tearing off mucous polypi, etc., can often be performed under nitrous oxide. With this agent from ·5 to 1 minute of unconsciousness can be expected. If the operation is likely to occupy more than this time, and if the cautery is not to be used, gas with ether should be employed, as this combination will prolong anæsthesia. In operations accompanied by severe hæmorrhage, but which do not need much time, the gas and ether mixture possesses an advantage, inasmuch as the patient rapidly resumes consciousness, and so the danger of blood being drawn through the trachea into the respiratory tract will be avoided. In operations for the removal of **post-nasal adenoid growths,** I have for some years extensively used gas and ether with success. Some specialists prefer chloroform for such cases (i.) because a more profound and lasting anæsthesia is thus obtained, (ii.) because less violent bleeding takes place at the time of the operation. On the other hand, the rapid resumption of consciousness under ether certainly minimises the danger of blood entering the lungs. When the operation is likely to prove a prolonged one, chloroform will be more satisfactory to the operator.

Staphyloraphy necessitates the mouth being open, and it is a matter of consideration that the operator should have free and uninterrupted access to the buccal cavity. To effect this, the patient can be put under the influence of chloroform and maintained so by anæsthe-

tising through the nostril (as described in Chap. V.). The same procedure answers for operations about the **tongue.** (See also Chap. IV).

Removal of the upper or lower jaw should be performed under chloroform, as the cautery is often requisite and the use of a face piece impossible. In extensive removals of growths about the jaws, it is frequently advisable to perform a preliminary tracheotomy, and then give the anæsthetic through a Trendelenburg's tube, at the same time plugging the pharynx.

Operations upon the larynx, *e.g.*, thyrotomy, will require a preliminary tracheotomy, and in these cases I prefer to keep up the anæsthesia by a Junker's inhaler to the afferent tube of which is fixed a catheter. By this means the amount of chloroform given can be more safely adjusted than when a Hahn's tube and funnel are employed. In all the above mentioned cases in which chloroform is mentioned as being more convenient an alternative method exists, namely, rectal etherisation.

Operations about the **eyes** require extreme narcosis, absolute immobility and freedom from coughing being essential. Nitrous oxide and ether, provided the ether be pushed very far, answer well; there is of course the possibility of ether exciting a fit of coughing, which, should the case be one of excision of a cataract, and should a preliminary iridectomy have been already done, may lead to forcible extrusion of the vitreous. But this can only arise when the patient is not sufficiently under the anæsthetic. There is less fear of coughing with the use of the A. C. E. mixture.

In excision of the eyeball, where coughing is not of such moment, ether may be used, and should be pushed

to deep narcosis before proceeding with an operation. For passing probes or slitting up the lacrimal canals, gas is not satisfactory, as the jactitation interferes with the operator; here the use of gas and ether answers every purpose by obviating involuntary movements.

For operations about the **thorax,** a mixture (A. C. E.) is usually more advantageous than chloroform or ether when given alone, so that where there is especial reason for fearing the respiratory difficulty of ether, this agent should be substituted. For tapping in cases of pleuritic effusion, gas is sufficient. Chloroform in cases of empyema seems peculiarly liable to dangerous results, the heart is usually hampered and respiration abnormally performed; several deaths have resulted from chloroform given in such cases.

It is in these operations that rectal etherisation seems likely to be of very great service. (See Etherisation by the Rectum).

Abdominal Surgery.

In dissecting operations, when tranquillity of respiration is desired, as in operating for the radical cure of hernia in young children, a mixture, methylene, A. C. E., &c., must be employed instead of ether, but for all prolonged and exhausting operations ether should be given unless strongly contra-indicated. Thus I have found for cæsarian sections, ovariotomies, hysterectomies and ablation of the kidney, ether if carefully given answers very well.

In Labour.

There is a consensus of opinion in favour of chloroform in these cases, based partly upon the assumption

that this agent is comparatively safe for parturients, and partly upon the more agreeable character of the substance. This assumption, however, is open to doubt, for chloroform cannot be in any way deemed freer from danger in childbirth than at any other time. If chloroform be employed it should not be entrusted to the hands of a nurse or other person unless skilled in its use. The various mixtures answer well in assuaging the pangs of childbed, and are probably safer than chloroform. Ether, though advocated by some, is disadvantageous in these cases, as it may provoke straining, coughing, sickness, and headache,* but for general obstetric operations, and especially where the patient is exhausted and needs stimulating, ether may be usefully employed. In short it may be said that chloroform or the A. C. E. mixture may be employed as an anodyne in labour, ether when surgical anæsthesia is necessary.

* In my private practice I have met with cases of women who after trying chloroform preferred to take ether in their confinements, stating that it produced more exhilaration and general feeling of well-being, while it assuaged their pangs more efficiently than chloroform.

CHAPTER III.

Nitrous Oxide Gas—Laughing Gas or Simply "Gas."

Chemical and Physical Properties.—Nitrous Oxide Gas [N_2O] is a colourless body almost devoid of odour. It possesses a neutral reaction and consists of nitrogen and oxygen in chemical union, thus differing from the air, which is composed of these gases in mechanical mixture. Nitrous oxide gas possesses well-defined anæsthetic properties, which appear to be quite distinct from the asphyxial symptoms frequently accompanying its administration. This gas agrees with oxygen in many of its chemical properties; thus, it supports combustion when ignited bodies are plunged into it. At a pressure of fifty atmospheres and a temperature of 44·6° F. (7° C.), it becomes liquefied, and advantage is taken of this to enable the gas to be carried about in iron or steel bottles, these latter occupying less space.

Nitrous oxide is decomposed at a red heat, but shows no tendency to undergo change at lower levels of temperature. Cold water dissolves more than its own volume of this gas, while hot water dissolves less, hence it is advantageous to collect it over water at 15° C. Alcohol takes it up in a still larger proportion.

Preparation.—Granulated nitrate of ammonia is pounded to ensure its being finely divided, and is placed in a strong glass retort. The capacity of the generator should be one pint to allow of safe decomposi-

tion of three-quarters of a pound of nitrate of ammonia, one quart for that of two pounds. One pound of the salt will make thirty gallons of nitrous oxide gas. The generator is then carefully heated in a sand bath or over a bunsen, after being connected by tubing with wash bottles of at least the capacity of a quart, as indicated in the figure. At 226° F. the salt melts; at 460° F. it gives off gas, and the temperature must not exceed this by many degrees, otherwise nitric oxide will come over, contaminating the laughing gas. The nitrous

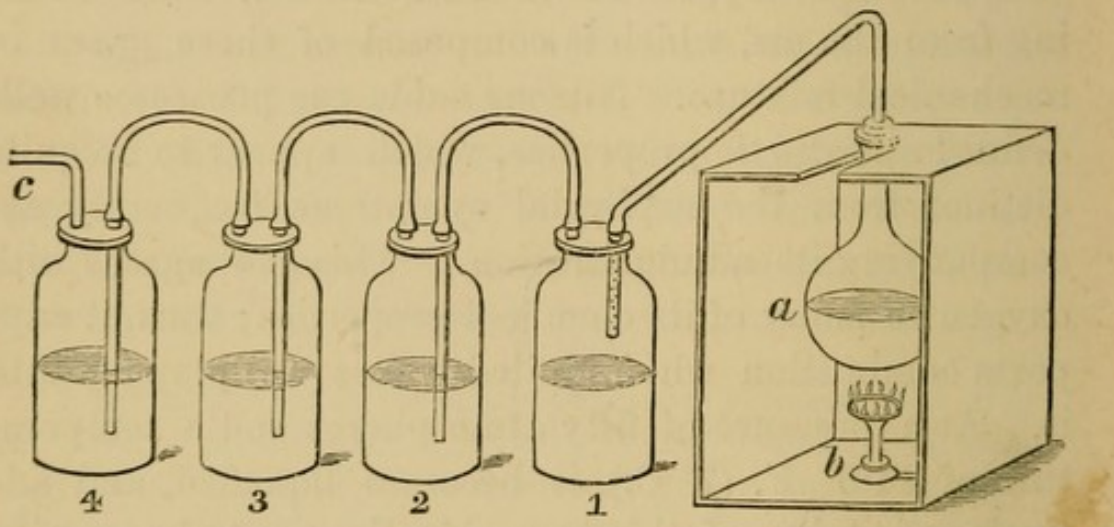

FIG. 1.—Apparatus for the preparation of Nitrous Oxide Gas. *a*. Generator. *b*. Bunsen's burner. 1 to 4. Wash bottles. *c*. Delivery tube to be connected with a reservoir for storing the gas.

oxide should *bubble* over, not *boil* over, not more than thirty gallons being allowed to volatilise in an hour. It is well to have a self-regulating gas jet, which is lowered as the temperature rises too much and *vice versa*. Bottle no. 1 nearest the retort, which may with advantage be placed in cold water, answers the purpose of catching the drippings which come over from the generator; it contains clean cold water almost up to the lower end of the long tube. This tube is per-

forated in order to break up the gas as it passes over, and to ensure its being washed out thoroughly. In bottle no. 2 about four ounces of ferrous sulphate are placed, and water to a few inches added. Bottle no. 3 contains a stick of potash, and water also added. It is sometimes advisable to use an additional bottle or two containing simply water for washing the gas further. Having traversed these bottles the gas is received into the gasometer, which should have a capacity of 30 or 40 gallons. When nitrous oxide is stored in bottles, special apparatus will be needed to force the gas in under the pressure of fifty atmospheres.

The impurities to which nitrous oxide is liable are:—

Sulphates.

Chlorides.

Other oxides of nitrogen, which produce coughing and feeling of suffocation.

Oil (from lubrication of apparatus) which gives a rancid nauseous smell to the gas.

To test for these impurities, let the gas bubble through solutions of barium chloride, which will precipitate sulphates, and through solutions of nitrate of silver, which will precipitate chlorides, while the other adulterations will be detected by the nose.

Purification of nitrous oxide is of undoubted importance, as was shown in the earlier days of anæsthesia, when the most bizarre symptoms were constantly arising, many, if not all of which, were traceable to foreign products being contained in the gas employed.

Some persons prefer the freshly prepared gas, but liquefied gas stored in bottles gives results practically as good.

Physiological Action of Nitrous Oxide—The Vegetable Kingdom.

It appears to suspend rather than extinguish vitality. Seeds will not germinate but remain uninjured when kept in it an indefinite period. Seeds, if sprouting, cease to develop when placed in an atmosphere of this gas, but resume their growth when again placed in the air. Jolyet and Blanche found that plants placed in nitrous oxide gas cease to absorb carbonic dioxide, and do not increase in size. When oxygen is allowed to mix with the nitrous oxide the seeds germinate, and the plants grow.

The Animal Kingdom.

Cold-blooded animals die in an atmosphere of nitrous oxide in two hours. This contrasts with what obtains when the same creatures are placed in indifferent gases, such as hydrogen or nitrogen, for under these circumstances death does not occur for three hours and is preceded by stupor but not true analgesia. Kappeler has shown that frogs placed in it lose reflexes after a very few minutes, whereas the reflexes persist for several hours when the frogs are placed in an indifferent gas, *e.g.*, nitrogen (Goldstein). Sir Humphry Davy, in his careful research, showed that small mammals and birds soon die in it, although when it is mixed with oxygen they live until the oxygen tension sinks to 6 per cent., as against a carbonic dioxide tension of 12 per cent. Exposed to such measures the animals remain sensitive to the last, and it may be

stated generally that mixtures of nitrous oxide with other gases under normal pressure are useless for anæsthetic purposes.

Animals placed in non-respirable indifferent gases become convulsed before death; this does not obtain when they are made to respire nitrous oxide. Their respirations simply grow more and more shallow, and finally cease without any of that *besoin de respirer* which is elicited when simple deprivation of oxygen is practised.

Krishaber experimenting with rabbits found a marked acceleration of the rate of the pulse, with increased force at first in the heart beat. Subsequently where anæsthesia was determined some retardation occurred, while the cardiac rhythm became less regular. Respiration was accelerated and death resulted in two or three minutes. He performed control experiments by ligaturing the trachea. In these cardiac rhythm remained unchanged until after the fourth minute, when the heart beats grew irregular, and ceased at times varying from seven to eleven minutes. The animals remained sentient to the very last. I have repeated these experiments, using dogs and cats in preference to rabbits because these last are peculiarly liable to fright, and this disturbs the rhythm alike of the heart and respiration, and in the main my results agree with Krishaber's. While dogs die in from two to three minutes in nitrous oxide, they do not succumb to asphyxia for five; under nitrous oxide they grow wholly insentient in from fifteen to thirty seconds, while in asphyxia consciousness to pain only ceases with life. Under nitrous oxide I found the heart little affected until the respiration was gravely interfered with, and

then it gradually failed before totally stopping. The creatures seemed under the gas to sink to sleep, and from sleep to pass into death, while when asphyxiated they struggled from first to last.

In the Human Subject.

It is probable that this gas when administered pure, and not mixed with oxygen, enters the blood by diffusing through the thin walls of the air-cells in the lungs. In the blood, a small quantity is dissolved, but the bulk is connected in some loose way with the blood constituents, probably being associated more or less closely with the albumins and albuminoids of the liquor sanguinis and corpuscles. According to Hermann nitrous oxide destroys the red blood corpuscles. The effect of shaking arterial blood with nitrous oxide gas is to darken it, showing that nitrous oxide gas is able to displace oxygen. But whatever union does take place is very unstable, as blood parts at once with its nitrous oxide when left in free contact with oxygen or air.

Under nitrous oxide, the respiration becomes slowed and shallow, and, if the gas be pushed, a complete cessation of respiratory movements eventually takes place. The amount of tissue change occurring in nitrous oxide narcosis is lessened, and so the quantity of carbonic dioxide which the lungs give off is diminished. Subsequently to the administration, the exhalation of carbonic dioxide is increased. The heart beats quietly, fully and regularly under this gas, the pulsations are somewhat slowed in profound narcosis. There is, however, but very slight danger of heart failure result-

ing from inhalation. In animals killed by nitrous oxide gas the heart goes on beating even after the respirations have quite stopped. It is therefore less important to watch the pulse than the respiration. Blood-pressure is somewhat lowered except in the brain and cord, the vaso-motor system of different areas being, it would appear, diversely affected. This lessened pressure is, however, but slight.

In some observations I made upon this subject, I found that while asphyxia caused diminution of the bulk of the brain and cord, nitrous oxide produces so great an enlargement as to force out the cerebro-spinal fluid. There can be no doubt these changes are vaso-motor in origin, and explain many of the nervous phenomena elicited in persons narcotised by nitrous oxide. The great distension of the vessels must press upon the nerve-cells and fibres both of the brain and cord, and so interfere with their function. (Physiological Action of Nitrous Oxide, *Transactions of Odontological Society*, vols. xviii. and xix.).

In a recent essay, Dr. George Johnson has sought to establish the contention that nitrous oxide acts wholly or mainly as an asphyxiant. The experiments upon which he bases his belief, however, appear to have been made without due care being taken to eliminate concurrent asphyxia. His statement that the pulse under nitrous oxide is diminished, and even becomes imperceptible, is utterly opposed to my experience. Since nitrous oxide has to be given under ordinary circumstances without access of air or oxygen, asphyxial symptoms will eventually supervene, but these come on subsequently to true anæsthesia and need never be produced. The peculiar muscular effects of nitrous oxide

gas which constitute "jactitations" are very different from an epileptiform convulsion to which this writer has compared them. In cases of true epileptics to whom I have given nitrous oxide, jactitations have assumed their normal form, and sometimes a regular epileptic fit has occurred subsequently to the recovery of consciousness. It would seem reasonable to suppose that, were the nitrous oxide anæsthesia a simple asphyxial state culminating in an epileptiform fit, in the cases to which I have just referred, the epileptic fit should follow directly or even replace the jactitation. Again, in persons who take nitrous oxide together with oxygen either simply or under pressure (Paul Bert), no asphyxial symptoms develop, and yet a more or less complete anæsthesia is attained.

The senses of a person passing under nitrous oxide are at first rendered somewhat more acute, after which follows a condition of analgesia. During the first stage of unconsciousness, a loose tooth may be extracted without pain, although the patient has a vague idea that something is being done. A few seconds later, and the individual is profoundly unconscious and insensitive to all his external surroundings. Irregular discharges of nervous energy frequently show themselves at this stage in jactitations of the arms and legs. If the gas continues to be respired, the limbs become rigid, the rigidity being every second or two broken by a sudden contraction of the flexors. Rhythmic tremors of hands and arms are occasionally elicited. More rarely the whole body of the patient arches forward like a bow (opisthotonos) jerking him out of the chair. This condition is especially liable to occur in children. The muscles soon relax and remain flaccid. The degree of

rigidity and the amount of jactitation vary in different cases; children show jactitation early, and the movements of the limbs are more marked in them than in adults. The superficial reflexes are abolished, that of the patella tendon, however, persists; and in many cases ankle clonus is developed under nitrous oxide.* The pupil usually undergoes wide dilatation when complete anæsthesia is attained, however this phenomenon is not absolutely constant and cannot be taken as an indication of danger.

During the condition of hyperæsthesia which precedes anæsthesia, the subject is often affected by hallucinations, frequently of an erotic nature, and the impressions then received remain firmly imprinted upon the brain. The difficulty of convincing persons that such impressions are not realities should lead every administrator to secure independent evidence of his actions while his patient is unconscious. The bladder and even the rectum may be involuntarily emptied under nitrous oxide, and hence it is always wiser to allow patients to pass urine beforehand. As a rule the alimentary tract is unaffected by nitrous oxide, and nausea, vomiting, and bilious derangement, rarely occur after its administration. However, some persons through nervousness swallow the gas, and this causing distension of the stomach may give rise to a reflex vomiting. In view of the possible occurrence of this trouble, it is well for patients to abstain from food immediately before taking nitrous oxide gas.

Later effects, which are said in some instances to

* For further particulars on this point see a paper by the author on "Ankle Clonus under Nitrous Oxide," *Brit. Med. Jour.*, Sep. 24th 1887.

ensue from the gas, are various functional derangements of the nervous system, tinnitus aurium, headache, and amaurosis, but these conditions occur only with the most exceptional rarity.

The Administration of Nitrous Oxide Gas and the Purposes for which Applicable.

When used alone, nitrous oxide gas produces a period of anæsthesia which seldom exceeds a minute. Many persons, and especially children, pass out of the condition of unconsciousness with very great celerity, and in them the anæsthetic stage cannot be relied upon for longer than 15 or 30 seconds.

General Surgery.

Nitrous oxide has been used for prolonged operations, by narcotising with this gas, then letting the patient almost resume consciousness, and again applying the face piece and administering the gas. Dr. Carnochan removed a breast, the patient being kept under nitrous oxide for sixteen minutes. And the same surgeon performed other major operations with the same anæsthetic. Mr. Bailey tells me he kept a patient unconscious for forty minutes while a surgeon removed a malignant growth from a male breast.

As a rule, when nitrous oxide is administered more than once at one sitting, headache and malaise are liable to ensue.

For the opening of abscesses, whitlows, and carbuncles; for the insertion of setons; the tapping of

antral abscesses; the removal of portions of the uvula, tonsils, or nasal polyps; for cauterising, and possibly for the passing of Eustachian and other catheters, and the slitting up of the lacrimal canals, nitrous oxide may be used. Tenotomy, divisions of fascias, breaking down adhesions in and about joints, and divisions of fistulas, may be undertaken with this agent, but as a rule it will be found better in such cases to supplement its use with that of ether.

Many other operations of minor surgery can be carried through under nitrous oxide, and it is possible, by judicious management, to prolong anæsthesia for several minutes by administering the gas again and again; such a practice, however, cannot be commended as it is liable to produce headache, faintness, and great discomfort to the patient.

Dental Surgery.

Nitrous oxide alone, or combined with a very small dose of ether in the manner to be described hereafter, is the safest and best anæsthetic for this branch of surgery. When nitrous oxide is used alone and pushed to the point of stertor and jactitation, two or three teeth may be extracted at one sitting, and expertness in operating may enable even more to be done. Abnormality of the teeth or mouth may render extraction so difficult as to prevent the successful removal of one tooth at a sitting, and in all instances care should be taken to avoid promising the extraction of more than two or three unless the case be manifestly an easy one. If the extracting be kept up too long, pain will be felt,

and the patient complain that he could feel the removal of every tooth; to obviate such complaints, an operator would do wisely to place himself in the hands of his anæsthetist, who should generally be better able to judge what may be done with impunity. Unless some special reason exist for desiring to extract several teeth at one sitting, it is advisable to let the patient attend twice or thrice rather than to subject him to more than one administration on the same day. Extracting a number of teeth simultaneously produces more or less severe shock.

Apparatus Required.

I. **Apparatus for giving nitrous oxide alone.**—The apparatus I find to answer best is one which is here figured (fig. 2), and which has been made for me by Mr. Blennerhassett, of London. Its main peculiarities are that (1) it is provided with an efficient "silencer" (*K*) which ensures absolute quietude, (2) it is adapted for gas only, and so offers no temptation to the administrator to give "only a whiff of ether," (3) it possesses a special contrivance to filter the air, and, if necessary, to impregnate the gas with aromatic or other vapours. It consists of the usual tripod (*A*), used because it is so portable and compact; this supports a steel bottle containing fifty gallons of compressed nitrous oxide (*B*). To the outlet pipe (*a*) of this bottle is fixed the silencer (*K*), which checks all the hissing and spluttering of gas, and from this a wide-calibred mohair tube conducts the gas into the ordinary Cattlin's bag (*C*). Another tube is attached to this, which communicates with a chamber made in metal and opened or closed by a valve, per-

mitting either air or nitrous oxide gas to enter. In this chamber (*D*) are placed morsels of fine honey-combed sponge or teased-out medicated cotton-wool.

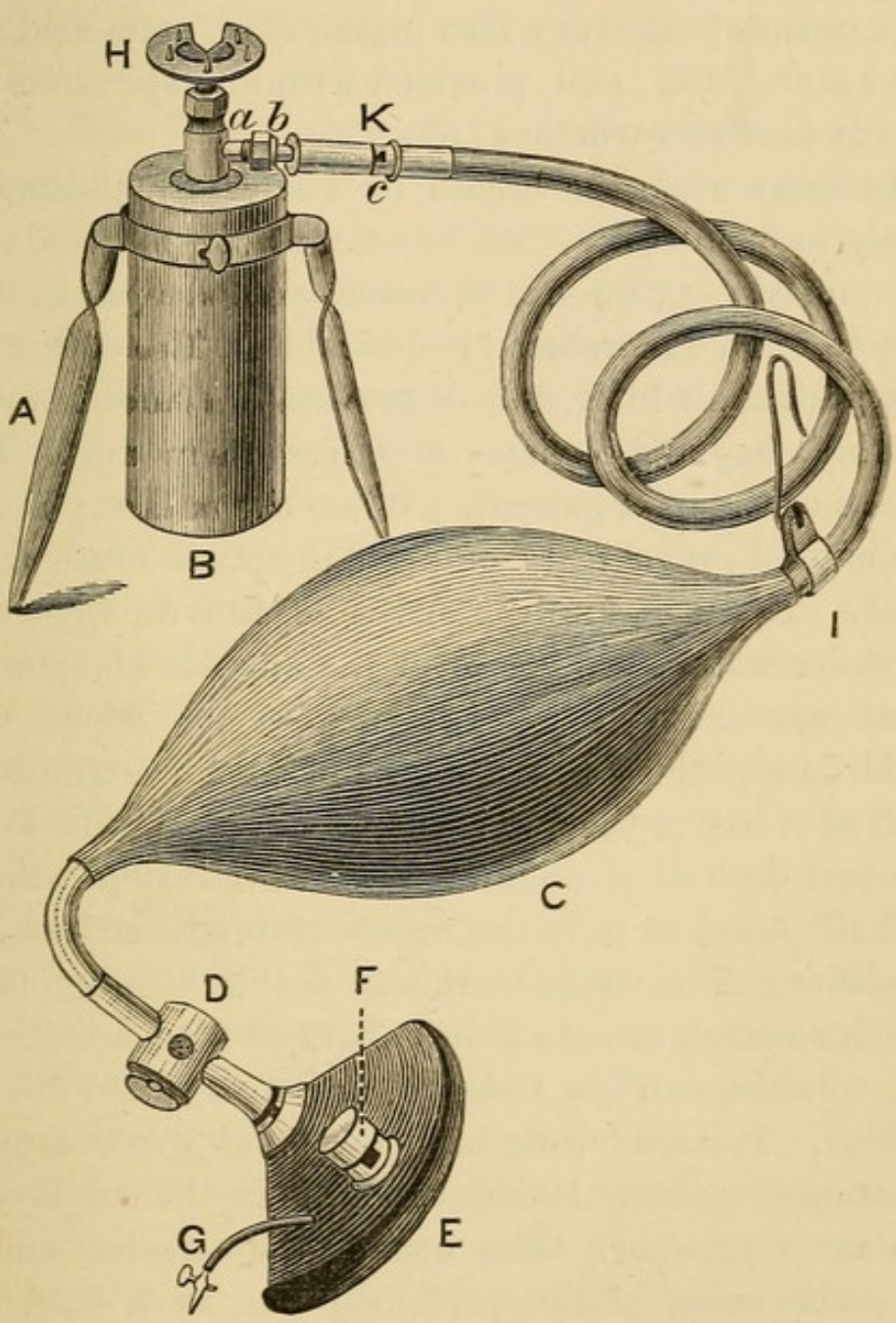

Fig. 2.—Dr. Dudley Buxton's Apparatus for giving nitrous oxide. (*A*) Tripod. (*B*) Steel bottle containing liquefied nitrous oxide. (*C*) India-rubber bag. (*D*) Chamber containing sponge, cotton-wool, etc. (*E*) Face piece fitted with (*F*) cap expiration valve. (*G*) Tube for inflating the air cushion. (*I*) Hook attaching tube to administrator's button hole. (*K*) Quieter.

These substances can be moistened with lavender water, eau de Cologne, or with sal volatile, or liq. ammoniæ dil.—if a stimulating action is needed. The ordinary Clover's face piece *(E)* is attached by a bent metal tube, and provided with an expiration valve of peculiar construction (*F*).

In cases when the breath or buccal exhalations are likely to be infective,* as, for example, in phthisis, syphilis, quinsy, etc., the use of cotton-wool steeped in a germicide, such as terebene, is desirable. The cotton-wool is a perfect air filter, and so prevents all infection of the Cattlin's bag and obviates any fear there might be of infecting the next patient. When the ordinary apparatus is used grave fears of such infection must always arise. The use of a drop or two of eau de Cologne or lavender water sprinkled over the morsels of sponge is most convenient. It gives a pleasant odour, which children especially appreciate, and will, if permitted to sniff at it before the gas is turned on, allow one to give the first dose of gas—always the initial step which is difficult—and so pave the way to ultimate success. In conditions of extreme weakness or the "feeling faint," which so often attacks ladies about to have a tooth out, sal volatile, eau de Cologne, or liq. ammon. dil. is of service. It need hardly be added that other aromatic substances or stimulating vapours may be employed in the same manner. The use of the silencer and the agreeable scent of the perfumed gas, as a rule, make

* The danger of infection was pointed out some time ago by a correspondent to the *Journal of the British Dental Association*, who recommended that a fresh Cattlin's bag should be used after each case. This somewhat expensive precaution is rendered unnecessary by my simple contrivance.

nervous patients willing to inhale gas freely, and obviate the distressing noises in the head and horrible dreams which were often determined by the hissing of the gas, and which are always intensified in the hyperæsthetic stage of anæsthesia.

II. **Gas in combination with ether.**—In cases in which more time is required than nitrous oxide gives, the use of ether—but in conjunction with the gas—is to be recommended. The apparatus which I have found most serviceable is what was called Clover's Gas and Ether Inhaler, although since Mr. Clover's time many useful alterations have been made in its construction. The gas supply is derived from a steel bottle (fig. 3, *B*), fixed as before in a tripod, and the gas traverses an india-rubber tube (*m*) to the inhaler (*D*). This is shewn in fig. 3. The apparatus is so arranged that gas can be given alone, or if ether also is needed, by turning a tap (*k*) the gas passes directly into the receiver (*C*) containing ether, and having traversed it and passed over the surface of the ether, escapes into the face piece (*P*) along a tube (*n*). The amount of admixture of gas and ether is regulated by another tap (*o*). The whole apparatus is light, and is suspended by a hook (*i*) from the administrator's buttonhole.*

The advantages of this apparatus are :—

1. The absolute control the administrator possesses over the strength of vapour with which he is working; thus he would commence the administration with pure gas, then permit some gas to play over the ether, and by degrees permit full ether vapour without exciting spasm or coughing.

2. Its great simplicity and portability. It has been

* The apparatus is made by Messrs. Mayer and Meltzer, of London.

termed unsightly and cumbersome, but no one familiar with its use would find it either the one or the other.

3. It is the only inhaler in which the gas is made to actually traverse the ether.

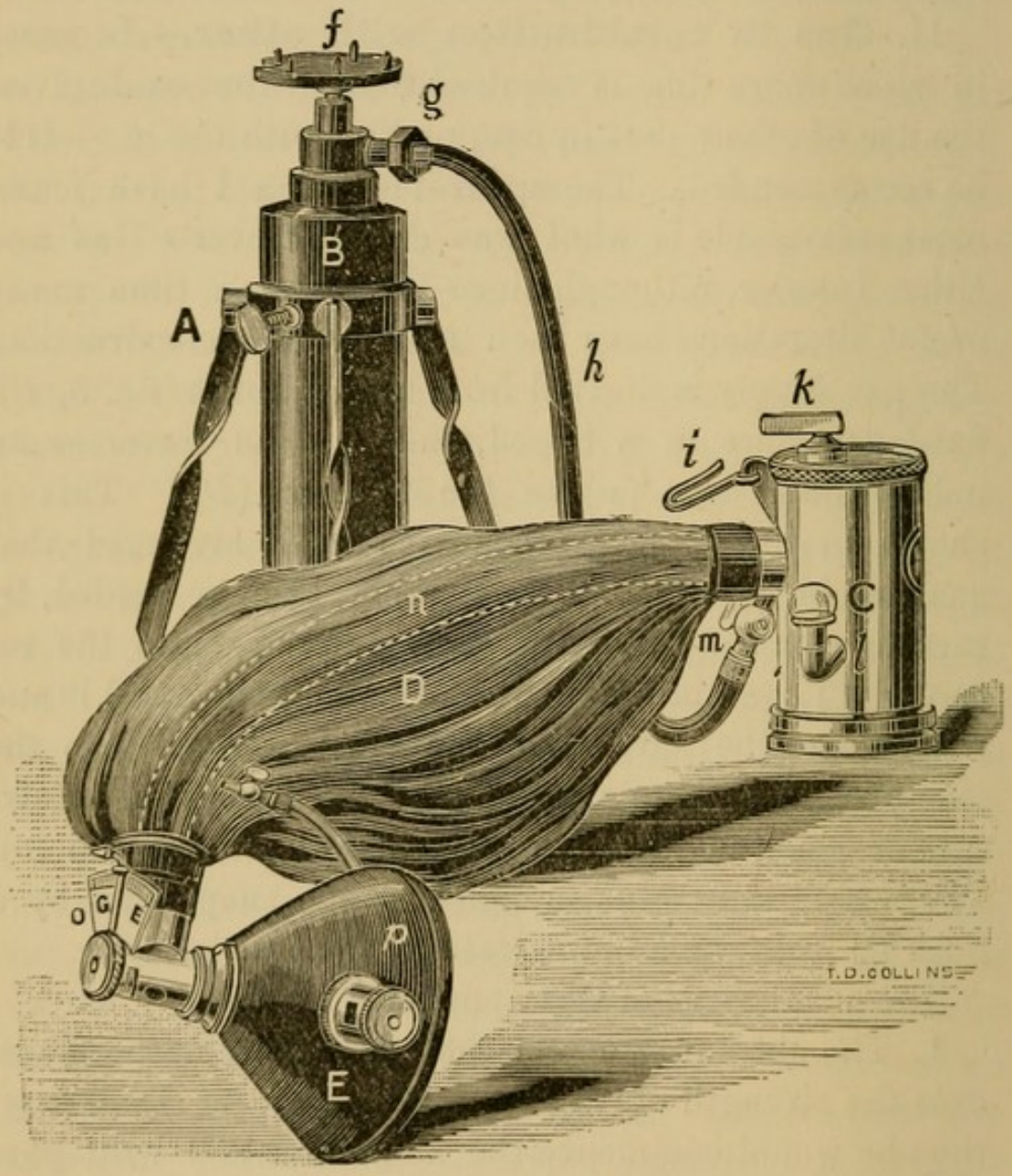

FIG. 3.—Apparatus for the administration of nitrous oxide and ether. (After Mr. Clover.)

When ether only is used the same apparatus is equally satisfactory.

In either apparatus the gas supply is controlled by

the foot, which, placed upon the foot piece (*f*) rotates it from right to left to turn the gas on, and from left to right to turn it off. Some persons prefer to have the bottles placed horizontally, thus obviating the necessity for the tripod. In this case the exit valve is so situated that a foot piece placed on the long axis of the bottle regulates the supply.

When gas only is required it is always well to have two bottles yoked side by side and connected by an ordinary junction, so that when one bottle becomes empty, the valve of the second is opened and the supply of gas is not interrupted.

When ether is to be given in succession to nitrous oxide the apparatus figured (p. 42) is used. The patient is rendered unconscious with gas, and as soon as the quiet rhythm of respiration assures us that such is the case the stop cock is turned into the long axis of the bag, and the indicator, which is seen in the figure as standing midway between the letter *G* and *E* on the dial plate (*o*), is slowly rotated from *G* where it stands when gas only is being given. As this indicator passes from *G* towards *E*, more and more ether vapour passes into the face piece, until when it stands at *E* no fresh gas supply is permitted and the patient breathes pure ether vapour.

The india-rubber tube, the ends of which are figured *g* and *m*, is then detached at *m*, but the tap which is there placed is left open to permit air to enter the bag and dilute the ether vapour.

To complete the description, we have only to mention that the cushioned face piece used by Clover and supplied with a single expiratory valve is as convenient as any.

Should a supplemental bag be used, the face piece must be provided with an aperture to which this accessory can be adjusted. The stop-cock in this arrangement is kept shut until the residual air of the lungs is presumably exhausted, when it is opened, the finger is

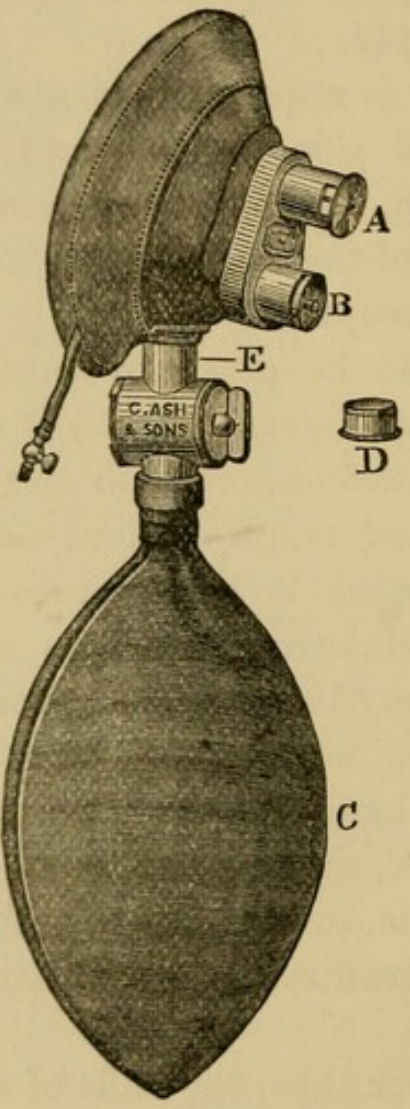

FIG. 4.—A. Expiratory Valve. B. Inspiratory Tube which gears on to Cattlin's Bag. C. Supplemental Bag. D. Cap to cover Mount when the Ether or Supplemental Bag is not used.

placed upon the expiratory valve and the patient allowed to breathe backward and forward into the bag. When desirable, however, it is a simple matter to convert the Cattlin's bag itself into a supplemental bag, by

placing a finger upon the expiratory valve, and so causing the patient to expire back into the Cattlin as well as inspiring from it.

Where a gasometer is kept, a modification of the above apparatus is in use. A long tube screws on to the efferent pipe of the gasometer, conveying the gas to a bag of 2 or 3 gallons' capacity. This may be connected directly with a face piece or conveyed to it by another length of tubing, and by using a three-way-cock it is easy to combine this apparatus in gear with Clover's smaller ether inhaler.

As face pieces are almost universally employed in the United Kingdom, it is scarcely worth while to describe the mouth pieces sometimes used in America. Briefly, we may say, they are flute-like in shape and are taken between the teeth. The nose is slightly pinched while the patient draws in the gas through the opening in the flute piece.

The employment of supplemental bags (see fig. 4, *C*) has been advocated by Mr. Braine. The bag fits on the face piece and is guarded by a tap. The patient, having presumably emptied his lungs by a few very deep inspirations, is allowed to breathe to and fro into the supplemental bag, the tap of which is turned to allow gas to enter. The gas supply and the expiratory valve are closed. It may be necessary to empty the bag and refill from the reservoir. Those who employ the supplemental bag claim for it that it is economical and produces a slightly more prolonged period of unconsciousness. The disadvantages are—it is liable to produce headache, it takes longer to get the patient well off, and it is, I believe, opposed to the knowledge we now possess of the physiological action of nitrous

oxide gas, since it gives a mixed narcosis partly asphyxial and partly due to the gas inhaled.

Another apparatus for the giving of nitrous oxide,

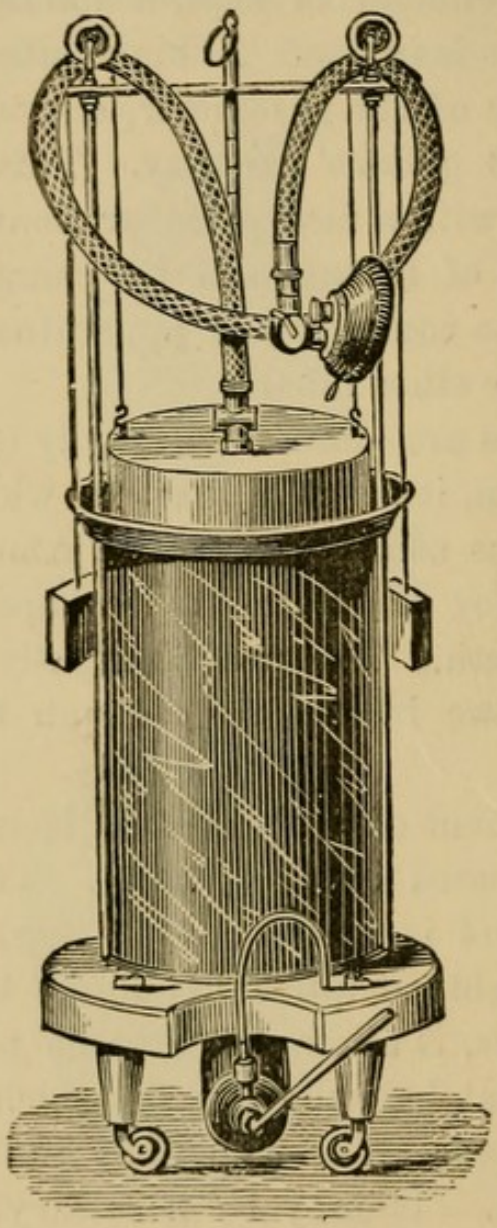

Fig. 5.—Barth's portable gasometer for liquid nitrous oxide.

and one useful to persons who desire to keep a supply always ready in their rooms, is figured above. (Fig. 5).

The Administration.

Various adjuncts are used, such as gags, mouth openers, mouth props, the oral spoon, tongue forceps.

Gags.—Various forms are in use, the one made for me has special advantages from the facility it offers for rapid removal and replacement. It consists in replacing the screw-fixing arrangement by a ratchet as is seen in the figure.

By putting the finger upon the free end of the ratchet and pressing it backwards as one does a trigger, the ratchet is released and the gag closes. To open it, it is only necessary to press the handles together and the

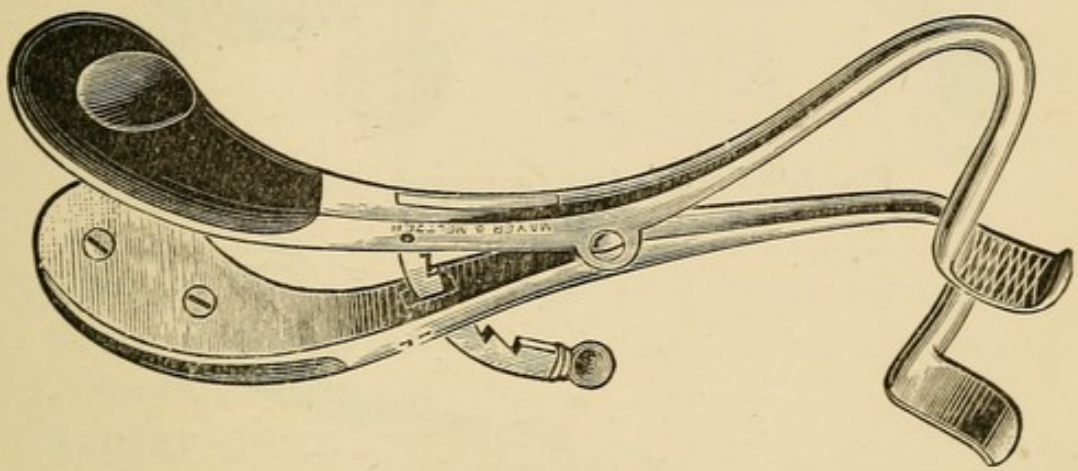

FIG. 6.—Gag fitted with ratchet arrangement. (Mayer and Meltzer).

ratchet will automatically gear and prevent closing of the mouth. I find it safer to wire the tube pads on to the ends of the gag; this prevents their casting loose in the mouth, and is easily accomplished when the pads are changed, as should frequently be done. The ratchet arrangement can be used with long or short handles, personally I prefer the latter.

The usual form of gag (Mason's) is figured p. 48.

A very convenient gag has been devised by my friend Mr. Gowan, which combines the advantages of a sure gag and a mouth opener in cases in which the teeth are sufficiently apart to allow its insertion. It acts by turning the millhead from left to right, and fixes itself

without requiring any screw. This gag is as ingenious as it is useful.

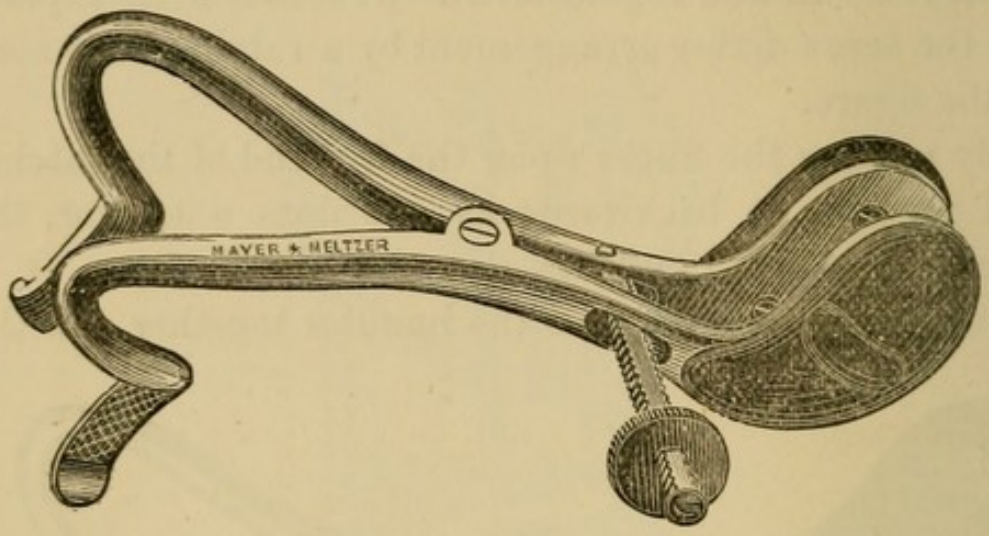

FIG. 7.—Mason's Gag (improved by Croft).

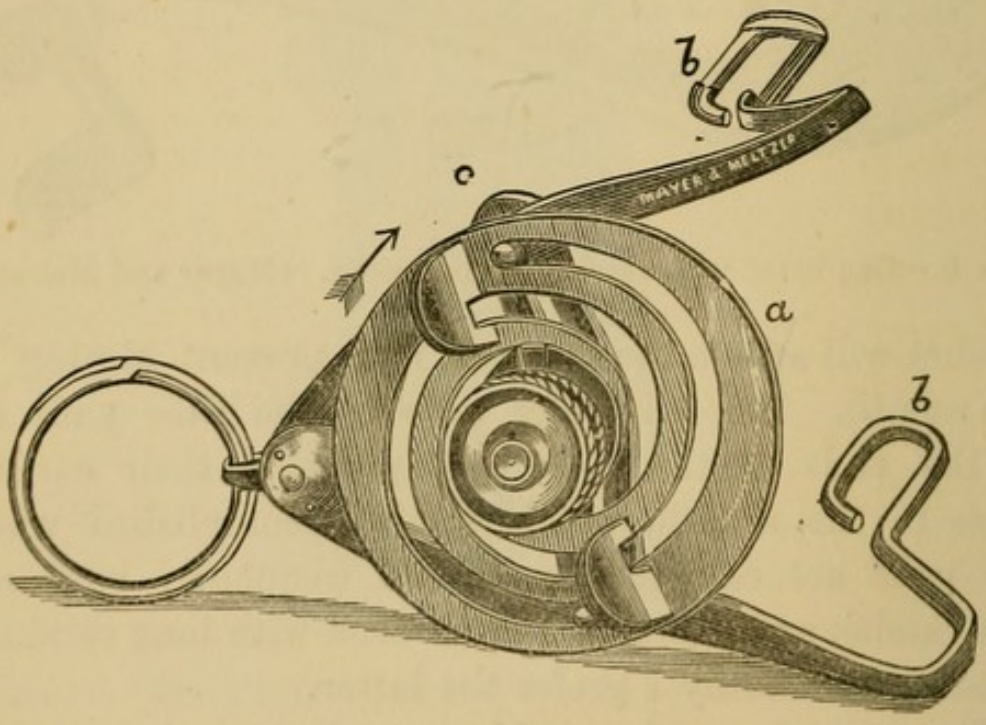

FIG. 8.—Gowan's Gag. By revolving the disc *a* to the right or left the gag is opened or closed. The disc being eccentric, no screw is required for adjusting the gag.

Of mouth dilators, or more accurately openers, Heister's, figured below, is the best. It possesses enormous power, so it must be used with care. Its

employment is of course indicated in cases of severe trismus, partial ankylosis, etc. The blades may be inserted either in a gap caused by the previous ex-

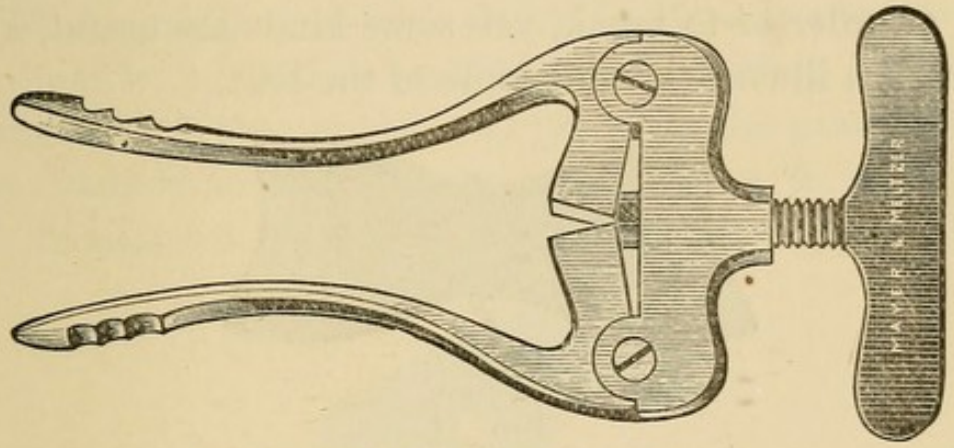

Fig. 9.—Mouth Opener (Heister's).

traction of a tooth, and if possible between the molars. If placed between incisors the risk is run of forcing these teeth out of their sockets.

Dental props.—Many kinds are in use. Mr. Clover employed those made of hard wood, but, although very convenient and not liable to slip, they are apt to get chopped and split.

The cleanest and nicest I know are those figured below and made of vulcanite. I have them made in six sizes.

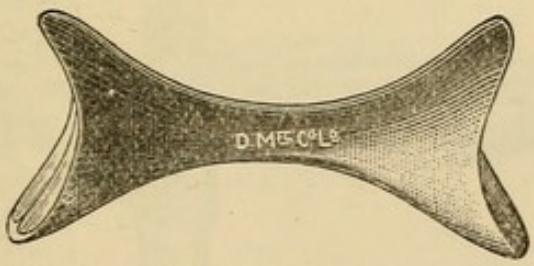

Fig. 10.—Mouth Props.

The mouth prop spoken highly of by Mr. A. S. Underwood and figured below is also useful. (Fig. 11).

All loose props should be tied with fishing gut, and a long piece made to hang out of the mouth.

Although spring and mechanical props are objectionable upon the general ground of their liability to get out of order or to break, yet some kinds are useful, and I subjoin illustrations of some of the best.

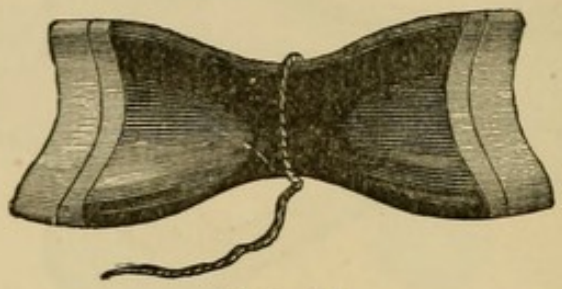

Fig. 11.

A central prop, fixing upon the anterior teeth with a rotating arm, permits of operations upon one or other side of the mouth according to the necessities of the case. A very convenient form is figured below.

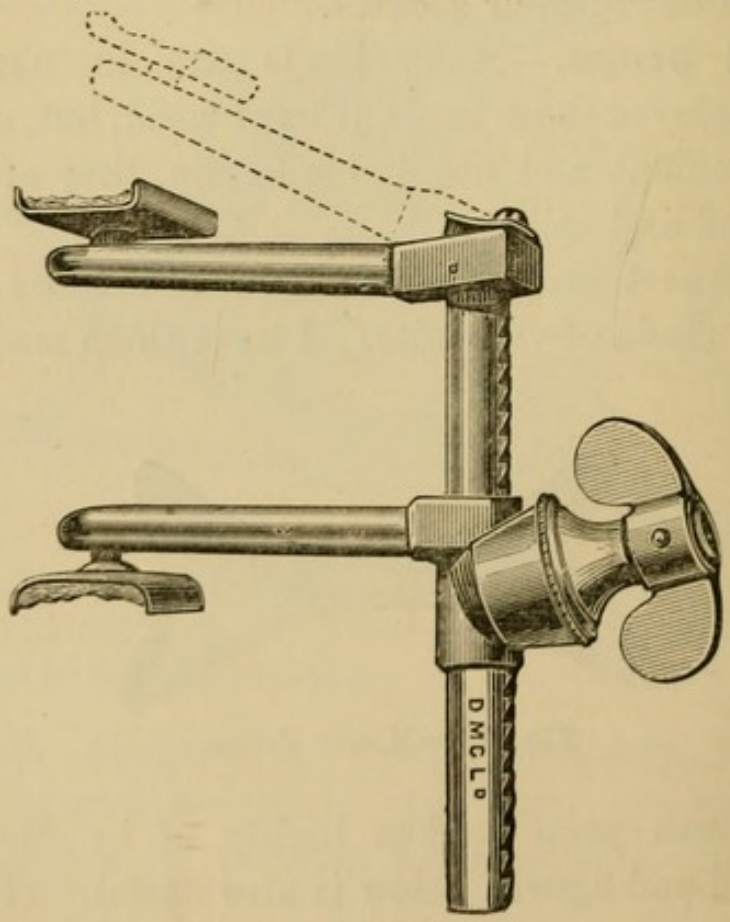

Fig. 12.—Weller's Gag.

It possesses an easily working screw, which permits of very nice adjustment. The plates should rest upon more than one tooth in each jaw.

Dr. Frederick Hewitt's prop is also useful. (Fig. 13).

No mouth prop or cork should be placed in the mouth without being first securely tied to a counterpoise which hangs out of the mouth, and prevents the prop becoming wedged in the larynx or œsophagus in the event of its slipping. The few minutes spent in carefully

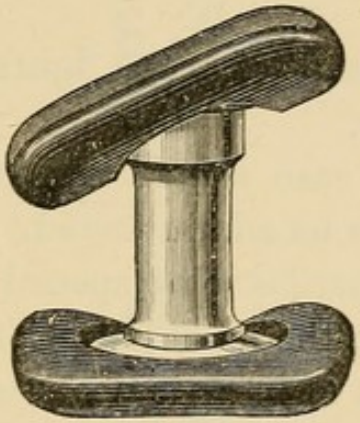

Fig. 13.

adjusting the prop between the teeth should not be grudged, as the after success of the operation depends largely upon the security obtained in this manœuvre. It should be adopted as a general rule, when possible, that the dental prop be placed not further forward than the bicuspids.

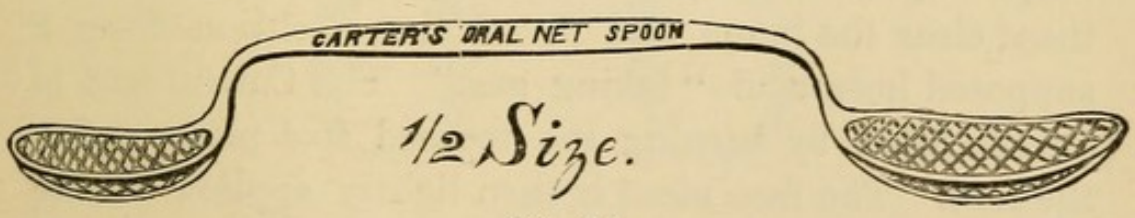

Fig. 14.

The mouth spoon (fig. 14), made for me by Messrs. Ash, is safer than its archetype, the invention of Mr. T. S. Carter, in that the shank of the spoon in that in-

strument is liable to separate from the bowl, and then a risk is run of the detached bowl getting impacted in the gullet or windpipe. By carrying the shank to the distal end of the bowl as in my pattern, this danger is obviated. The use of the oral spoon is to catch any teeth or roots which may fall out of the forceps. Bicuspids are especially apt to spring out of the beaks. The spoon is held below the seat of operation, care being taken not to allow it to get in the way of the operator.

The tongue forceps (fig. 15) figured below needs no special description.

A tracheotomy case should always be at hand when an anæsthetic is to be administered.

We will now describe some special manœuvres which are resorted to in the administration of nitrous oxide, when the mouth is open as is necessary in dental operations. The prop should be carefully fixed in the opposite side of the mouth to that upon which the operation is to take place, and a glance cast round for artificial dentures, or an obturator, which if present must be removed. The patient is now to be reassured by a few cheering words, and directed to breathe freely. It is well to allow a nervous subject to take several very deep inspirations before applying the face piece, as these clear the lungs and divert the attention from a supposed horror of "taking gas." The Cattlin bag is quietly filled by turning the toothed foot piece under the foot. The face piece is then lightly applied to the patient's face, and retained by just enough pressure to prevent the escape of gas or the entrance of air. In a second or two, the patient becomes accustomed to the face piece, and is then instructed to take a very deep

breath. At the instant of inspiration the stop-cock is turned so that the patient breathes in the nitrous oxide from the Cattlin's bag. During the administration it

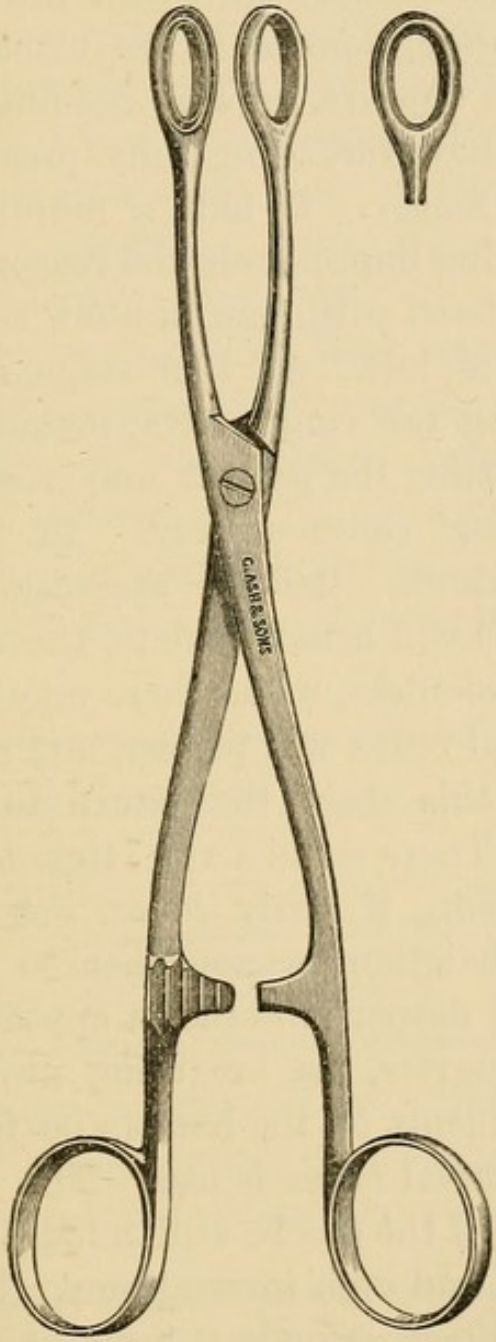

FIG. 15.

is important to keep the bag full of gas, and to do this the foot must from time to time be turned and gas be allowed to flow from the bottle into the bag. It is well

to open the ingress of gas during inspiration and close it during expiration.

After the first fifteen or twenty seconds, that is, after the lungs are presumably filled with nitrous oxide, and when gas is gaining tension in the blood, slight duskiness of the skin appears, the ears and finger tips darken, consciousness, however, being fully present for ten or fifteen seconds longer. In half a minute the patient's power of receiving impressions and reasoning upon them is greatly interfered with, and in a few seconds later all consciousness is lost. At this stage, incautious acts such as touching the conjunctiva, making loud noises, or roughly handling the patient may lead to his completely regaining consciousness. In from forty-five seconds to a minute after the application of the face piece, the pupils will usually dilate, the eyes becoming dull and expressionless, while there may be strabismus. The conjunctival reflex will persist, and if the face piece be removed at this stage, the return to consciousness will be rapid. There is, as a rule, time for the extraction of one tooth, if fairly loose, but not of more. When the inhalation is not checked at this time, further signs of deeper anæsthesia appear. In about a minute and a quarter, the breathing grows stertorous, muscular movements of the hands and feet supervene, and the conjunctival reflex is lost. The eyeballs begin to oscillate, and if the gas be still inhaled the breathing becomes slowed and even intermittent. Should it stop for more than fifteen seconds (Clover), air must at once be given. At this period of deep anæsthesia there is great stress imposed upon the heart, so that the pulse should be watched, and if it flag all further administration should cease. The patient is now ready for opera-

tion, and it is not wise to attempt to push nitrous oxide beyond this point.

Further inhalation of gas and air intermittently by means of a tube passed through the nose and down the naso-pharynx has been suggested as enabling the anæsthetist to maintain unconsciousness for operations about the mouth; but it is a method hardly to be commended, and one which presents few if any advantages over that of prolonged anæsthesia with ether impregnating nitrous oxide, as above described.

Patients vary in the time they require to become anæsthetised by nitrous oxide, and even the same individual will differ at various times, being influenced by general health, nervousness, or exhaustion from pain.

The Committee appointed by the Odontological Society of Great Britain found the following averages to obtain :—

	Time Going off.	Duration.	Time from Commencement to Recovery.
Males	1 min. 21 sec.	24 sec.	1 min. 55 sec.
Females	1 ,, 16 ,,	28 ,,	2 ,,
Children (under 15)	1 ,, 3 ,,	22 ,,	1 ,, 40 ,,

As a general rule, stertor* or slight jactitation are signs that the patient is ready for operation. In giving nitrous oxide to children, the face piece should be re-

* Laryngeal stertor must be carefully discriminated from "snoring." Patients with a thick pendulous uvula or enlarged tonsils or post-nasal adenoids start snoring a few seconds after the commencement of inhalation, persons also with loose baggy cheeks make a stertorous-like sound, but these conditions should be ignored. The true stertor caused by vibration of the arytæno-epiglottidean folds only comes on after at least a minute, and is more vocal in character.

moved with the very first sign of jactitation, otherwise their small bodies become so convulsed that it is difficult to keep them still for operation, and valuable time is lost in the attempt to place them in a convenient position. It is important to be able to recognise the tokens of returning consciousness, so as to know when to desist from further operative measures, and this can usually be done with certainty. In the first place, the normal colour of the face returns, the lips change from their ashen hue to a natural crimson. The patient commonly moves a limb or utters a cry, though not one which implies consciousness; restless movements of the body often occur. The time which elapses between removal of the face piece and the period of recovery to consciousness, varies somewhat; it may be as short as thirty seconds or less; while, on the other hand, it may be prolonged to over a minute.

After Effects

Are as a rule conspicuous by their absence; hysterical women may laugh and cry and work themselves up to a pitch of excitement, which sympathetic friends attribute to "the gas"; persons exhausted by fasting and vigil or disease may become faint; epileptics occasionally have a fit during the exhibition of the gas or immediately afterwards. Vomiting is rare after nitrous oxide gas, although such a complication may occur with children, or if the anæsthetic be given immediately after a meal. Pareira states that in one case loss of taste followed it, and I have met with one in which anosmia was complained of for some days subsequently to the extraction of a tooth under gas. Among a few persons

of peculiar organisation, certain nervous symptoms have been known to follow, as, for instance, severe headache and general malaise. Such symptoms, however, are rare after a single administration, but are less infrequent when the gas is repeated twice at one sitting, so that it is distinctly inadvisable to repeat the dose immediately.

Dangers Attending Nitrous Oxide Administration.

Syncope.—Among the graver complications may be noted syncope. While syncope seldom occurs during nitrous oxide narcosis, it is undoubtedly a possible danger, especially among the neurotic and the feeble. It may occur before complete unconsciousness, and is then probably due in part to subjective sensations, such as dread of the impending operation, terror of the anæsthetic, or fear of suffocation. There are reported cases where syncope has only been observed after removal of the face piece, while in others, all has apparently gone well until the operation had commenced, when the condition of the patient suddenly became alarming. Whether death from syncope due wholly and solely to nitrous oxide has ever taken place is doubtful. In the few fatalities which have attended its use and been reported, incomplete anæsthesia has played an important part, while fright and shock have undoubtedly gone far in bringing about the untoward event.

Faintness.—Less severe forms of heart failure, however, such as faintness, do sometimes supervene, and should be met by placing the patient prone on the ground, chafing the hands, applying smelling salts, or aromatic vinegar to the nostrils, and slapping the face

and chest with towels wrung out in very cold water. All garments about the waist, chest and neck should be loosened if this has not been done, as it should have been, before the gas was administered. The inhalation of a few whiffs of nitrite of amyl will, by emptying the blood into the dilated arterioles, relieve the heart. It is sometimes advised to inject ether under the skin, but the utility of this is doubtful, nor is it likely to be called for in the class of cases above mentioned.

A measure which I have practically tested and have reason to estimate very highly is total inversion of the patient. In the moveable dental chairs so commonly used this can be done even in the case of ladies without indelicacy or difficulty.

Respiratory difficulties. — Breathing in some cases becomes very shallow and may stop altogether, but this need not cause alarm unless indeed it should cease for longer than five or six seconds. Then it is well to press up the ribs from below by standing in front of the patient, and grasping the chest with both hands placed about the lower half of the bony thorax. This simple manœuvre will initiate spontaneous respirations, and all will go well.

Asphyxia caused by foreign bodies.—Among dangers occurring during nitrous oxide narcosis, must be mentioned those which arise rather from surgical interference than from the agent employed. Thus, when a prop is placed between the teeth, it should be guarded from slipping back into the wind-pipe by being tied to another hanging freely outside the mouth, and the props used should be made of some material not liable to crack or break off. The mouth should be cleared of artificial dentures, especially small

plates. Accidents have arisen from teeth or portions of teeth being allowed to fall from the beaks of forceps back over the glottis, a deep inspiration then drawing the tooth into the trachea. The tooth forceps have in recorded cases broken, and a fragment become lodged in the trachea.

The dangers of these casualties are: (1) immediate; from asphyxia due to laryngeal spasm excited by the foreign body becoming entangled in the larynx; and (2) secondary; from the working down of the foreign body into the bifurcation of the trachea and there setting up pulmonary trouble.

To deal with such cases.—Firstly, as to precautions. All instruments used for the mouth should be carefully examined for flaws, and all gags, props, &c., be secured by fishing gut or some strong cleanly material and attached outside the mouth.

In extracting teeth the forceps should after each extraction be wiped quickly *twice* across a napkin, in order to free them from the tooth just removed before attacking another. Fragments of teeth should never be left loose in the mouth, even with the object of gaining time; each should be removed before proceeding any further.

Some operators employ a plated lattice mouth-spoon (see fig. 14) so held as to catch whole or broken portions of teeth. Should there be any fragments detached from the tooth or forceps, etc., which cannot be seen and picked out, the anæsthetist may at once bend the head forwards and sweep the finger round the mouth so as to carry any foreign body forwards, when it can be seized and removed; in this way it may sometimes be possible to dislodge a foreign body situate at the epi-

glottis. It should be remembered that the tongue must not be drawn forwards, as by so doing the larynx will be left exposed, the epiglottis being dragged from it, also because the patient is thereby induced to take a deep inspiration which may cause the foreign body to enter the air-passage.

If the obstruction cannot be felt, and there are signs of impending asphyxia, inversion should be attempted, and the patient instructed to expire very deeply, coughing with the act, while he inspires as shallowly as he is able. This manœuvre has succeeded in dislodging a tooth which had passed into the trachea.

At the same time it must be remembered that inversion may cause the foreign body to lodge in the larynx and so excite spasm. Failing these measures, if the patient be dyspnœic and death by asphyxia seems imminent, the trachea must be opened by the crico-tracheotomy operation (*see* Chap. X.).

Is nitrous oxide dangerous to any particular class of persons?

It sometimes happens that the anæsthetist is consulted as to the safety and expediency of giving nitrous oxide to pregnant women, women during lactation, or at the menstrual period; persons whose vitality is greatly lowered by age or disease; the subjects of grave heart or lung disease.

Pregnant women, provided they be not within a very short period of their accouchement, are not prejudicially affected by laughing gas. The shock of a surgical operation, the extraction of a tooth or what not, is quite as likely to provoke premature delivery as giving the gas. The child also appears to be quite unaffected, as one would expect, since its oxygen ten-

sion is habitually low, and further because the elimination of nitrous oxide from the blood is very rapid. At the same time, especial care should be given in administering nitrous oxide in these cases, as the nervous system is peculiarly liable in these persons to receive strong impressions and is easily thrown off its balance. Hysterical emotional outbursts if they occur will certainly be attributed to the inhalation, so that unless imperatively called for, operative measures should be deferred until after parturition. In the early months of pregnancy vomiting may be excited by nitrous oxide.

Lactation is not in the majority of cases prejudicially affected by nitrous oxide gas. **During menstruation** women may safely take this anæsthetic, with this reservation that since their nervous system is at this time less stable than ordinary, these patients will be a little more likely to be "upset," hysterical, and so on. It is noticed elsewhere that erotic hallucinations under gas are more prone to occur at the "monthly period" than at other times.

Age, as such, offers no reason for declining to administer nitrous oxide, patients over ninety having taken it successfully. When great **vascular feebleness** exists, there is more risk, as the greater tax imposed upon the heart by checking oxidation in the lungs, and so impoverishing the tissues, may provoke syncope. However, with due care and watchfulness even the very feeblest can take nitrous oxide with impunity. In practice I have found it wise to administer a little ether in conjunction with the gas when great circulatory enfeeblement is present.

In extensive lung disease, especially in phthisis, when hæmorrhage has been known to have occurred,

nitrous oxide must be given with caution, as there is danger of exciting fresh bleeding from the lungs. According to Mr. Braine, narcosis deepens in phthisical patients after the withdrawal of the face piece, and so special care is needed in the management of such cases. It is probable that this is really due to enfeebled expiration preventing the usual elimination of the nitrous oxide.

Heart disease, save in so far as that the tendency to syncope is considerably increased, is no contra-indication for giving the gas. In all cases, it is necessary to weigh in one's mind which will be most likely to jeopardise the patient's welfare—the performance of an operation without an anæsthetic, or the giving of the anæsthetic. Broadly it may be stated that if the patient can bear up against the operation, he will certainly survive the anæsthetic. (Snow). Valvular diseases, unless marked want of compensation is present, are not contra-indicatory to nitrous oxide inhalation. When the heart is greatly dilated and the hypertrophy has failed to overcome the obstructed circulation, or when marked muscular degeneration of the heart fibres has taken place, there is necessity for caution, and of such patients the most anxious care should be taken.

Laryngeal spasm is said to occur in rare instances during the administration of nitrous oxide gas even when the gas is pure and given with skill.*

* An instructive case is published by Dr. F. Hewitt. A patient æt. 35 suffered from fixation of the bodies of the vertebræ which precluded all save very slight rotatory and nutatory movements. The neck muscles were unduly rigid and the jaws could be opened only to a fourth of the normal extent. The fixation was the result of rheumatic fever. The gas was taken well and the tooth extracted. It was then remarked that the usual recovery did not occur, the respira-

Deaths from Nitrous Oxide Administration.

Several deaths have been imputed to the use of this agent, but it is doubtful whether any of the cases recorded were directly due to the physiological action of this substance. In some instances insufficient narcosis was maintained, and as a result the patient *felt the pain*, and syncope ensued. In others, either the entire gag or a portion of it slipped, and found its way into the patient's larynx, there to excite spasm and suffocation. In one instance, a person apparently whilst intoxicated, kept the face piece applied and fixed it so that he became asphyxiated.

Paul Bert's Method of Administering Nitrous Oxide.

Paul Bert, in the course of various experiments undertaken to ascertain the most safe and advantageous method of establishing anæsthesia by nitrous oxide, found that by administering it in conjunction with oxygen under pressure, he could prolong the administration practically for an indefinite period, while no injury to the subject resulted. Without referring in detail to Bert's experiments, which are out of place in

tion becoming more and more embarrassed "as though some obstructive condition of the air passages" existed. "The sound made by the last attempt at respiration was to a certain extent suggestive of fluid at the back of the throat." General fixation of the thoracic walls and rigidity of the jaws and muscles of the neck rendered the measures usually adopted, such as artificial respiration, swobbing out the pharynx, &c., impossible; and as inversion failed to restore the patient's respiration, Dr. Hewitt performed laryngotomy which at once relieved the spasm and the patient did well.

a practical manual, it may be well to epitomise his reasoning and give his results.

Nitrous oxide, when diluted to a certain point with air or oxygen, is incapable of producing satisfactory anæsthesia. When, however, it is given pure, the patient's tissues become de-oxidised from want of fresh income of oxygen. Further, nitrous oxide does not produce anæsthesia by dint of its replacing oxygen, nor is it rendered inoperative in the presence of oxygen, provided its tension in the blood be sufficiently high. It therefore appeared probable that, were nitrous oxide to be administered under a pressure of two atmospheres (that is, so that fifty per cent. only of the atmosphere so inhaled was nitrous oxide, and the other fifty per cent. air, the nitrous oxide tension in the blood being then equal to one atmosphere, and at the same time sufficient oxygen entered the blood to maintain the due oxidation of the tissues), anæsthesia would result without any asphyxia. An apparatus was accordingly made by Dr. Fontaine (fig. 16) which enabled the patient to be kept under an atmospheric pressure equal to 26 inches mercury, and this was successfully worked. Under this pressure nitrous oxide and oxygen being given in the proportion of 5 to 1, the tension of nitrous oxide was equivalent to one atmosphere.* Several operations lasting from five minutes to half an hour were successfully performed under anæsthesia produced by Bert's method.

Recently Dr. F. Hewitt has revived Paul Bert's idea of

* For an excellent account of Paul Bert's method see the admirable work of M. Rottenstein, *Anethésie Chirurgicale*. M. Rottenstein assures me that even in France this method is now but little used.

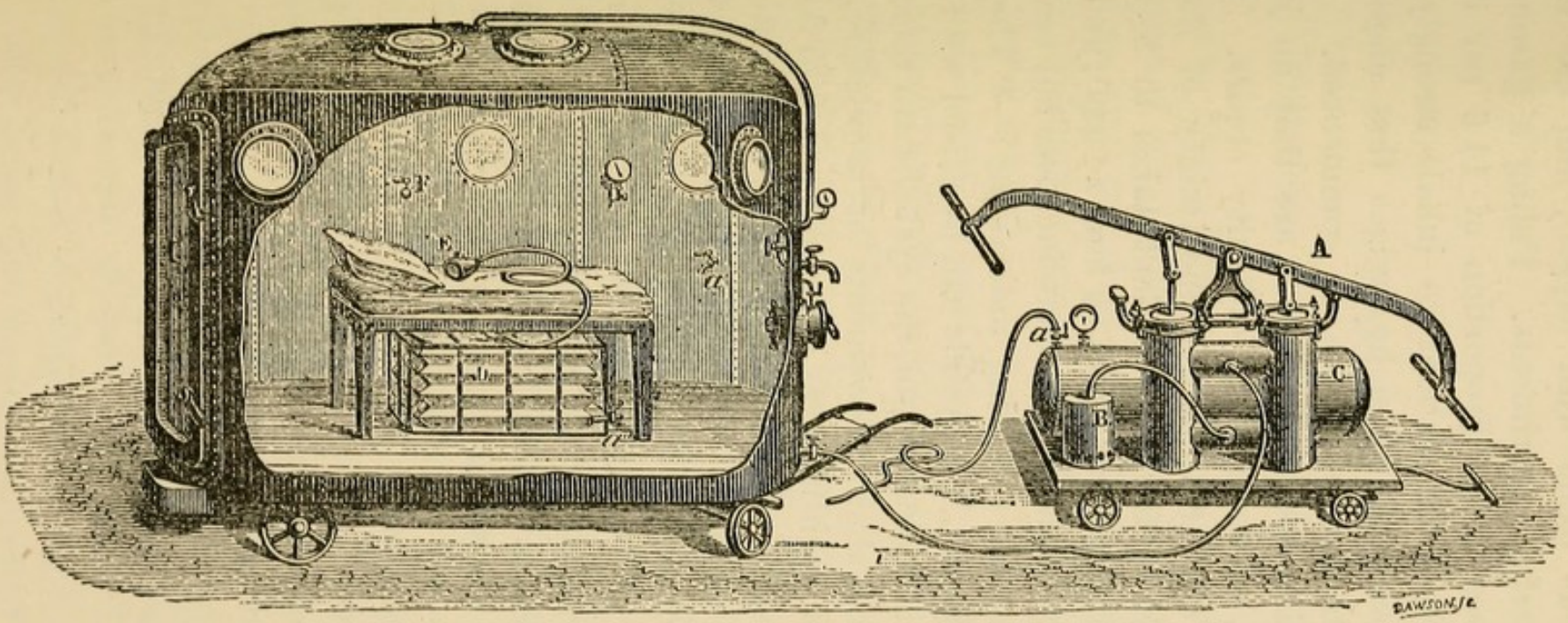

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FIG. 16.—Fontaine's chamber and apparatus for forcing in air under pressure.

A. Double barrelled air pump.

B. Refrigerator through which the air passes.

C. Sheet iron container capable of holding 350 litres of the gaseous mixture under a pressure of 10 atmospheres.

D. Gas bag communicating with the face-piece E by a flexible tube.

blending nitrous oxide with oxygen, and has made some very careful experiments. Filling a gasometer with these gases in the proportion of 14·5 per cent. oxygen he allows the patient to inhale strongly for several minutes, and when he judges that anæsthesia is complete the operation is commenced. The advantages claimed for this mixture are that no jactitation, lividity, or respiratory difficulty occurs. The disadvantages appear to be the uncertainty of its action, the length of time the patient takes to become anæsthetised (about three times as long as gas), and the difficulty of ascertaining when consciousness has ceased. Dr. Hewitt gives the following indications :—"The extremities are relaxed, the eyelids can be raised with the finger without inducing spasm, the eyeballs are vacantly fixed or present slight movements of oscillation, the patient does not open his eyes when requested to do so, and the respiration is extremely calm." Sometimes slight rigidity replaces relaxation; corneal reflex is retained; no change of colour takes place. From twelve gallons of the mixture are required for each case. An apparatus has been constructed for Dr. Hewitt by Messrs. Barth, which is fairly portable, and is said to answer its purpose very well.

CHAPTER IV.

Sulphuric Ether—Anæsthetic Ether.

Ether or Ethyl Ether $\overline{C_2H_5}^2O$, more accurately known as oxide of ethyl, was discovered in 1540 by Valerius Cordius, and called by him *oleum vitrioli dulce*. In 1730, Frobenius changed this name for the one it now commonly bears.

Chemical and Physical Properties.—It is a clear, translucent highly volatile liquid, of a penetrating odour and a burning taste which is followed by a sensation of cold and numbness. It has a specific gravity of ·723 (at 54·5° F.) and boils at 35° C. (95° F.); when pure it does not redden litmus. It crystallises in fine white laminæ. Ether does not mix with, but is slightly soluble in water, freely uniting with alcohol and chloroform. Applied to the skin, it gives a sensation of intense cold caused by the extreme rapidity of its evaporation.

Ether is highly inflammable; its vapour when mixed with air is liable to explode if brought in contact with flame; it is hence important to avoid the proximity of lighted gas jets, candles, &c., and to refrain from pouring ether out of one receptacle into another in such surroundings. The substance is prepared by acting upon strong alcohol with sulphuric acid and heating the mixture to 140°-150° C. (280°-300° F.). This compound undergoes double decomposition, ethyl sulphuric acid and water being first liberated, the ethyl sulphuric acid

afterwards combining with a molecule of alcohol to form ethyl ether and sulphuric acid, thus :—

$$\begin{array}{cccccc} C_2H_5O & + & HSO_4 & = & HO & + & HSO_4 \\ H & & H & & H & & C_2H_5 \\ HSO_4 & + & C_2H_5O & = & HSO_4 & + & C_2H_5O \\ C_2H_5 & & H & & H & & C_2H_5 \end{array}$$

and the sulphuric acid is ready to attack another molecule of alcohol. This, the so-called continuous etherisation process, is practically interminable, provided a fresh supply of alcohol be maintained. The ether so prepared is passed over fused chloride of calcium, which removes the water and alcohol and is then rectified.

Ether, if kept in hot places and in an imperfectly stoppered bottle, is liable to undergo oxidation, acetic acid and other products form, and the reagent is thus rendered unfit for use. Ether, if pure, forms a clear mixture with oil of copaiba, but if it contains water or alcohol an emulsion will result.

The impurities to which ether is subject are :—

1. Water, detected by adding tannin, for when water is present the mixture becomes syrupy, while if absent the powdered tannin remains unchanged.

2. Alcohol, if present, gives a red stain with crystals of fuchsine; it also increases the specific gravity.

3. Acids, sulphuric and sulphurous, detected by the precipitate they give with barium chloride; acetic acid which produces a deep-red colour upon the addition of an iron salt.

4. Fusel oil, may be detected by its leaving a greasy stain on paper.

General properties and uses.—Ether is an exhilarant and finally a narcotic; it is the safest known agent for the production of prolonged narcosis. It is employed

alike for its power of producing local anæsthesia, which it does by provoking such a rapid abstraction of heat as to numb the cutaneous endings of the sensory nerves, and also on account of its capacity for inducing complete insensibility to pain (general anæsthesia) through its action upon the cerebro-spinal centres.

Ether for general purposes is the best and safest anæsthetic; it is superior to nitrous oxide, because it may be inhaled for hours without endangering life; it is less dangerous than chloroform because its undiluted vapour is practically safe, whereas chloroform, unless kept below four per cent. of the air breathed, seriously imperils life.

There are, however, cases in which ether should not be used.

In protracted operations about the mouth, jaws, nose or pharynx, which necessitate the mouth and nose being uncovered. Since consciousness rapidly returns when the supply of ether is discontinued, there is not time for prolonged surgical procedure.

All operations which require the employment of the actual cautery, or lighted candles, lamps, &c., near the mouth, ether being highly inflammable and, when mixed with air, detonating, so that the incautious bringing of the apparatus near a light may lead to grave consequences.

There are, also, certain conditions in which the advisability of using ether ought to be carefully weighed.

Persons who are suffering from bronchitis, the emphysematous (if the condition be very pronounced), and as a rule asthmatics, bear ether badly, since it excites cough and may clog the bronchial tubes with a quantity of excessive secretion.

In renal disease, when extensive, ether is said to induce suppression of urine, so that if given at all in these cases it should be with the utmost caution.

The vascular excitement to which ether gives rise contra-indicates its use for persons whose arteries are presumably brittle, or in whom circulatory perturbation is likely to be harmful. It is obvious that when cerebral hæmorrhage from rupture of an artery has once occurred, ether might, by increasing arterial tension, induce a repetition of so dangerous an accident.

In infants and very young children ether may sometimes produce pulmonary trouble from its irritating effects upon the delicate mucous membrane of the respiratory tract.

Although, in selecting an anæsthetic, it is well to carefully consider these objections, yet, I think few of them are of great weight except perhaps in very marked cases of disease.

In tropical climates it is both difficult to obtain and to keep ether, and also to administer it satisfactorily.

As ether often provokes rapid breathing and not infrequently coughing, it should not be used when these are prejudicial to the patient, or to the success of the operation.

In operating upon the brain when turgescence and relaxation of the blood-vessels is undesirable, ether should not be used, and according to Wood it is contra-indicated in the presence of brain tumours.

Physiological Action of Ether.

According to Hermann it destroys the red corpuscles. Ether when first inhaled induces a burning sensa-

tion in the mouth and pharynx and a feeling of impending suffocation. It appears to act in two ways; indirectly through the nerve centres as a powerful deliriant and anæsthetic, and directly upon the endings of the nerves supplying the pharynx and respiratory tract. Thus, it increases the flow of saliva, and causes considerable discharge of watery secretion from the bronchial mucous membrane. Its extreme volatility makes it exert a marked cooling action upon skin or mucous membranes when allowed to come into contact with them; and further, the vapour, if injudiciously employed, may excite a highly prejudicial chilling effect upon the bronchial lining membrane, resulting in catarrh or even bronchitis. Ether is absorbed both by the mucous membrane of the respiratory tract and that of other mucous surfaces, *e.g* , the rectum. When ether vapour enters the rectum, the vapour is perceptible in the breath after a few minutes.

In the rhythm of *respiration*, ether brings about marked changes. If the full strength of ether vapour be allowed to impinge upon the glottis, the adductor muscles are thrown into spasm, and the rima becomes temporarily closed. Indeed ether has been shown by Horsley and Semon to exert a marked local action upon the laryngeal muscles. These observers have proved that this differs according to the degree of anæsthesia induced. Slight ether narcosis causes adduction, while deep etherisation produces abduction of the vocal cords, and these results obtain with strong or weak currents and whether the recurrent laryngeal nerve is divided or left intact.

At first the respirations are hurried and deep, subsequently they become slower and more shallow, and

would eventually, were ether pushed to such a dangerous extent, altogether cease. This slowing and final cessation appear to be due to ultimate poisoning of the respiratory centre in the medulla.

The *heart's action* is at first excited and increased in force; later this subsides, the heart quiets down, or even grows somewhat weaker, though such weakening is always trifling. The blood pressure is increased until very deep narcosis is present, when a slight fall of pressure occurs. A peripheral vascular dilatation reveals itself in flushing and rubescence of the skin, together with sweating and a roseolous rash. According to Sansom, in the earlier stage of etherisation, capillary constriction takes place. Under ether the *muscles* at first become rigid and firmly extended, but later these conditions give place to extreme flaccidity; in some persons the muscles maintain their rigidity much longer than in others, while there is a difference in the time which muscles in various regions take to relax. Ringer, experimenting on muscle, found, that in frogs, the vitality of involuntary muscle persisted far longer in the case of ether than in that of chloroform. Peristalsis although lessened is not abrogated, even when death is induced by ether.

The *nervous system* during etherisation becomes profoundly affected. The *cerebrum* first succumbs. Excitement and hallucinations appear, the patient believing that he is engaged in mortal combat, or in some habitual pursuit. He may struggle and cry out; soon his speech becomes thick and inarticulate, his struggles cease and his mind no longer controls his movements. The *sensory nerves* of the spinal cord then fail to convey impressions from without, although

stimulation of the motor nerves induces movements. Later, the *motor nerves* also cease to respond, save to powerful electrical excitation (Longet). The *medulla* becomes next affected; at first sensory impressions fail to reach it, finally its motor centres become paralysed, respiration is arrested, and the heart ceases to beat. It appears that these results are due to the direct action of ether, conveyed by the blood to the nervous centres, since they occur after section of the pneumogastric nerves, or when the anæsthetic is injected directly into the veins. Hence it would seem that ether directly affecting the centres acts first as a stimulant and later as a depressant. When artificial respiration is maintained, the heart will continue to beat for a prolonged period, and this even in spite of very large quantities of ether. The bodily temperature is reduced under ether; Kappeler fixes a minimum at ·3° C., and a maximum at 1·5° C. (·5°—2·7° F.). It increases the secretions with perhaps the exception of that of the kidneys. Elimination takes place rapidly and is mainly effected by the lungs.

Methods of Administrating Ether.

Ether may be given alone or in combination with nitrous oxide gas, the latter method possessing the following advantages:—The patient is spared the disagreeable smell and taste of ether; he becomes narcotised more rapidly and without struggling or excitement.

The main indications for the successful administration of this anæsthetic are:—that the air inhaled be

saturated with ether vapour, unsaturated air being excluded; that the vapour shall not escape into the room and impregnate the air breathed by the operators and bystanders; that during the first few respirations the patient shall inhale a vapour so dilute as not to irritate his larynx. Ether cannot be given advantageously from a folded towel.

Inhalers.—Of these several have been devised. They may be classed under two types, those following the plan of Mr. Clover, and those which are modifications of the cone.

Clover's Portable Ether Inhaler (Fig. 17) consists, as reference to the figure indicates, of a dome-shaped ether receptacle (*a*) pierced by a central shaft (*b*) into which are adapted (i.) a tube bent at right angles (*c*), which carries the india-rubber bag (*d*), into this the patient breathes, and (ii.) a metal tube (*e*) which serves for the attachment of the face-piece *(f)*. Moving with the face-piece *(f)* is a metal indicator (*g*) which as the ether receiver (*a*) rotates on *(f)* indicates the amount of ether admitted; (*h*) is a tube and stop-cock for inflating the air cushion which rims the face-piece and helps it to fit the face accurately.

The face-piece *(f)* is edged with an air cushion inflated through (*h*). The ether vessel and water chamber (*a*) which surrounds it and maintains it at the desired temperature for evaporation, rotate upon the mount of the face-piece *(f)*. When the instrument is first applied, the arm (*l*) should be opposite the patient's forehead, and the indicator (*g*) which travels round the lower end of the water chamber pointing to the figure 0. He now breathes directly in and out of the bag. The bag (*d*) should not be placed in posi-

tion until the patient has taken two or three inspirations, it must then be inflated by blowing air into it and be fitted to the upper end of the water chamber as shown in the figure. As the ether vessel is turned round the indicator travelling from 0 to 1, 2, 3, and F successively, the air has to traverse the ether vessel before reaching the bag, and so the patient gets gradually a more and more highly saturated ether atmosphere. Two ounces of ether are poured into the

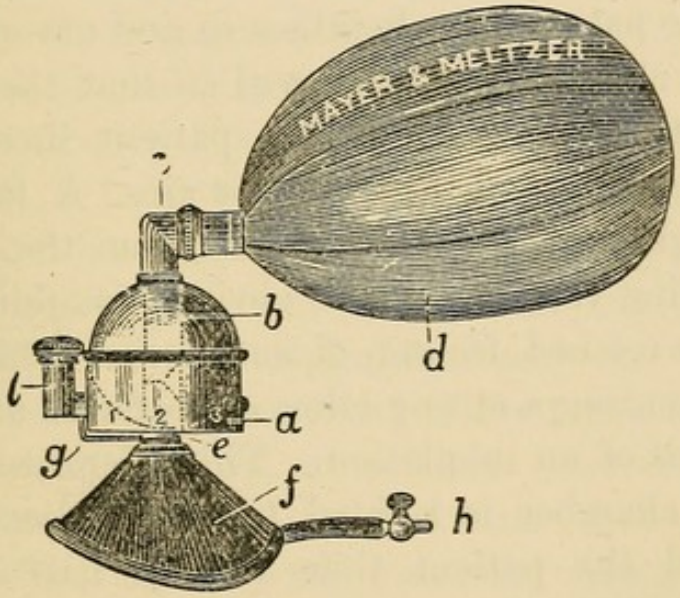

FIG. 17.—Clover's Portable Ether Inhaler.

projecting arm (*l*) before the operation, and these usually suffice for the case. The opening is so arranged as to prevent an excessive quantity being used and to guard against the possibility of a few drops escaping through the inner openings. The ether vessel and surrounding water chamber are so arranged, that although the vapour freely escapes, no fluid overflows in whatever position the inhaler may be held.

The following is the method of using this inhaler. A face-piece of an appropriate size having been selected, and two ounces of ether placed in the receiver, the air-bag is removed and the indicator turned to 0. The patient is then directed to inspire deeply, and the face-piece applied gently but firmly. Uniform pressure is well borne, while hard pressure if unequally distributed will not be tolerated. When the patient has taken two or three deep breaths, the air-bag is filled by the administrator blowing in air, taking care not simply to breath into it, and is slipped into its place, so that the patient now breathes in and out of the bag. The ether chamber is now moved so that the indicator points to the figure 1 and the patient then breathes one-fourth ether and three-fourths air. A few breaths of such a dilution of ether will accustom the larynx to the irritating vapour, and so obviate coughing, spasm, and the wretched feeling of suffocation which ensues upon presenting a strong ether atmosphere at the commencement of an inhalation. This tolerance achieved, the ether chamber is rotated, till the indicator points to 2, and the patient then inhales half ether and half air. If this strength of vapour does not distress him, the indicator, by further rotation of the ether chamber, can, after a few seconds, be made to point to 3 (one-fourth part air, three parts ether) and then to F (all ether). The patient will in from ninety seconds to two minutes and a half, be completely unconscious and ready for operation. Some persons require more ether to put them off, and those who persistently resist taking the anæsthetic by holding their breath or by taking the shallowest breaths consistent with life, will delay the onset of unconsciousness much longer. These

persons also, since they voluntarily semi-asphyxiate themselves by repressing respiratory movements, suffer great additional discomfort from the feeling of suffocation they induce.

As soon as complete anæsthesia is thoroughly established, the indicator may be brought back to 2 by turning the ether chamber round and there kept until the operation is over. It may be necessary in warm weather, and in the case of prolonged operations to renew ether in the receiver. This is easily done by removing the inhaler from the patient's face, loosening the cork, and pouring in a further supply.

The patient will, during a prolonged operation, require the inhaler to be taken off his face every sixth breath or so, in order that he may take a few inspirations of air. The necessity for this will be readily recognised by any cyanosis apparent in the face or ears, and by the character of the respirations and the pulse. It should be carefully borne in mind, that the amount of an anæsthetic required to produce narcosis is much greater than is needed to maintain that condition. Also the degree of narcosis must be varied, in correspondence with the region of the body upon which operative measures are being pursued. When it becomes necessary to anæsthetise the patient in the prone or semiprone posture, a useful addition to the Clover's smaller ether inhaler is the angular adjuster figured below. This useful contrivance is the invention of the late Dr. Charles Sheppard (see fig. 18).

This inhaler was intended by Mr. Clover for the administration of ether alone, but several persons have adapted it for the exhibition of that vapour in conjunction with nitrous oxide gas, and Mr. Clover writing in

1877 himself says, "by connecting the bag with a supply of nitrous oxide it forms a tolerably efficient substitute for the gas and ether inhaler." Thus by attaching a stop-cock in the metal bent piece to which the bag is attached, gas can readily be admitted into it by a long india-rubber tube coming directly from the gas bottle (see Fig. 17, *k*).

Another method, which has been in use for some

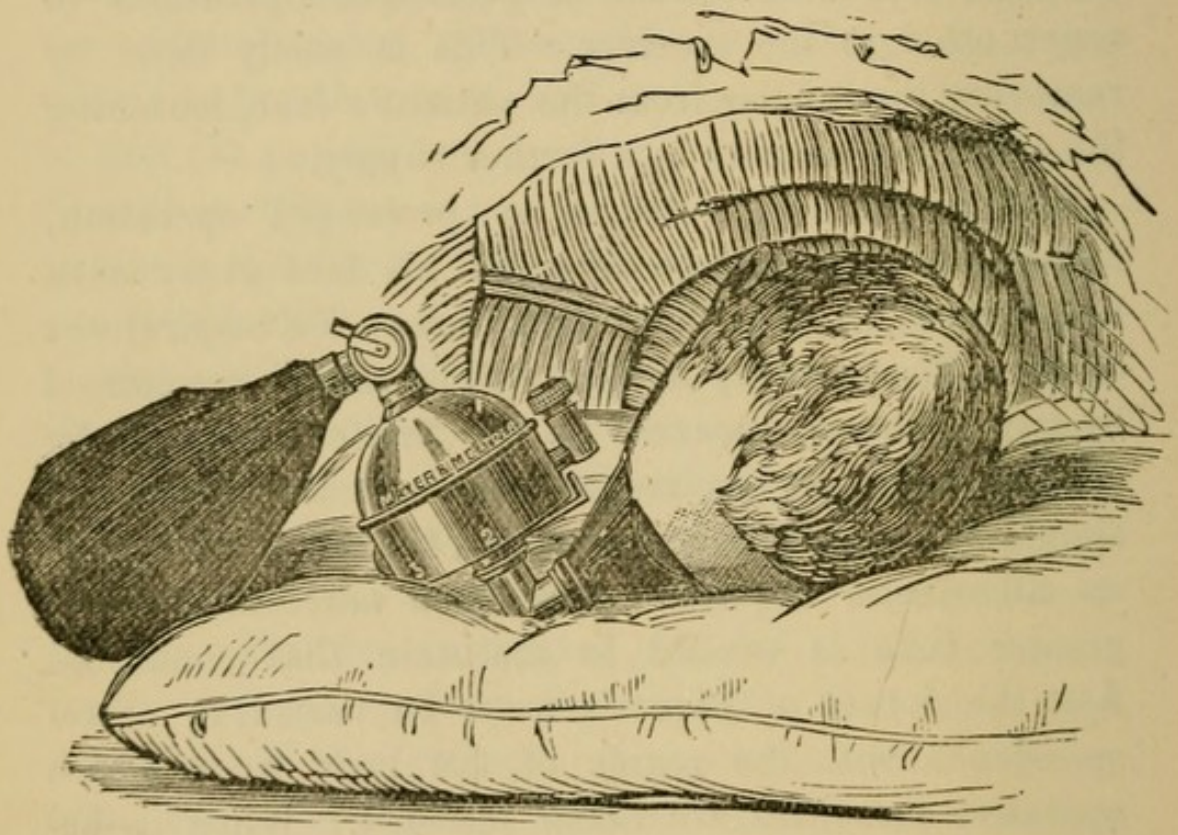

Fig. 18.

years at University College Hospital, is to introduce a three-way valve with stop-cock between the face-piece and its rotatory mount. In this apparatus the third way is connected with the supply tube of gas.

Dr. Frederic Hewitt has introduced a convenient form of apparatus for giving gas and ether which is figured below.

In this apparatus the inspiratory and expiratory valves are placed, not in the face-piece, but in a little chamber near it. Below this valve chamber is a two-way stop-cock. The valves may be thrown into or out of action by the tap T (Fig. 19). When T is turned as in the figure, the valves act and all expirations (whether of air or gas as determined by the stop-cock below) escape. When T is turned in an opposite direction, to and fro, breathing (of gas or air as the

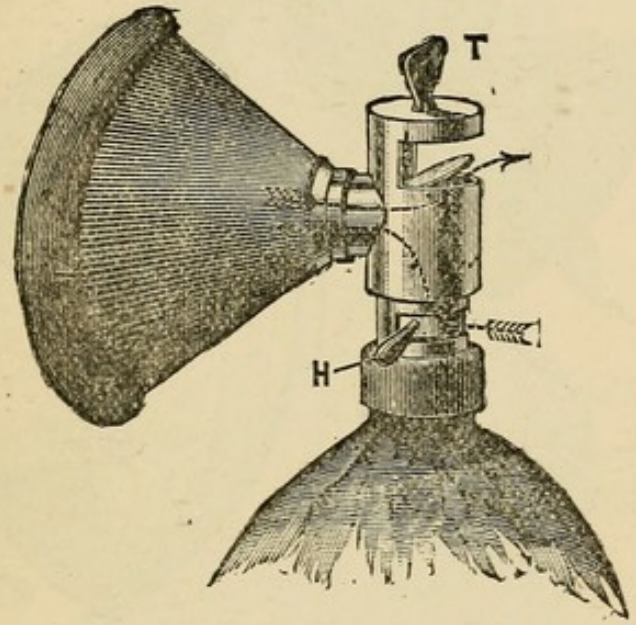

FIG. 19.—Face-piece, stop-cock, and gas bag for the administration of nitrous oxide gas only. (Dr. Hewitt's apparatus).

case may be) results. To use the apparatus, first allow the patient to breathe air (in the direction of the dotted arrow) and see that the valves act freely. Then turn on nitrous oxide by moving round the handle H. Should nitrous oxide unexpectedly fall short the valve-action may be stopped by turning T and the patient would then breathe gas into and out of the bag till anæsthesia occurs.

The apparatus is so made that a very free draught

through it is permitted, the valves, which are of thin india-rubber, acting very easily and thus giving no sense of difficulty in breathing. When nitrous oxide followed by ether is required, the stop-cock, &c., can be fixed to a Clover's portable apparatus as shown in Fig. 20*.

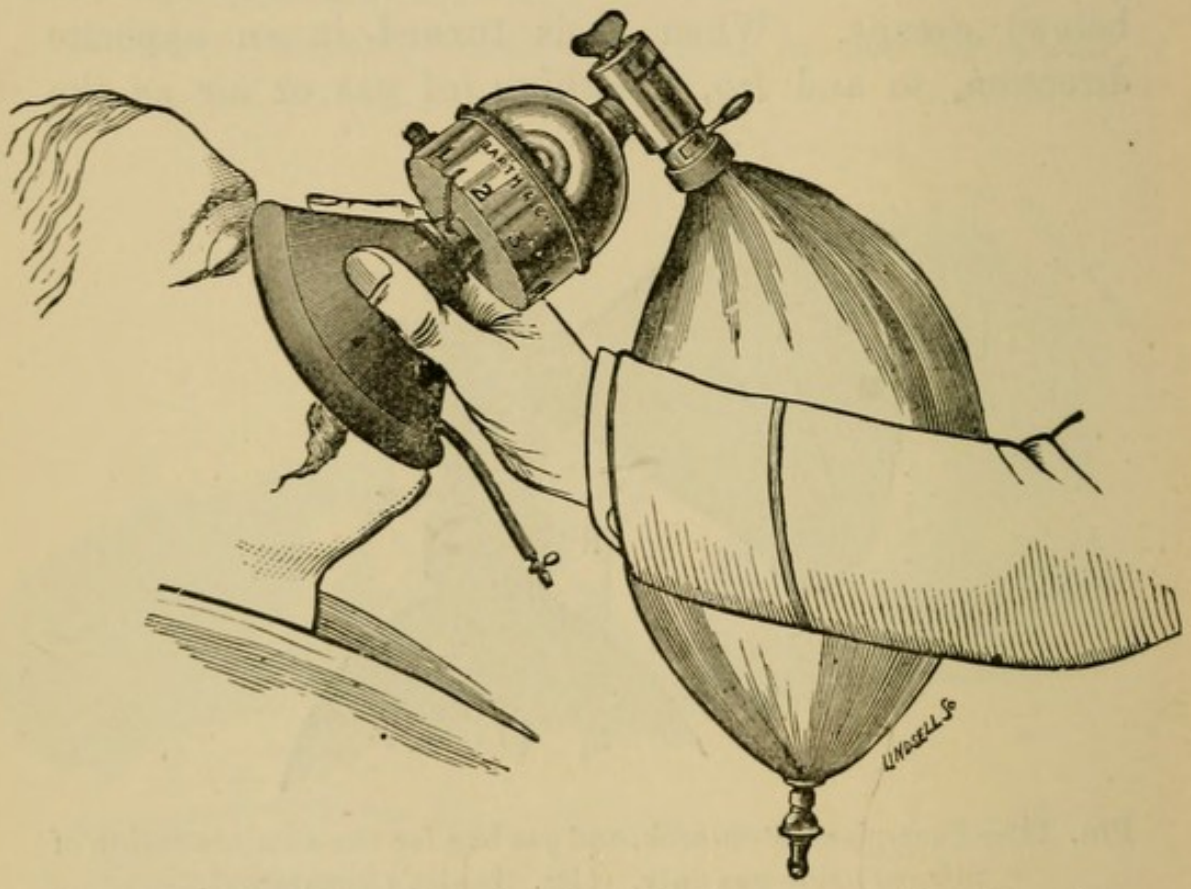

Fig. 20.— Face-piece, Clover's ether chamber, stop-cock, and gas bag for the administration of nitrous oxide and ether. (Dr. Hewitt's apparatus).

Clover's larger inhaler is figured and described on Fig. 3, p. 42. It is used mainly, if not exclusively, for giving nitrous oxide and ether in combination. The method of using it without nitrous oxide is simple. The air bag is fully inflated by the administrator, who then moves the indicator off the dial plate and turns the

* For this description I am indebted to Dr. Frederic Hewitt.

ether tap (k). The indicator is next turned to G when air only will be taken. As soon as the indicator passes towards E, ether begins to be received; the same principles and cautions guide the further proceedings with this, as were employed for the other inhaler.

The Cone.—This is a contrivance largely used in

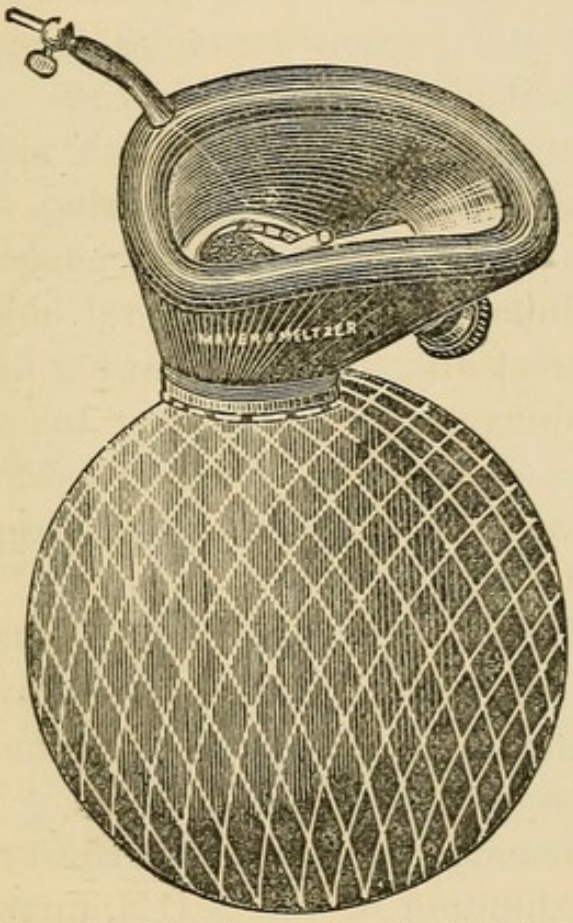

Fig. 21.—Dr. Ormsby's ether inhaler.

America. The ether is poured into a cone, upon a sponge, and renewed from time to time by inverting it and pouring in a fresh supply.

Ormsby's Inhaler.—It consists (see Fig. 21) of a leather face-piece with cushioned rim, provided with a valve, which can be opened at the pleasure of the administrator; at the top of the face-piece is a cone-shaped wire cage, covered externally with leather, and

leading into a soft leather bag covered by a loose net which prevents its undue expansion. In the wire cage, a sponge is placed, and upon this an ounce of ether is poured. The apparatus is applied to the patient's face and he strives to take a full breath. Even when the valve is kept widely open the sense of suffocation is so great (the rush of ether vapour producing more or less spasm), that the patient struggles fiercely to escape what appears like impending asphyxia.

Should it be necessary to add fresh anæsthetic during the operation, it is done by pouring ether down a tube which enters the centre of the sponge.

Ormsby's inhaler is open to several objections; *e.g.*, it produces great discomfort by allowing undiluted ether vapour to impinge upon the larynx; the sponge is very liable to freeze hard, and so no evaporation of ether can take place; it occasions great struggling; it is wasteful of the ether.

Messrs. Krohne and Sesemann have designed a modified cone of which a description is given on p. 115, which although designed for chloroform can be used either for ether or the A C E. mixture.

For administering ether I prefer Clover's apparatus, but for the exhibition of the A.C.E. mixture, the cone or one of the modifications mentioned above is preferable as admitting of more free air dilution.

The apparatus for administering ether by the rectum is described on p. 87.

Allis' Inhaler. (Fig. 22).—Another useful form of inhaler is that invented by Dr. Allis of Philadelphia, supplied by Messrs. Mayer and Meltzer. It is applicable for the use of ether or the mixture, and is efficacious and cleanly, and is probably the best form of open inhaler.

It consists, as can be seen from the wood-cut, of a metal frame so arranged that flannel bandage can be stretched across and across. The outside is covered with a leather case, which being prolonged below the

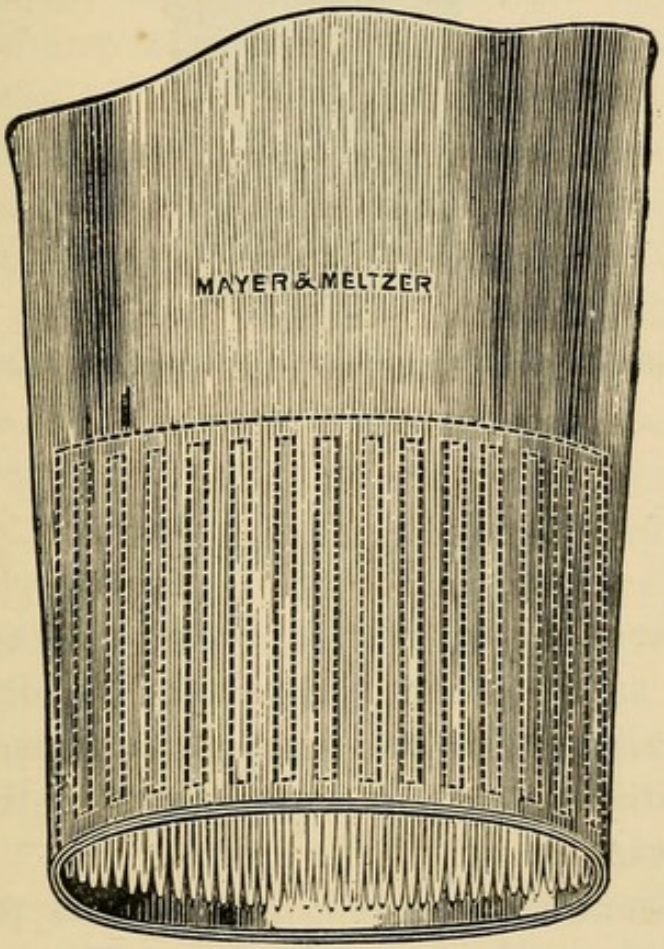

Fig. 22.—Allis' ether inhaler.

metal serves as a well adjusting face-piece. Fresh additions of the anæsthetic are dropped from time to time upon the flannel from above.

Rendle's ether mask figured below needs no special description. (Fig. 23).

Many other forms of apparatus have been invented, but as they possess no peculiar merits and are seldom

used in this country, I must omit further mention of them.

FIG. 23.—Rendle's mask and flannel cap in cone.

THE ADMINISTRATION.

The effects of ether inhalation will vary considerably according as the patient is narcotised rapidly or slowly. Slow etherisation possesses no advantages, and is indeed positively harmful by prolonging the stage of delirious excitement.

The patient being placed in the supine position and his clothing ascertained to be loose, his mouth is examined for artificial teeth or an obturator, and if such exist they are to be taken out and ether administered by one of the above forms of apparatus. Although the supine position is best, yet for operations for the removal of teeth and upon the post-nasal cavity the patient may be allowed to be propped in a sitting posture.

When the patient first breathes ether vapour, he catches his breath, may cough, and resists the ingress

of the vapour. This will be in proportion to the strength of vapour used. A few inspirations will render him dazed, the face will flush, the eyes grow suffused, and the breathing become rapid. The pulse in this stage is large, softer than natural, and accelerated. Although stupefied, the patient can still perform certain voluntary acts, *e.g.*, putting out the tongue if loudly ordered to do so. The feeling of suffocation which was at first experienced now gives place to one of exhilaration, the dyspnœa disappears, and the respirations are full and deep. Formication and tingling are felt in the hands and feet. The pupils usually contract in this stage. The exhilaration, however, soon passes into a condition of delirious excitement. Bert denied that true excitement occurs, believing that progressive loss of muscular power supervenes, while the disorderly movements commonly put down to excitement of delirium are he thought to be explained as *une sorte d'anarchie cérébrale*, the guiding centres being in abeyance. In whatever way we regard these movements, they certainly appear to be the result of temporary delusions. Thus, military men will, in this stage of etherisation, shout words of command; while those inclined to pugilism will attempt to box with the bystanders. The respirations and heart's actions are considerably accelerated; the skin grows moist, the face dusky. Soon a period of quiet follows, and it should be the aim of skilled etherisation to curtail as much as possible this condition of excitement. In the succeeding quietude the limbs stiffen, the muscles grow strongly contracted and firmly set, the whole body becoming rigid. Breathing is hampered by the rigidity of the thoracic muscles and needs watching at this

time. Should respirations stop it will be necessary to firmly press two or three times upon the chest, and so force in the air. The pupils dilate and the skin becomes bedewed with perspiration, while a roseolous rash appears in patches about the neck and chest. These patches coalesce. The pulse resumes its normal rate, and although soft, yet remains regular and somewhat more forcible than before the anæsthetic. Now ensues the stage of muscular relaxation. The patient lies absolutely insensible to all external impressions with his muscles perfectly flaccid. The breathing slows although it keeps quicker than normal, and is much more shallow. At this time anæsthesia may be taken as complete, and operative measures may proceed.

Rectal Etherisation.

Pirogoff as early as 1847 suggested that ether should be given by the rectum and finding that liquid ether could not with impunity be injected (Magendie), he employed an apparatus which permitted ether vapour only to enter, and obtained such good results that he believed rectal etherisation would replace pulmonary inhalation. More recently Dr. Axel Yversen of Copenhagen, Dr. O. Wanscher of the same city, and Dr. Mollière of Lyons as well as Drs. Bull and Weir of New York have tried rectal etherisation and speak well of it.

I have now used the method pretty extensively and find it to answer admirably for operations about the mouth, nose and post-buccal cavities, for intra- and extra-laryngeal operations, for staphylorraphy and for

operations for the relief of empyema. For the removal of the tongue, for excision of the jaw, or jaws, and for plastic operations about the face, the method gives greater facilities and freedom to the operator than any other plan I have tried. Mr. Appleby recommends the method also for prolonged dental operations. The advantages claimed are (i.) less ether is used, (ii.) recovery is more rapid, (iii.) after effects are less severe, (iv.) the stage of excitement is lessened or abrogated.

Its disadvantages are; the greater length of time the patient usually takes to become ready for operation however this does not always apply; the uncomfortable feelings some patients complain of, although Dr. Wanscher says some of his patients having been anæsthetised first by the usual method and subsequently by the rectum, preferred the latter.

In some cases it is alleged that severe meteorism, diarrhœa and even melæna have followed the use of ether by the rectum. Unquestionably the method requires the greatest care and some experience before a uniformly happy result can be expected, and the anæsthetist must remember that carelessness in permitting too rapid an evolution of the vapour will lead to grave suffering if not to danger.

The apparatus I have employed is in effect an ether receiver holding about 2 or 3 ounces, this is plunged into a second vessel which should contain water at 120° F. The ether vessel communicates by an india-rubber tube with a glass intercepter devised to prevent the entrance of liquid ether into the rectum The further end of the intercepter is joined by another and short tube to an anal tube. This is made for me by Messrs. Mayer and Meltzer. Some persons have em-

ployed the water at a higher temperature, but my experience leads me to believe that the untoward experiences which have been recorded have in most, if not all, cases been brought about by having the water too hot, and so permitting a too rapid evolution of ether vapour.

The usual signs of anæsthesia are present and so nothing need be said about them. As a rule children go under more rapidly than adults, when ether is given by the rectum, but the time occupied in inducing complete anæsthesia varies within wide limits. I have succeeded in 3 minutes and have had to wait 15 or 30 minutes. Dr. Stimson informs me that American surgeons have had several fatalities in employing this method.

Dangers and Accidents of Ether Inhalation.

The chief troubles which occur during ether narcosis are connected with **respiration.** In the first place the breathing may be stopped through obstruction in the larynx, the rima glottidis becoming closed and no air entering the lungs. In some cases the rigidity of the muscles may cause impediment to air entry by provoking tight closure of the teeth. Inspiration through the nose is greatly hindered or prevented by the nostrils being sucked in with inspiration. In this way little air can enter the chest and the patient grows cyanotic. If the teeth be forcibly opened by a screw gag, air will enter freely and the cyanosis pass off. The movements of respiration do not cease in the condition of laryngeal spasm, whether partial or complete. In edentulous persons with long flabby lips, these are sucked in and act as a kind of valve permitting expira-

tion but hindering inspiration. To obviate this I have found keeping the jaws apart by a Fergusson's gag useful, and administering the ether with the mouth so propped open.

Treatment.—The head must be thrown back and the tongue drawn forward; by this means respiration may be induced to start, but failing this, tracheotomy must be performed.

A more troublesome, although fortunately rare complication occurs, when the thorax becomes fixed by the rigidity of its covering muscles. The treatment here is to maintain the air way open, and to attempt to overcome spasm by artificial respiration. In spasmodic fixation of the thorax, abdominal respiration must be practised, and the floating ribs compressed in expiration. Stimulation of the nasal mucous membrane will sometimes initiate a deep inspiration. This can be done with quills of bibulous paper soaked in sal volatile or an ammoniacal solution.

But if ether be incautiously pushed for a prolonged period, without allowing the patient to renew the air in his lungs from time to time, the respiration may stop altogether, although the muscles will be quite flaccid. This condition would appear to ensue upon the overloading of the blood with ether, leading to poisoning of the respiratory centre. The treatment is the immediate performance of artificial respiration. If this be properly done the blood soon becomes duly oxygenated, and the nerve-centres being once more supplied with depurated blood, recover their control over the respiratory mechanism, and so natural respiration ensues.

Rarely, the **heart** may give trouble. In a few recorded cases fatal syncope has occurred at the com-

mencement of ether inhalation, but whether such casualities can be justly imputed solely to ether influence, is I think doubtful.

Less important inconveniences of ether inhalation are the increased secretion from the mouth and respiratory tract; this although interfering with respiration is seldom of any great importance. It must be remembered, however, that in infants and weakly persons it may prove a grave after complication, giving rise to blocking of the tubes and water-logging of the lungs.

Coughing occurs in many persons, especially if ether vapour be given in too concentrated a form; but it is a mistake to remove the inhaler for this in all cases, as frequently while a dry cough occurs in the earlier stages of etherisation, it is suppressed by pushing the anæsthetic.

Vomiting during the operation is nearly always due to the giving of too little ether, and follows upon the partial resumption of consciousness. The patient will be observed to inspire irregularly with shallow breaths, followed now and again by yawning inspirations. This will be succeeded by efforts at swallowing, rapid and chiefly abdominal inspirations ensue, and the patient retches and vomits. Conjunctival reflex returns just before the sickness.

Treatment.—Two indications are now paramount, to get rid of the vomited matter and to avoid any of it being drawn into the larynx by the deep inspiration which always follows the act of vomiting; secondly to prevent complete return to consciousness. To obviate these the patient's head should be turned to one side without being raised and all vomit removed with the finger; then the inhaler should be rapidly re-

applied, and if further vomiting occur recourse must be had to similar manœuvres. But a judicious pushing of the anæsthetic at the first signs of the onset of vomiting will often, if not always, prevent the occurrence of sickness. In carrying out this plan great care must be taken, lest if it fail and vomiting occur, the ejected matter should enter the windpipe. If vomit be drawn into the trachea and cannot be coughed up, it may be necessary to open that tube and to take measures for the removal of the foreign bodies from the air passages.

Collapse.—When it is necessary to administer an anæsthetic to persons already collapsed, and ether is selected as most likely to assist the heart's action, it is well to obviate any further shock from difficulty of breathing, chilling, &c., by removing the bag from Clover's regulating ether apparatus, and so letting the patient inhale a very dilute ether vapour. Another plan is to take the apparatus off the face during the first half inspiration as well as during expiration.

After Effects of Ether.

Ether chills the body, so that when the anæsthesia has to be kept up for any length of time it is advisable to keep the patient well covered up, and to apply hot water bottles to feet, thighs and flanks. The arms and legs may also be bound up in cotton wool especially when rectal etherisation is contemplated. It has been suggested that the use of a hot water table for prolonged and grave operations would counteract the shock.

Nausea and **vomiting** in some cases prove troublesome and very intractable. They usually occur in persons whose general health has been impaired before receiving the anæsthetic. All food and stimulants must be withheld for three or four hours after ether, and the patient be encouraged to take tea-spoonfuls of *hot water;* tepid water provokes more vomiting, hot water checks it. The use of metal spoons in so administering the water should be avoided, that the lips and tongue may not be blistered. In some cases iced soda water in sips will check vomiting, while iced black coffee with a dose of bromide is often efficacious (gr. x. to a small cupful). Absolute quiet with an enforcement of the supine position must be observed, while the patient is placed in an airy room, with windows opened, and well covered with blankets or rugs. In lesser degrees of sickness, sucking pieces of ice is useful; but the loading of the stomach with ice-cold water is a measure often followed by great sickness and discomfort.

Should vomiting continue and there be accompanying collapse, iced dry champagne may be given in tea-spoonful doses every quarter of an hour until improvement occurs.

Some persons suffer from great nausea without much sickness. Small doses of tincture of nux vomica will do good in these cases, one minim in a tea-spoonful of water, by preference hot, may be taken every ten minutes for an hour. This will usually check the nausea, and failing it, Dr. Ringer's suggestion of drop doses of vin. ipecac. may be tried. Dilute hydrocyanic acid in minim doses is also useful.

Hiccough, which is sometimes very severe after ether,

may be cured by mustard (ʒj. infused and added to ℥iv. of boiling water) taken in sips. Less unpleasant remedies are cajeput, musk, chloral, and morphine (administered hypodermically). A small cup of strong green tea, taken hot and without sugar or milk, will often check hiccough.

Diarrhœa, and passage of blood per anum after rectal etherisation should be treated by emollient injections containing opium, while the general strength of the patient be attended to, and his collapse treated upon general principles.

CHAPTER V.

Chloroform.

Chloroform ($CHCl_3$) was discovered by Mr. Samuel Guthrie of Brimfield, Massachusetts, U.S.A , who contributed an article in the *American Journal of Science and Art*, Oct. 1831, upon "A spirituous solution of chloric ether." This paper was in the hands of the publisher in May although it was not actually published until the October. In January, 1832, Soubeiran independently discovered chloroform, but as on analysis he overlooked the presence in it of hydrogen, he called it bichloride of ether. Liebig also discovered it independently in November, 1831, and classed it as a liquid chloride of carbon. It was not, however, until 1834 that the true composition of chloroform was understood, and its properties enunciated by Dumas. As is well-known, its employment as an anæsthetic was due to the advocacy of Sir James Y. Simpson, in 1847, after its having been introduced to his notice by Mr. Waldie, of Liverpool.

Chemical and physical properties.—It is a limpid heavy liquid with a specific gravity of 1·497 at 62·5° F. (17° C.) (Regnault); vapour density 4·199 (Dumas). It has an agreeable ethereal smell and sweet taste. Its vapour is not easily inflammable, but if ignited burns with a green flame. It is very volatile, but although mixing freely with air, pure chloroform vapour can only exist at a temperature of 140° F. When exposed for some

time to light, chloroform splits up into chlorine and hydrochloric acid. Chloroform vapour diffused in a hot room when illuminating gas is burning splits up and a quantity of suffocating fumes are liberated. It boils at about 142° F. (61° C.) (Regnault). To test-paper, chloroform should be absolutely neutral. Soluble only to the extent of one-half per cent. in water it freely mixes with ether and alcohol.

Chloroform is prepared by the action of rectified spirit on chlorinated lime in the presence of slaked lime. After distillation the impure product is refined with water which removes the alcohol, chlorine, &c.; oily matters are disposed of by washing with sulphuric acid, while the remaining matter is eliminated by distillation over dry chloride of lime and slaked lime.

Chloroform may also be manufactured from methylated spirit; the product when carefully purified is said to be chemically indistinguishable from that obtained from proof spirit.

A further source of chloroform is acetone. The acetate of lime is carefully distilled and purified, and the acetone so obtained diluted and forced into a still which contains chlorinated lime in the presence of water. The mixture is kept agitated, crude chloroform distilling over. Subsequent purification and the addition of a small quantity of alcohol completes the process. The reaction may be represented as follows:—

$$2C_3H_6O + 6CaOCl_2 = 2CCl_3H + Ca(C_2H_3O_2)_2 + 2Ca(HO)_2 + 3CaCl_2.$$

A further process consists in the dry distillation of crude acetate of lime and the formation of chloroform from crude ketones or the mixed acetones obtained by this distillation.

It is asserted, however, by some that chloroform possesses a slightly varying physiological action according as it is derived from one or the other source detailed above.

Chloroform is liable to contain certain impurities:—

Alcohol.—This must be present in a small quantity in order to prevent decomposition of the chloroform. The impurity is detected firstly by the specific gravity, which below 1·48 points to adulteration, probably by alcohol.

Tests.—1. A few drops of the doubtful chloroform are added to a solution of white of egg, and if *alcohol* be present to the extent of 2 or 3 per cent. (Letheby), the albumen coagulates.

2. A mixture of equal parts chloroform and almond oil becomes turbid if *alcohol* be present.

3. The suspected chloroform is dropped into distilled water; if containing alcohol the otherwise transparent globules look as if surrounded by a milky halo of opalescence (Mialhe).

4. Chloroform if contaminated with *alcohol* gives a green colour with chromic acid.

Ether may be found in some samples of chloroform, its presence being revealed by its odour and by globules taking a dull-red colour with iodine, thus contrasting with the violet shade which pure chloroform gives. (Berchon).

Crystallised nitro-sodic sulphide of iron is dissolved if *alcohol* or *ether* be present in chloroform.

Methyl Compounds.—These give rise to nausea, headache, lassitude; they are detected by adding strong sulphuric acid to the chloroform, which becomes black in their presence.

Hydrochloric acid and *chlorine* are liable to be devel-

oped if chloroform be exposed to light and air. The first gives an acid reaction; the last has a characteristic irritating odour, and bleaches. Suspected chloroform may be shaken with distilled water and this tested with nitrate of silver for chlorides. The presence of free acid is also shown by adding sodium, which in contact with the acid produces an evolution of gas. It is useful to remember that in a room lighted with gas, chloroform is very liable to undergo the above decomposition, noxious fumes being liberated which may prove deleterious to the patient and seriously inconvenient to the operator. It is wise to ensure thorough ventilation, and as little burning of illuminating gas in the presence of chloroform as possible.

Physiological Action of Chloroform.

Upon the blood corpuscles this substance acts as a solvent. It is a protoplasm poison rapidly destroying the irritability and contractility of muscle.

Prolonged inhalation of chloroform repeated day after day for a considerable time is said to lead to fatty degeneration of the tissues, and it is further asserted that like changes occur in a less marked degree even when but little of the narcotic is taken.

Chloroform behaves somewhat differently according as it is applied—(1) to the skin or an abraded surface; (2) to the mucous membrane of the alimentary tract; (3) to the mucous membrane of the respiratory tract.

Upon the skin and abraded surfaces chloroform benumbs and acts as a strong irritant. If the contact be prolonged, and if evaporation be prevented, vesication will ensue. It is therefore important to guard against

these effects during the administration of chloroform, by protecting the face with a little vaseline smeared over the lips and nose.

Upon the mucous membrane of the alimentary tract.— When swallowed, chloroform produces a sensation of warmth, and has a sweet taste. Anæsthesia follows the swallowing of a considerable quantity, but other and dangerous symptoms of irritant poisoning are provoked by the introduction of this drug into the stomach. (See *Medico-legal Aspects of Anæsthetics*, Chap. XII.). Acute gastritis and death from collapse have in some cases followed.

Chloroform when inhaled produces very different effects according as it is given pure or diluted with air. Given to the lower animals in concentrated vapour (air saturated), artificial respiration being performed, chloroform soon causes the right ventricle to distend and become engorged, the heart ceasing to beat. McWilliam has demonstrated experimentally that even when chloroform vapour is diluted it produces a dilatation of all the cavities of the heart. Up to a certain point of concentration, chloroform vapour will not permanently damage the resiliency of the heart, and its muscle will, upon withdrawal of the narcotic, contract, while the ventricles and auricles resume their normal size. When a certain point of concentration is reached, however, the myocardium fails to contract even when no further chloroform is given, and rapidly becomes insensitive to stimulation, being only thrown into fibrillary contraction (*delirium cordis*). A heart once so dilated beyond the point of its ability to re-contract never recovers and the creature dies. When respiration is not maintained by artificial means, it ceases either before the heart

stops or simultaneously. The members of the Hyderabad Commission, however, came to conclusions at variance with these statements. Their investigations were undertaken in India and carried out with great care and skill, a large number of animals being subjected to experiment. Their results may thus be summarised. In every case respiration stopped before the heart, the interval in most cases between the two events being from two to six minutes, although it was only one minute in some instances, and in one case eleven (in a dog), in another twelve minutes (in a monkey).

On the other hand it has been urged that the conclusions at which the Commission arrived are open to objection; since in the first place their experiments were too few (600) to prove, because they never observed heart failure to precede cessation of respiration, that therefore primary heart failure does not occur. In the second place, other observers working in temperate climates affirm they have repeatedly met with primary heart failure among the lower animals. Dr. Lawrie, supporting the conclusions of the Commission, states he has a record of about 40,000 cases of human beings subjected to chloroform in none of whom primary heart failure occurred, indeed he met with no case of death. Various American and European persons of authority traverse this by pointing out the fact that in temperate climes deaths from chloroform inhalation occur in the practice of the most skilled anæsthetists, and that such deaths have been repeatedly observed to have resulted from primary heart failure. I have found that the hearts of animals killed by a lethal dose of chloroform show fibrillary irritability for some time

after the heart-muscle as a whole is incapable of contracting in response to electrical or mechanical excitation. This state no doubt corresponds to the condition called by Professor McWilliam "delirium cordis."

The various parts of the nervous system appear to become affected in the same order as obtains in the case of ether, that is to say the cerebral centres are influenced before the sensory fibres of the cord, and these before the motor fibres, while last of all the medulla becomes paralysed. It therefore would seem that chloroform may kill in two ways: firstly by interfering with the heart's action and so inducing syncope, and secondly by paralysing the vital centres in the medulla. In the former case death takes place early in the narcosis, but in the latter only when the blood is saturated to a certain (at present unknown) point.

Chloroform seems to have a selective action upon the nervous system, analysis of the tissues of persons who have been killed by chloroform showing that the brain and cord contain proportionately more of it than other tissues (Lallemand, Perrin and Duroy). What is the nature of the action upon the nerve centres we are unable to say, but evidence points to the probability that it is exerted upon the tissues themselves. Harley and others have asserted that chloroform produces destructive changes in the red blood corpuscles, and they explain the occasional jaundice following chloroformisation as arising therefrom. Others have believed, but upon insufficient evidence, that chloroform exerts its influence by changes which it effects in the process of oxidation. It has been shown that chloroform exercises a direct influence upon the muscular tissues of the heart, although voluntary muscle is but slightly affected.

Chloroform, although possibly in part split up (Zeller), certainly in bulk remains unaltered, and is eliminated unchanged in the urine, the breath, and the milk. Its use produces a marked lowering of blood pressure, although this may be preceded by a very transient rise. The fall is due in part to paralysis of the vaso-motor system as has been shown by Bowditch and Minot, and in part to the diminished force of the heart's action, itself a result of the chloroform. Large doses of chloroform cause the heart to stop at once, and it becomes absolutely inexcitable. It is doubtful whether arrest of the heart be due to direct action of the chloroform upon its substance, or to reflex inhibition through irritation of the nerve endings of the pneumogastrics in the lungs. We know from experiment that chloroform is able to stop the heart when applied directly to its substance, and we know further that it actually kills the heart muscle and destroys its contractility.

With regard to the reflex theory above mentioned, it must be admitted that we are at present without any actual proofs of its truth. The conclusions of the Hyderabad Commission upon these points are worthy of notice. They assert that the fall of blood-pressure, when due to vagal stimulation brought about by asphyxial conditions, is really protective. "The slowing of the heart and circulation which is produced by irritation of the vagus by any cause, such as holding the breath in chloroform administration, retards the absorption and conveyance of chloroform to the nerve-centres."

Chloroform, as has been previously pointed out, acts upon the medullary centres; presumably each individual can take a certain quantity varying according

as he is capable of eliminating the drug, and when this quantity is exceeded, the respiratory centre becomes paralysed, and respiration ceases while the heart-beat persists for a few seconds longer. Taniguti, working under Salkowski, found that chloroform inhalation or ingestion by the mouth produced a rise in the excretion of nitrogen showing increased disintegration of albumen. No such effects followed when ether was substituted for chloroform.

The further action of chloroform upon the body is slight; it produces some increase in salivary secretion, and in small quantity excites vomiting. In a certain proportion of persons it provokes icterus. Astigmatism has been observed as following the narcotism of chloroform. Albuminuria and glycosuria are also recorded as being induced by this agent.

The Human Subject.

In describing in detail the action exerted by chloroform upon the human subject, it is convenient to divide the period of narcosis into five stages.

In the first stage—from commencement of inhalation to impairment of consciousness—fulness of the head, ringing, buzzing in the ears, and palpitation of the heart, are sometimes felt; there is also some diminution of common sensation.

In the second stage the mental powers are impaired although not suspended. The patient remains passive as if sleeping, or occasionally makes a voluntary movement. Sometimes laughing, singing, talking, are indulged in during this stage. Snow believed that

dreaming occurs at this time and then only. Towards the close the patient becomes restive, he attempts to remove the face-piece or towel, for he is conscious of being inconvenienced by the vapour but not of the necessity for remaining passive. Common sensation is much blunted, so that patients submit without expostulation to painful manipulation. This degree of narcotism is sufficient for obstetric practice, and the after stage of prolonged operations. As a rule, struggles or expressions of pain which show themselves at this time are not subsequently remembered.

In the third stage all voluntary movements are lost. The conjunctival vessels become full, the muscles rigid, and struggles, even epileptiform convulsions, may supervene. As the stage advances the muscles relax, inarticulate jabbering and mouthing occur. Although really insensitive to pain, the patient may flinch or even cry out. Later in this stage all reflex acts are abolished, the conjunctival and nasal receding last. The patella jerk also persists late, while under deep anæsthesia the ankle-joint phenomenon in some cases appears.

In the fourth stage breathing is stertorous, the pupils dilated, and the muscles completely relaxed and flaccid. At this period the patient is profoundly unconscious and is drifting into danger. Such deep narcosis is seldom needed save for the reduction of old-standing dislocations, &c.

The fifth stage is the interval which, following the fourth degree of narcosis, intervenes between the respiratory embarrassment and total cessation of breathing. Even after dyspnœa has passed into apnœa, the heart continues to beat for a brief while. This

stage marks the period when chloroform tension in the blood is great enough to paralyse the respiratory centres in the medulla oblongata.

Chloroform enters the blood until an equilibrium is established between the tensions of chloroform in the residual air in the lungs and that in the serum. So long as the tension in the air is maintained above or equal to that in the blood, no chloroform can leave the serum through the agency of the pulmonary mucous membrane. Snow demonstrated this theoretical assertion by actual experiment substantiating the truth of the *à priori* statement, and so he arrived at the following law:—"As the proportion of vapour in the air breathed is to the proportion that the air, or the space occupied by it, would contain if saturated at the temperature of the blood, so is the proportion of vapour absorbed into the blood to the proportion the blood would dissolve."

The amount of vapour which can be taken up (held in solution) by the air of the atmosphere, varies with the elastic tension of the chloroform vapour at different temperatures. Thus at 40° F. a small quantity of chloroform would evaporate into air; at 130° F. so much would volatilise as to give rise to an almost pure chloroform vapour. In the following table, taken from Snow's "Anæsthetics," the amount of chloroform in vapour is shown in 100 cubic inches of saturated mixture of air and chloroform at different temperatures.

One grain of chloroform in one hundred cubic inches of air produces the second degree of narcosis, but never carries chloroformisation further. This corresponds to a proportion of 1 part by measure of chloroform in 16,285 parts blood, or 0·0000614 the proportion by

weight. Two grains in each hundred cubic inches of air, or $\frac{1}{28}$ saturation (unity being saturation), produces the fourth stage of narcosis, or 0·0001228 the proportion by weight.

Any proportion above two grains in the hundred causes interference with respiration, three grains in the hundred seems about the ratio which renders respiration impossible. Three grains represent 2 3 cubic

Degrees. F.	Air. per cent.	Vapour. per cent.
40	94	6
45	93	7
50	92	8
55	90	10
60	88	12
65	85	15
70	81	19
75	78	22
80	74	26
85	70	30
90	65	35

inches vapour, and as air at 100° F. can take up 43·3 per cent. of its volume, the blood must contain from $\frac{1}{18}$ to $\frac{1}{19}$ of the proportion it is capable of absorbing when the respiratory centres are poisoned.

Snow found further, that calculating the weight of the blood as thirty pounds, twelve minims of chloroform in the circulation produces narcosis of the second degree; eighteen minims the third degree (surgical anæsthesia); twenty-four deep narcosis (fourth stage), and thirty-six should paralyse the medullary centres. In practice more is needed because a certain proportion evaporates from the tracheal and bronchial surfaces and is carried

out in expiration. If twelve minims be evaporated into a bladder and inhaled to and fro, no more air being allowed than can be blown from the lungs, narcosis of the second degree actually results. Now taking thirty-six minims as a lethal dose, the following considerations, upon which Snow strongly insisted, explain how easily this quantity may enter the circulation if the administrator be not perpetually upon his guard against over dosage; 18 minims represents the amount absorbed to produce surgical narcosis, this amount might be absorbed by the use of 36 minims, the remaining 18 minims being exhaled as above mentioned. These 36 minims represent 37·5 cubic inches of vapour, which at 60° F. would require 257 cubic inches of air. The 300 cubic inches thus formed would be inspired in twelve respiratory acts (25 cubic inches being the amount of tidal air). Now if a vapour of this strength were continuously inhaled, the residual and complemental air would become saturated, and as about 250 cubic inches represents the air in the lungs, this amount would at 60° F. contain the vapour of 30 minims. Assuming only half this quantity to be absorbed, that is 15 minims, we should then have 18 + 15 or 33 minims in the blood, an amount almost if not quite enough to paralyse the respiratory centre. These points being held in remembrance will explain many cases of chloroform death, ascribed to "idiosyncrasy" or the "fatty heart" which stands inexpert chloroformists in such good stead.

These considerations, which cannot be studied too carefully, point out the importance, not only of taking precautions against giving an overdose of chloroform, but the equal if not greater importance of maintain-

ing a completely unimpeded elimination of the drug. The Reports of the Hyderabad Commission again and again urged the grave dangers which follow when asphyxia (by which is meant impediment to thorough air exchange in the lungs) is even in the slightest degree permitted to complicate chloroform narcosis. Such asphyxial complications of course mean impaired elimination, itself tantamount to accumulation of chloroform in the blood. Broadly speaking it is true to say that a dose of chloroform which is safe, provided due air exchange is ensured, rapidly grows dangerous when its elimination is interfered with. Death from chloroform does not, however, always result from respiratory paralysis.

Dr. Lawrie and the Hyderabad Commissioners on Chloroform have ably traversed the work of previous investigators, and assert most positively that in their view primary heart failure never occurs in the human subject as a result of chloroform. They consider their experiments justify them in stating that death from chloroform always results from respiratory failure, and that in every case the heart beats for some minutes after the complete cessation of breathing. These views Dr. Lauder Brunton, acting as assessor for the *Lancet* during the second Hyderabad Commission, appears to have adopted, basing his change of opinion upon the series of very careful and beautiful experiments at which he himself assisted. It would serve no useful end to discuss these here: I may, however, say that many observers contend that although pertinent and cogent enough as far as they go, they cannot be said to have substantiated any facts proving the non-occurrence of primary heart failure, although

they offer weighty arguments tending to that conclusion. The research, as far as it deals with the question of the causation of respiration-failure under chloroform, has placed our knowledge upon a more sure basis.

Working on similar lines to Snow, Paul Bert examined the action upon animals of small percentages of chloroform vapour in air. He asserted that atmospheres containing chloroform below a certain percentage failed to induce anæsthesia; below a higher percentage (*zone maniable*) produced anæsthesia without danger to life, even when a vapour of this strength was persisted in for an indefinite period; while above this higher percentage death always occurred. The lethal percentage he found to be double the smallest quantity necessary to induce anæsthesia. Lister, who repeated Bert's experiments, found no true *zone maniable* ("workable zone") to exist. Indeed, the French observer appears to have overlooked the important fact that chloroform not only kills by paralysis of the heart, but also by failure of respiration. Richardson, whose views seem to differ from those who adhere to the percentage theory, suggests that death from chloroform is, when it occurs in the latter stage, due to the cumulative action of the drug.

Dr. Kirk of Glasgow has recently advanced a "new theory" explaining primary cardiac syncope under chloroform. He contends that the drug acts (1) directly upon the mucous membrane of the lungs, (2) by absorption into the blood. Accepting the second mode of action as that which ordinarily obtains, Dr. Kirk believes that in the first way quite a similar action takes place, and that it reaches a maximum intensity more rapidly in the case of (2). This action he terms the "ex-

ternal," that due to absorption into the blood as the "internal." He further asserts that there is a corresponding reaction equal and opposite to both this internal and external action. In the early stage of chloroformisation, say within 2½ minutes or so, if this external action ceases by the withdrawal of the chloroform vapour, then a rapid and vigorous reaction sets in and it is this sudden swirl and bound of the circulation which Dr. Kirk believes gives rise to primary cardiac syncope. Dr. Kirk insists that the Hyderabad Commission was in error in denying primary syncope, and believes the best means of counteracting its danger is to give "plenty of chloroform" and take pallor or other threatening of syncope rather as an indication for more chloroform than for the withdrawal of that drug.

The Administration of Chloroform.

Various as are the methods in vogue in this and other countries, they may with propriety be grouped under two headings. 1. When an inhaler is employed. 2. When the open method is followed.

Among the multitude of inhalers which have been devised, we may notice **Clover's chloroform apparatus,** which consists of a large bag capable of containing a given volume of air; into this the vapour of a given quantity of chloroform is allowed to enter, and the mixture is so arranged that the tension of chloroform vapour in the air is maintained below 4·5 per cent. The bag is constructed large enough to hold sufficient

for several patients. It is connected at one end by a flexible tube with a face piece, and at the other, with a bellows worked by the foot. To the bellows is attached a small metal receiver, into which a known quantity of chloroform is pumped by a graduated syringe inserted into the lid. Forty minims of the narcotic are supplied with every thousand cubic inches of air pumped in, and as these represent forty-five cubic inches of vapour, the percentage of chloroform never exceeds about $4\frac{1}{2}$ per cent.

Chloroform kills by concentration of its vapour, hence our aim in its administration is to maintain the amount of chloroform in the respired atmosphere below the dangerous percentage (five per cent.). A percentage of five is very distinctly lethal. But it has also to be borne in mind that chloroform is a cumulative drug, that it is not changed during its passage through the body, and that its elimination depends upon the healthy working state of the emunctories, more especially lungs and kidneys. Hence the percentage of chloroform with which we start will be unnecessarily high for the maintenance of anæsthesia when narcotism is once affected, and any method employed which hinders free expiration, or hampers chest movements, is most prejudicial to the safety of a patient. Yet again, persons vary so largely in their resistive power towards chloroform, that it is impossible to feel sure that a percentage which would be necessary in one case would be adequate in another. But while we are dealing with an agent which is admittedly dangerous in high percentages, one is apt to rush into another extreme, and allow the percentage to fall so low that complete anæsthesia is not maintained. In this case the patient's safety is as much in jeopardy

as when he is inhaling too concentrated a vapour. It will readily be seen that even the best inhaler may involve many risks, as, with perhaps the exception of Clover's, none can absolutely maintain the desired percentage.

Snow's Inhaler.—This consists of a metallic cylindrical vessel, in which are fastened four stout wires descending nearly to the bottom, which fix two coils of blotting paper going quite to the bottom. The coils are cut into four, and are thus allowed free circulation of air, which enters through perforations in the upper part of the cylinder. Outside this part of the apparatus is another cylinder, which is filled with cold water; communicating with the interior a glass tube passes to the outside and so enables the administrator to see when fresh chloroform will be required. The face-piece is fitted with an expiratory and an inspiratory valve, which last communicates with a $\frac{3}{4}$-inch tube fixed to the inhaler. The air enters through perforations in the upper part of the inhaler, traverses down through the notches and takes up chloroform vapour volatilised from the bibulous paper, thence it passes up the centre of the inner cylinder into the tube attached to the face-piece. During inspiratory efforts the valve trapping this tube permits of chloroform vapour entering the patient's lungs, while during expiration this ingress valve closes, and the patient freely evacuates his lungs through the expiratory valve. From two to two and a half drachms of chloroform are placed in the inhaler at once, and more added from time to time as this evaporates.

Sansom's Inhaler.—Dr. Sansom has modified Snow's apparatus. The receiver is a cylinder 3 in.

high by $1\frac{1}{2}$ diameter, filled with a coil of lint upon which the chloroform is poured. The top is provided with a freely perforated plate through which air passes, to become impregnated with chloroform. The receiver communicates by an exit tube with a face-piece to which are attached inspiratory and expiratory valves. The receptacle is covered with gutta percha, which Dr. Sansom believes equalises temperature better than the cold water jacket of Snow.

Junker's Inhaler.—This inhaler (Fig. 24) is of value, though it must not be supposed that by its use the patient is placed outside the range of possible danger. In my modification of this apparatus, half an ounce of chloroform is poured into a bottle through a funnel-shaped opening fixed in a screw top ; air is then pumped *through* the chloroform, and in its passage takes up the vapour. The foot bellows are fixed by straps, one of which slips over the toes, while the other receives the heel in the long loop. When the foot presses lightly, the air in the bellows is forced through the tube into the bottle, thence through another tube to a face-piece. The net-enclosed ball is for equalising the stream of air and the avoidance of splashing. It is important not to put more than half an ounce in the bottle at once, and not to pump in air spasmodically or too forcibly, otherwise chloroform may be driven through the system of tubes into the face-piece. Even if this should not happen, a strong blast of chloroform-impregnated air is very unpleasant and deleterious if allowed to impinge upon the face. When the bottle has become nearly empty, the mill-headed stopper which closes the funnel is removed and more chloroform added; thus the apparatus need never be unhooked from the adminis-

trator's coat, and the top never unscrewed until the administration is over, when the bottle should be emptied and cleaned.

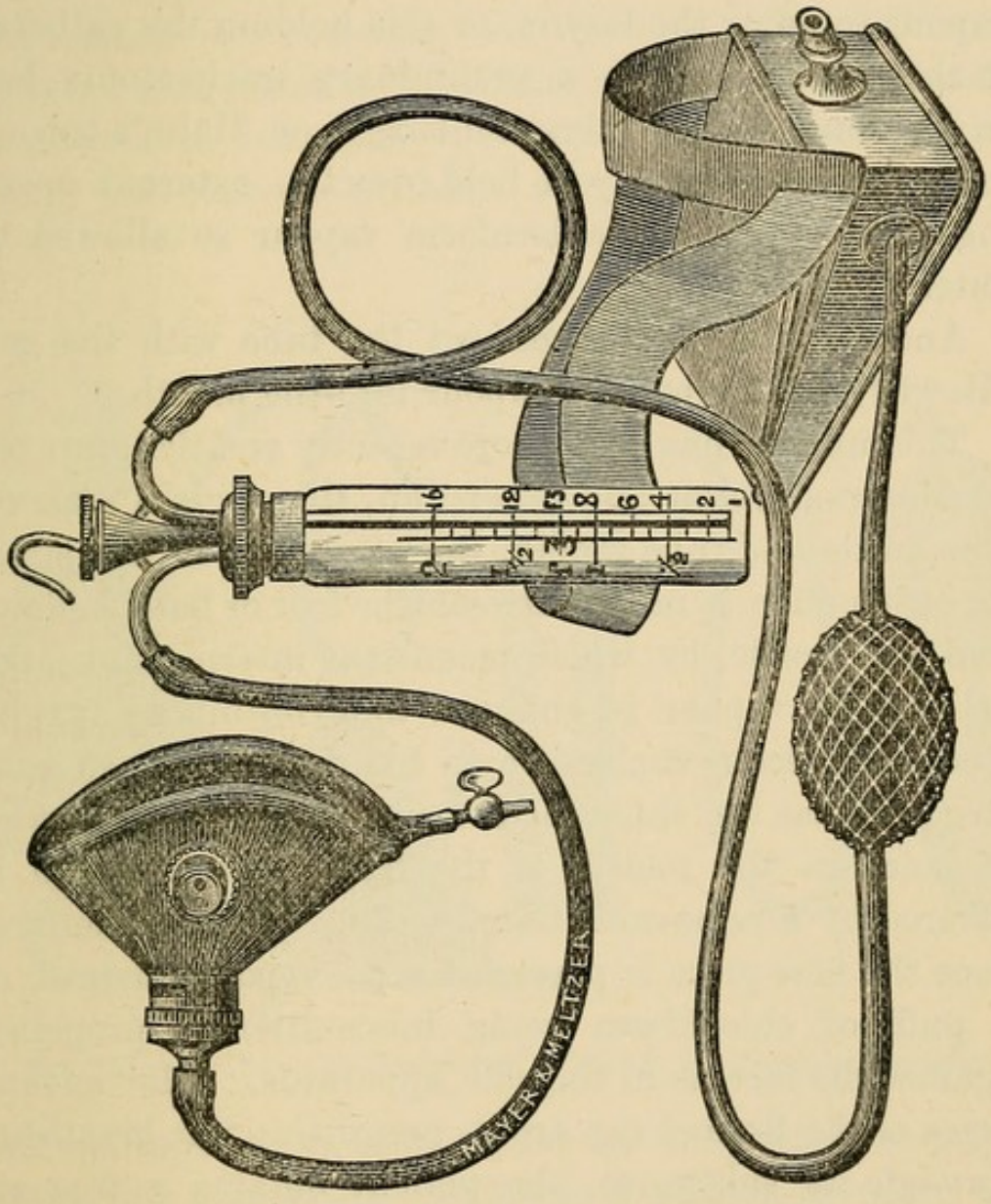

FIG. 24.—Junker's Inhaler for chloroform, modified by Dudley Buxton.

When chloroform is administered for operations about the mouth or nose, *e.g.*, removal of an upper jaw, the tongue, &c., the anæsthesia having been obtained by chloroform is best maintained by fitting the effer-

ent tube of a Junker's inhaler (*i.e.*, the tube not connected with the bellows) over a catheter, and either passing the catheter through the nostril so that the end hangs down behind the soft palate, and permits the vapour to enter the larynx, or else holding the catheter in the mouth. When a preliminary tracheotomy has to be done and a Trendelenburg's or Hahn's tube is used, the catheter may be held over the external opening of the tube, and chloroform vapour so allowed to enter the trachea.

Another plan is to connect the tube with the gag (Hewitt), and pump the vapour into the mouth.

This inhaler has been more recently greatly improved by Messrs. Krohne and Sesemann, the original makers. The bottle and tube remain the same, but in the latter an obstruction is made between the foot or hand bellows and the bottle, by which means the intermittent jerky delivery of vapour is changed to a continuous supply. The face-piece is replaced by a Skinner's mask so constructed that the chloroform vapour escapes by a series of holes in the midrib of the frame. The frame is covered by a removable flannel cap. By this contrivance the face-piece is pervaded with vapour instead of a puff of chloroform being intermittently propelled against the face as in the old apparatus. The advantages of the flannel cap are its permitting free breathing through its substance, the patient obtains a free air supply, and further the administrator can, by placing his hand over the mask, feel whether or not a sufficient blast of air is being expired. It is cleanly, as it can be removed easily and be washed.

The same firm have made a face-piece, figured below, which is provided with an expiration valve guarded by

a stiff feather. This rises in expiration, falls in inspiration, and affords a register of the presence and strength of expiration. (Fig. 25).

A simple inhaler, much used abroad, consists of a framework of wire fitting over the nose and mouth, and covered with flannel. Chloroform from a drop bottle is allowed to fall upon this while the patient inhales from the concave surface. Although convenient, this

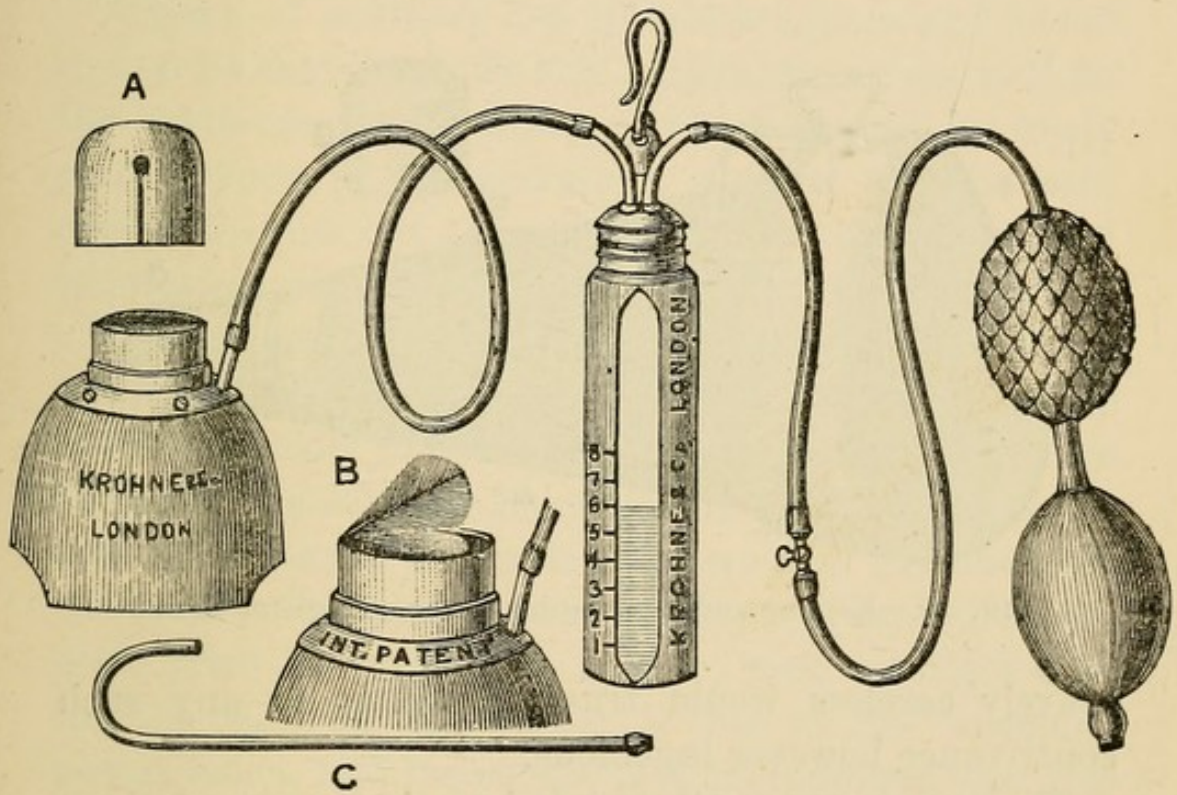

FIG. 25.—Krohne and Sesemann's Feather Respiration Register.

inhaler is far from safe; it has no pretensions to regulating the percentage of vapour it allows to enter the patient's lungs, and so must be used with the utmost caution.

A cone has been devised by Mr. Krohne and figured below (Fig. 26), which is guarded by a free expiration valve covered with the feather register as described above. The cone is simply a light wire netting twisted into a

cone and covered on the outside by red flannel perforated by a circular hole for the dropping in of the anæsthetic employed. The interior is occupied by a flannel bag freely removable and to be changed for washing whenever desirable. While all mechanical guards to inhalers are open to the objection that they propose to replace the constant watchfulness of the administrator by a device to attract attention, yet this feather register is useful, although no one who is not

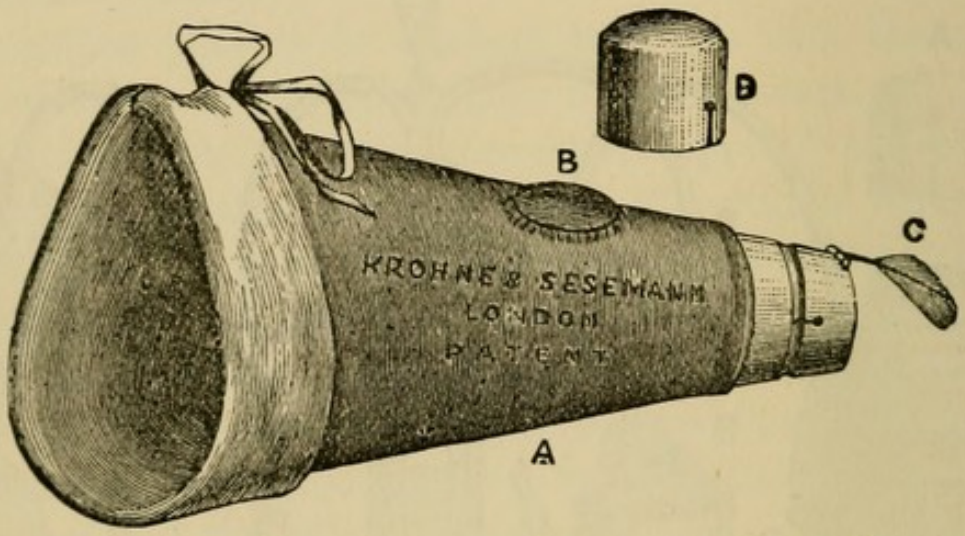

FIG. 26.—Krohne and Sesemann's Feather Register Cone.

gravely careless would trust implicitly to any such contrivance however ingenious.

There are many other inhalers, but most of them contravene the first law of giving chloroform, by impeding a free supply of air, and failing to regulate the latter to the proportion of chloroform inhaled.

THE OPEN METHOD.

Lister thus describes the Scotch method:—A common towel is arranged so as to form a square of six folds,

and enough chloroform is poured upon it to wet an area the size of a hand's palm, the precise quantity poured on not being a matter of any consequence. The patient is instructed to close his eyes to protect them from the irritating vapour, and the towel is then held as near to the face as can be borne without inconvenience. More chloroform is added from time to time as occasion requires.

A piece of ordinary lint 20 inches square and folded in four so that the fluffy side is inwards, serves well for the exhibition of chloroform, which should be freely poured upon it. If necessary, a towel may be held outside the lint, but on no account must it be permitted to interfere with the patient's free respiration.

I have found it best to commence the inhalation with a comparatively small quantity of chloroform upon the towel, especially in dealing with children. In a minute or so the sensibility to the irritating vapour is deadened, and the strength of the atmosphere may be increased. As soon as unconscious struggling appears, the narcotic must be pushed, as danger, such as exists during the stage of excitement, is due to the muscular perturbation, and the sooner it is overpowered the less is the patient's peril. When the towel is withdrawn for additional chloroform it should be quickly replaced. But as the vapour then given off will be increased in percentage amount, and as the fresh air entering the lungs during the withdrawal of the towel may induce a deeper inspiration, it is well to keep it a trifle farther from the face for a minute or so. Throughout chloroformisation the respiration must be *constantly* watched, both by regarding the regularity of the rhythm of the thoracic movements, and by testing

the amount of air passing from the trachea. Thoracic movements persist for some minutes after occlusion of the larynx or trachea, and so by themselves are no just criterion that sufficient air is entering the lungs. The pulse should be observed, for not only may the heart fail from chloroform depression, but from hæmorrhage, shock, fear, &c. When the exigencies of the operation allow it, the head should be quite low, supported by one small pillow. This arrangement should be made after the first stage of narcosis, because patients while conscious like to have their heads pretty high. Fitness for operation is to be judged by the loss of conjunctival reflex. To ascertain this, the eyelids are gently opened, and the cilia lightly touched with the palm of the forefinger; should no blinking occur, the operation may be commenced. To this rule, children and hysterical females form exceptions. They will often permit this test without flinching, but will evince lively evidence of consciousness if the unwary administrator permits surgical manipulation to proceed. The deep, almost stertorous breathing, the muscular rigidity or complete flaccidity of muscles, will in these cases help out the diagnosis. On the other hand, I have observed in some persons, especially if afflicted with conjunctival or ocular disease, that the conjunctival reflex persists for some time after complete anæsthesia has supervened. The size and mobility of the pupils, although somewhat uncertain in their indications, should yet be observed. In surgical anæsthesia by chloroform they are of normal size and usually sensitive to light, dilating however during emergence from narcosis, and especially before vomiting is imminent. But sudden dilatation also occurs when the patient has taken an

over-dose and the heart is dangerously depressed. To distinguish between these states needs the utmost caution. In the last condition deep narcosis and its signs will exist, the pulse will be almost imperceptible, and the respiration hampered; while in the first, the patient will give unmistakeable signs of returning consciousness, which may be accompanied by a flagging pulse. When dilatation of the pupil results from over-dosage, measures to effect restoration must at once be applied, but when due to returning consciousness, a fresh supply of chloroform will prevent vomiting, steady the pulse, and cause the pupils to return to their normal size. This must be done boldly but very warily. If the patient, in spite of all efforts to prevent him, should vomit, and especially if it be known that he has partaken of solid food within the last two or three hours, the head must be turned aside and free egress given to the vomited matter, and if necessary the mouth must be cleared with the finger. The danger to be avoided in this contingency is, lest the vomit be sucked back into the larynx when the patient makes the strong inspiration which always follows vomiting.

When the dilated pupil signals heart failure and cessation of respiration, all the signs of increasing and profound narcosis are present, and then it is that the chloroform must be removed and efforts promptly made to restore consciousness and stimulate reaction (see Treatment of Complications under Chloroform).

During the progress of the operation, attention should be paid to the condition of the pupil as above noticed, and to the pulse and respiration.

Although heart failure may occur at any time during chloroformisation, it is more liable to do so quite at

the commencement; while more danger arises subsequently from failure of respiration through accumulation of chloroform in the blood, and paralysis of the medullary centres. Weak pulse and shallow irregular breathing may indicate over-dosage, and then the amount of chloroform given must be diminished. The colour of the patient's face, lips, and ears, is a valuable guide to his condition; lividity, cyanosis and pallor, are all indications that danger is present. The operation completed, the patient should still be carefully watched until he has recovered consciousness sufficiently to prevent accidents, *e.g.*, dropping back of the tongue, vomiting, &c. If possible, it is best to allow him to sleep off the effects of chloroform, and it is always a mistake, unless there be some very good reason, to arouse a chloroform patient from his doze by loud speaking, shaking, putting water on his face, &c. Such procedure often induces vomiting and headache.

Exception has been taken to the open method upon the ground that it is impossible to regulate the amount of chloroform inhaled and so to obtain a definite percentage vapour; also because so much vapour escapes from the surface of the towel into the room and prejudicially affects onlookers. Dealing with these objections, Sir Joseph Lister has found after careful and ingenious experimentation that only sufficient chloroform escapes from the lower surface of the towel to constitute, when mixed freely with the circulating air, an atmosphere of 4·5 per cent., and of this only a portion would enter the patient's lungs. He further believes that inspiration does not affect the rate with which evaporation occurs. Of course these statements are only true as long as the open method is conducted

strictly, and with every precaution given in the preceding sections.

Sir Joseph Lister suggests the following simple way of devising a chloroform mask: the corner of a towel pursed up systematically into a concave mask to cover the mouth and nose by pinching it together at such a distance from the corner that when the pinched up part is held over the root of the nose, the corner extends freely to the point of the chin. "The cap formed in this manner being so arranged upon the face, chloroform is gradually dropped upon it till the greater part of it is soaked, the edges being left dry to avoid irritation of the skin by the liquid, and the moist condition is maintained by frequent dropping on the convex surface until the requisite physiological effects are produced."

Hypodermic injections of chloroform have been suggested as a means of producing anæsthesia, but (Dujardin-Beaumetz) they fail to induce general narcosis while affecting some local anæsthesia. This method is not free from danger as (Bouchard and Laborde) it has been shown that albuminuria and death have in the lower animals resulted from its use.

Method of Definite Mixtures.

Clover was one of the first to insist upon the importance of using definite mixtures of chloroform vapour in air, and his apparatus described above was an attempt to bring the method within the range of practical anæsthetics. P. Bert, however, studied the subject from the experimental side, and we owe to him much of our knowledge upon the matter. Although successfully employed by Péan, the method requires too cumbersome an apparatus to be used save in hospitals.

Complications arising during the Administration of Chloroform, and their Treatment.

Syncope.—Failure of the heart may occur quite at the commencement of the administration, that is, after two or three inspirations of chloroform vapour, or it may supervene much later—in the third stage. In the primary stage, syncope has been variously accounted for; it has been attributed to reflex inhibition of the heart excited by terror, or by the irritation by the chloroform vapour of the sensory nerves of the pharyngo-laryngeal mucous membrane and pulmonary tract; or to an individual obnoxiousness to chloroform vaguely called the chloroform idiosyncrasy. Cases have been recorded of sudden death, provoked by fear, in persons about to be operated upon, who have either taken no anæsthetic or have imagined, erroneously, they were being chloroformed, while in reality they were inhaling eau-de-Cologne, or an equally innocuous substance. It is unquestionably highly important that all perturbing causes provocative of fear, such as loud and technical talking descriptive of the horrors of the operation, should in the patient's presence be carefully avoided. No movement, such as uncovering the diseased area, suggestive of the commencement of the operation, should be permitted until unconsciousness is well established. Fear and trepidation must always be met by kindly re-assurance, while haste and brusque handling must be studiously avoided. Nothing can be more prone to produce fatal syncope than the commencement of the operation before complete anæsthesia has been induced, for here we have a lowering of the vital functions caused by chloroform, and the shock

of cutting the skin, especially over a sensitive area, communicated along sensory nerves whose conduction is not yet in abeyance. Records of death under these circumstances (incomplete anæsthesia), show how often the fatality arises in cases when trivial, although painful operations, such as reduction of dislocated limbs, circumcisions, &c., are performed. Under these circumstances, too, it must be remembered that the heart is peculiarly liable to reflex inhibition, as vasomotor paralysis occurs antecedently to loss of conduction along the sensory tracts of the nerves and cord.

Symptoms.—Fluttering feeble pulse, sudden stoppage of the heart, extreme and ghastly pallor, with blueness of the ears and finger-tips, wide sudden dilatation of the pupils, and cessation of respiratory movement, usher in this syncope. There is little or no warning of the onset of this heart failure, nor can the most careful preliminary examination give an indication of cases in which it is likely to occur. Persons the subjects of fatty degeneration of the heart, of aortic or advanced mitral disease, are of course always liable to syncope, but the robust and vigorous incur a like risk, and are frequently the victims of syncope occurring in the initial stage of taking chloroform. Syncope arising at other stages of chloroform narcosis commonly gives more warning; there is a gradual failing of the heart, evidenced by weakened and often intermittent pulse, pallor and cyanosis, cessation of hæmorrhage, and dilatation of the pupils.

Treatment.—Chloroform must be at once removed, the table tilted so that the head lies at a lower level than the feet, and when possible, the legs should be raised, so assisting a return of blood to the heart.

Complete inversion of the patient as practised by Nélaton is certainly the most important remedial measure we possess, but should never be employed when asphyxial complications co-exist with the syncope. The respiration, which will have ceased consequently upon the cessation of the heart's action, must be kept up by the artificial methods of Howard and Sylvester (see Chap. X.). When the thorax is grasped in expiration, it is well to slip the hand under the costal border on the left side, and so mechanically excite the heart. The chest and throat bared of all clothing, should be slapped with a towel wetted in cold water, and fresh air from an open window allowed free access to the patient. The injection of brandy in *hot* beef tea by the rectum, and hypodermic injection of ether, or failing that, whiskey, especially over the præcordium, should be promptly tried.

The inhalation of **nitrite of amyl** is vaunted as a specific, and certainly in cases of syncope occurring late in narcosis, or after an operation when much blood-loss has occurred, I have seen it do good. The most convenient way of using the drug is to smash a ♏iij. glass capsule and hold it beneath the patient's nose, taking care that artificial respiration is maintained so as to ensure the due entrance of the fumes into the lungs.

Among other measures advocated for counteracting this syncope must be mentioned **electrical stimulation** of the heart, and **acupuncture** of that viscus.

One electrode is placed over the neck behind the sternomastoid at about the juncture of its lower and middle thirds, while the other is wiped over the præcordium. I am not prepared to say that this step is

not more likely to produce inhibition than excitation of the heart muscle; by stimulating the diaphragm to contraction, it may possibly aid respiration. **Acupuncture** of the ventricle with a gold needle is believed to act by exciting that viscus to contract through direct mechanical stimulation.

Syncope arising late in the course of an exhausting operation must be met by the above methods of treatment, and as soon as the patient has rallied sufficiently to be able to swallow, brandy must be rubbed over tongue and gums, and when capable, the patient should swallow sips of brandy in hot strong beef tea, while sinapisms are applied over the præcordium, epigastrium, and calves of the legs. The head must be kept low, and any attempt at sitting up interdicted. Reaction must also be aided by hot water bottles applied to the feet and sides, and the flow of venous blood be promoted by firm rubbing of the limbs from the feet and hands towards the trunk. Inversion of the body, so that the feet are in the air, is often of signal service in extreme cases of cardiac weakness, when there is no reason to believe that the right heart is engorged.

Asphyxia from Cessation of Respiration.

This may result from (1) Mechanical, (2) Vital Causes.

Mechanical.—Sir Joseph Lister has shown that one of the most usual and dangerous accidents which occur under chloroform is occlusion of the larynx by the folding together of the arytæno-epiglottidean folds so that their posterior portions approximate, and, by

closing upon the base of the epiglottis, prevent any entrance of air. This accident is usually evidenced by stertor and irregular respiratory movements, but it may supervene without any such warning, and as the chest movements continue may be overlooked. If permitted to go unrelieved, the impeded breathing reacts unfavourably upon the heart, already depressed by the chloroform; cardiac rhythm is impaired or checked, and the ghastly aspect of the patient draws attention to his danger.

Treatment.—By seizing the tongue with forceps, (Lister employs ordinary artery forceps for this purpose), and dragging it somewhat forcibly out of the mouth, the obstructing portions of the arytæno-epiglottidean folds are caused to recede from the epiglottis, and so leave a free air-passage. This manœuvre acts, it is believed, reflexly, and not merely mechanically.

The Tongue may fall back and so occlude the laryngeal opening. When the patient is deeply under the anæsthetic, the hyoid bone drops and the tongue is carried back so as to close the laryngeal chink. The air is thus prevented from entering, as every inspiratory effort only sucks back the epiglottis, which acts as a valve permitting some expiration but no inlet of air. The thoracic movements continue even when this accident effectually prevents the entrance of air. Usually, but not always, snoring stertor is present under these circumstances.

The signs of asphyxia soon reveal themselves, the face becoming dusky, then blue, and finally a mottled black, the pulse weakens, and unless promptly relieved, the patient dies.

Treatment.—To prevent this accident, the chloro-

formist should keep a finger beneath the patient's chin so as to check falling down of the hyoid bone. To remedy the danger, it is necessary to pull forcibly forward the tongue, using forceps, and turning the head to one side, so that the weight of the organ shall not carry it backward. If the accident has not been noticed until respiration has ceased, it will be necessary besides the directions given above, to perform artificial respiration ; but usually forcibly compressing the thorax once or twice is all that is needed.

Mucus sometimes collects over the upper opening of the larynx, and in persons whose respiratory efforts are not vigorous, may cause suffocation. Insufficient air exchange leads to signs of asphyxia more or less pronounced, the most striking of which is the progressive duskiness of hue. In this case the throat should be sponged out and the chin jerked up, a manœuvre often sufficient to dislodge the pellet of mucus and restore normal respiration.

Entrance of Foreign Bodies into the Larynx or Trachea.

Teeth, natural or artificial, portions of bone, blood clot, masses of new growth, gags, sponges, are liable to drop back and enter the air-passages, or become jammed in the œsophagus and so provoke asphyxia by mechanical pressure. Small or soft substances which enter the larynx may set up spasm and so prevent passage of air, or they may pass into the trachea, with the same result. When suffocation can be attributed to this cause its relief must at once be obtained by per-

forming tracheotomy, and by sucking out blood, clots, masses of growth, &c.*

It is in all cases necessary to examine the buccal cavity, and if any foreign body be found loose it must be duly removed by the fingers or forceps.

Inversion is also of value in cases where it is feared that blood has entered the windpipe. After tracheotomy, sucking the tube is usefully supplemented by inversion.

Insufflation of the lungs by means of a catheter passed through the larynx has been recommended, but it would appear less effectual than tracheotomy and artificial respiration, aided when need be by sucking out blood or mucus from the tracheal opening.

Vital.—Asphyxia may result from over-dosage; the respiratory centre becomes paralysed, the movements of respiration grow more and more shallow, and at last cease. The heart ceases to beat a few seconds after breathing has stopped.

Treatment.—Artificial respiration must at once be practised.

Epileptic Fits may be provoked by chloroform in persons subject to such seizures; they usually appear in the third stage of narcosis.

Hysterical seizures also occur, but they usually appear in the second stage.

* An instructive case occurred under my charge at University College Hospital. A man from whom the upper jaw had been removed by Mr. Heath was under operation for a recurrence of epitheliomatous growth, when his respiration suddenly became hampered, and signs of impending suffocation appeared. Tracheotomy was promptly performed, the tube sucked, and several small masses of the growth withdrawn from the windpipe in this way. The man's breathing was restored and the operation was completed.

The treatment is simply that of preventing the patients from injuring themselves.

(See also Chapter on Accidents of Anæsthesia).

After-effects of Chloroform.

Vomiting.—By attention to the directions given above (Chap. II.), vomiting is rendered less liable to occur. The following further directions, if duly carried out, will tend to the same end. If bilious plethoric persons have their bowels well cleared before taking chloroform they are less liable to sickness. The patient's head should be kept quite low; he should not be moved from the operating table for half an hour after coming to himself, and then the utmost care must be taken to prevent his being shaken or his head raised.

Opium should not be given by the mouth; and unless there is obvious and urgent shock, brandy, ether, and sal volatile must be withheld. No food must be allowed, whether liquid or solid, for at least three hours after chloroforming, and then nothing warm should be taken until all nausea has vanished. Meat jelly, bread boiled in milk, to which a pinch of bicarbonate of soda is added, or sponge cakes soaked in a light dry sherry, may be permitted after this time; tea, coffee, soaked toast, may be tried, but all indigestible or solid food should be denied until the following day.

(For the medical treatment see After-effects of Ether, Chap. IV.).

Hysteria.—Fits of hysterics are sometimes excited in the neurotic, by chloroformisation; no specific treatment need be adopted. These attacks seldom last more

than three or four hours, and should cause no alarm. They may occur in either sex.

Jaundice and general biliary derangement in some instances follow chloroform administration. They should be treated upon general principles, and need give rise to no alarm.

Albuminuria and glycosuria of a transient and unimportant character may in rare cases follow the use of the drug.

Astigmatism, giving rise to fear lest the sight be permanently injured, has been noticed, but it is doubtful how far we should attribute this condition to chloroform.

Insanity may, in very rare cases, follow chloroformisation of predisposed persons (Savage). (See Medico-Legal Aspects of Anæsthesia, Chap. XII.).

Effects of Repeated Inhalations.—Paul Bert made a careful study of the effects of daily administration of chloroform for a definite time. His researches were made on dogs. After gradual failure of health, these creatures died on the 32nd day with well marked wasting of their organs and muscles, and fatty changes in the liver. According to Regnault and Dubois (Dastre) workers constantly exposed to the fumes of chloroform suffer from insomnia, neuralgic and rheumatic pains, with marked physical and mental depression.

CHAPTER VI.

Less Commonly Used Anæsthetics.

Amylene—Ethidene Dichloride—Bromide of Ethyl.

Amylene.

Amylene (C_5H_{10}), a translucent, colourless, thin, mobile liquid, possessed of an odour which is midway between chloroform and ether in pungency, was discovered by Balard in 1844. It has a sp. gr. of ·6549, boils about 102° F. (38·8 C.) (Watts), although the boiling point varies somewhat: it burns with a luminous white flame. Hardly soluble in water, it is freely so in alcohol and ether. When mixed with air it explodes on heating, and therefore should not be used in near proximity to flame.

Preparation.—Zinc chloride in concentrated solution is heated with amylic alcohol to 266° F., distilled from a water-bath over caustic potash and afterwards rectified.

Physiological action.—Snow made some experiments with this substance, and found small animals required a 10 per cent. vapour before losing consciousness, that 20 per cent. produced deep insensibility, while 25 per cent. could be respired with perfect safety. With 10 per cent. the "second stage" of anæsthesia is produced, *i.e.*, the mental faculties without being suspended are impaired; occasionally patients remember

what occurs during this period, and partial anæsthesia exists. Snow stated that "over-narcotism of the heart with paralysis of its muscle" could be attained with amylene, but that sudden death from this cause was less liable to occur than with chloroform. He found also that 40 per cent. of amylene would be required to effect such a mode of death.

In 1856, Snow employed amylene to produce general anæsthesia. He found it occasioned little or no sickness. The anæsthesia appeared with great rapidity, sometimes before consciousness was lost; the recovery was speedy and usually unaccompanied by headache, giddiness, or other unpleasant symptoms. Dr. Snow did not push the narcotism far enough to induce coma; in most of his patients the ciliary reflex persisted (thus contrasting with the effects of chloroform). The induction of narcosis by this agent is tranquil. Save in exceptional cases amylene produces complete muscular relaxation. The pulse is increased in frequency, especially during the earlier stage of amylene narcosis. Respiration is quickened as under ether. The pupils remain of natural size, unless the anæsthetic be pushed, when they dilate. The face flushes and sometimes perspiration bursts out, but the salivary and bronchial secretions are not augmented. A tendency to hilarity evinces itself in some persons just as they are passing into the second stage. Mental excitement is usually absent. Rigidity and struggling seldom occur under amylene, a fact which Snow believed was due to the slighter degree of narcosis needed to induce anæsthesia when that substance was employed. The great volatility (great as ether), and the slight solubility of amylene, make its liberation from the blood very rapid; hence

recovery from the effects of the drug takes place with great celerity. In some persons laughter and singing are provoked, but these phenomena usually pass off if the amylene be withheld for one or two inspirations. The Glasgow Commission failed to obtain satisfactory anæsthesia with amylene. More recently this substance has been used in Germany under the name of Pental with, it would seem, encouraging results.

Mode of administration.—The vapour of amylene must be of such a strength as to induce anæsthesia in three minutes; if a weaker vapour be used, no matter how long it is persevered with, it will fail to produce an effect. Snow employed the same inhaler as for chloroform (see p. 111). The patient once well under, Snow re-applied the inhaler every half minute, otherwise he found consciousness returned. Amylene may be given in a cone, or by the open method; the last, however, is not well adapted for its exhibition, on account of its extreme volatility.

Snow, suggested the dosimetric system for amylene.

After-effects and dangers.—Snow found the after-effects were fewer and less severe than those subsequent to chloroform or ether. Sickness occurred twice only out of 238 cases; headache was slight and transient; hysterical symptoms were shown by a few women.

Two deaths occurred in Snow's practice, the 144th and the 238th cases, and were attributed by him to the patients inhaling too strong a vapour (30 per cent.) of amylene. In Snow's opinion the variation of the boiling point in different specimens fully accounts for these unhappy fatalities. Thudichum asserts that the samples employed by Snow in these cases really contained no amylene, but only intermediate hydrocarbons.

Treatment.—The steps requisite to avert such accidents are similar to those described under "Accidents during the administration of chloroform."

Ethidene Chloride.

Ethidene Chloride (ethidene dichloride), more properly ethilidene chloride, $C_2H_4Cl_2$, has a sp. gr. 1·189, and boils at about 136·4° F. (58° C.), (sp. gr. 1·182 and B.P. 59° C. Dastre); this boiling point is not, however, uniform. It was first prepared by Regnault by the action of chlorine upon chloride of ethyl. Clover used samples with a sp. gr. of 1·225 and B.P. 239° F. (115° C). According to Watts, it is identical with monochlorinated chloride of ethyl, $C_2H_4Cl.Cl$, which possesses a boiling point of 64° C. and a sp. gr. 1·174 at 17° C. It is a colourless transparent oily fluid, tasting and smelling like chloroform. It is prepared from aldehyde by acting upon it with pentachloride of phosphorus. It is also formed as a bye-product in the preparation of chloral, and separated by distillation and subsequent fractionation. Insoluble in water, it is freely taken up by alcohol, chloroform, ether, and oils. It is less inflammable than chloroform. It is difficult to preserve, as in contact with air it rapidly decomposes and becomes acid in reaction and useless for anæsthetic purposes.

Dr. Snow was the first to employ this anæsthetic in England (June 20th, 1851), and it was subsequently used extensively by Clover, who I believe, until the time of his death, entertained a very high opinion of it. In Germany, Liebreich, Langenbeck, Sauer, and Steffen, have used it and published records of cases.

Physiological action.—The Committee of the British Medical Association carefully worked out this subject.

Frogs compelled to inhale the vapour become rapidly narcotised (4 minutes). Their hearts, however, beat on unaffected for twenty-six minutes.

Warm-blooded animals speedily passed under the influence of this ether (4 minutes), and remained narcotised without the failure of the heart. Being exposed and watched while artificial respiration was maintained, the heart showed some slowing, but without any material weakening. In an experiment made to compare ethidene with chloroform, a dog was narcotised with ethidene and the cardiac movements studied. While under this agent no interference with the rhythm was observed; when, however, chloroform was substituted, the right heart grew distended and dark, and rapid depreciation of cardiac force occurred. The Committee concluded "practically a dog will live for a lengthened period in a state of complete anæsthesia under the influence of ethidene dichloride, whilst it will die in a short time when chloroform is used."

Blood-pressure is slightly lowered by ethidene, the lowering taking place quite gradually, but after a while a partial recovery occurs, which is assumed to be due to the heart accommodating itself to the influence of the narcotic.

Respiration is slowed and may become spasmodic and jerky, persisting even when the heart has perceptibly ceased to beat.

Upon human beings, ethidene exercises the following effects:—At first a pleasurable glow extends over the whole body, then within a minute or two the senses are

confused, and often singing or whistling is induced. Some muscular rigidity then appears and anæsthesia follows. Patients take a longer time to recover consciousness than when chloroform is used, but they experience fewer after-effects. Thus, as soon as they come to, they can stand or walk (Clover) and are able to express themselves with clearness. No headache actually follows, vomiting is present after about one-third of the cases of major, and one-twentieth of minor, operations. This vomiting is less severe than that which follows chloroform and does not persist so long.

There is sometimes a little convulsive twitching. As the patient passes into unconsciousness, his breathing grows stertorous and his pupils dilate, but if air be now admitted, the stertor will pass off and the pupils resume their normal size. The pulse is liable to flag under ethidene, and hence caution is needed in its employment. In the fatal cases recorded, the patient died from heart failure, the myocardium being pathologically fatty.

Methods of administration.—Mr. Clover, who gave ethidene 1877 times with but one death, recommended administrators to commence the inhalation with nitrous oxide, and then to prolong anæsthesia by ethidene contained in his ether inhaler. Of course the initiation with gas is matter of choice. When given from an ether inhaler (see article, Ether) the anæsthetic should be pushed until after the stage of struggling has passed; subsequently it should be given far more sparingly, the inhaler being lifted from the face every third or fourth inspiration for the admission of fresh air. The patient becomes anæsthetised in three to five minutes. Dilatation of the pupil and stertor are signs

indicative of the necessity of reducing the amount of anæsthetic given. The Glasgow Committee gave ethidene by the open method upon a towel.

Ethidene is also given through Junker's inhaler, or Snow's chloroform inhaler may be substituted.

Accidents and after-effects.— These are similar in kind to those treated under the article Chloroform, to which the reader is referred, (see also Accidents of Anæsthesia, Chap. X.).

At least two deaths have occurred during the use of this anæsthetic.

Hydrobromic Ether.

Hydrobromic ether (bromide of ethyl) C_2H_5Br, sp. gr. 1·4733, boils at 104° F. (40·7° C.). It is a colourless translucent liquid, with a neutral reaction, ethereal smell, and a pungent sweet taste with a somewhat burning after-flavour. It is ignited with difficulty, and burns with a green, smokeless flame emitting an odour of hydrobromic acid (Löwig). It is prepared by distilling alcohol (ethylic) with either bromine, hydrobromic acid or bromide of phosphorus. It is only slightly soluble in water, but freely so in ether or alcohol. Serullas discovered this substance in 1827, but to Nunneley, of Leeds, we are indebted for its recognition as an anæsthetic (1849).

It was again brought into notice in 1865 by Nunneley, but eventually he gave up its use mainly owing to the extreme difficulty of obtaining it pure and on account of its great cost. Dr. Squire gave the results of his experience of its use in 1881, and Dr. B. W. Richardson, a

staunch supporter of this agent, wrote (*Asclepiad*, 1885) favourably of its claims, and urged that pure samples were free from the dangers which arise with the commercial bromide.

Physiological action.—Rabuteau has made careful researches upon the subject. Seeds not germinating are unaffected by it but do not germinate; plants die when placed in its atmosphere after a very short exposure. Frogs become deeply anæsthetised when immersed in watery solutions. Upon human beings it produces unconsciousness and anæsthesia in one minute, and complete muscular relaxation in two or three minutes. No suffocation or laryngeal irritation appears to exist, although there is much congestion of the head and neck, and an increased secretion of mucus which may give trouble. The breathing is quickened, the pulse accelerated, and the heart's action somewhat weakened. The pupils dilate. Return to consciousness after withdrawal of the ether is very prompt. Vomiting is said to occur frequently during the administration, and even to continue for some hours succeeding.

Blood-pressure, according to Wood, is slightly reduced by small, and very considerably by large, quantities. Where death ensues it is due to cardiac failure (Wolff and Lee); but these statements are denied by some observers. Ott believes ethyl bromide kills by direct action upon the respiratory centre, and does so whether injected subcutaneously or inhaled. The heart failure, he thinks, is secondary to the respiratory trouble.

Method of administration.—Ethyl bromide must be given like ethyl oxide (Sulphuric Ether), air being excluded. Turnbull, who has made careful

study of this substance, insists upon the necessity of quickly getting the patient under the influence of the vapour. An Allis's inhaler answers very well, or an Ormsby's apparatus. The inhalation must be stopped when palatine stertor or loss of conjunctival reflex occurs (Silk). There is said to be less struggling than with ether, but violent struggling certainly does in some instances take place. Owing to the great rapidity with which consciousness returns, extreme attention is needed on the part of an anæsthetist to maintain narcosis. The respiration and pulse require watching throughout the administration. No prolonged operation must be attempted under ethyl bromide, forty minutes being the limit of time during which it may be safely administered.

Cases suitable for Ethyl Bromide.

Short operations and those of minor surgery.—In dental operations the rapidity with which the patient shakes off narcosis renders ethyl bromide of little more value than nitrous oxide, while it would not seem to equal it in safety. The use of this substance in dental practice has recently been strongly advocated in Germany, and Dr. Silk using it in the Dental Department of Guy's Hospital speaks favourably of it. The frequency of more or less unpleasant after-effects which he states occurred among his patients would seem to detract from its value in this branch of surgery. In obstetric practice it is said by Dr Laurence Turnbull to be of the utmost utility, since it rapidly induces unconsciousness and the patient as speedily regains her senses. It must not be forgotten, however, that when

bromide of ethyl is given in small doses, much muscular spasm results, which is not desirable in accouchements.

Dangers resulting from the use of Hydrobromic Ether.—Richardson, entertaining a very high opinion of ethyl bromide as an anæsthetic, denies that fatalities have followed its employment. Eight deaths are stated to have resulted from its administration, but some of these were in reality due to impurities contained in the sample used. Dastre points out that pure hydrobromic ether has a sweet ethereal smell, but when impure the odour is most unpleasant. According to Dr. Laurence Turnbull, most of the ethyl bromide sold is impure, containing free bromine, carbon bromide (C_2Br_4), phosphorus, and bromoform. Further, this substance is very unstable and readily decomposes, liberating free bromine. The presence of these bodies renders the impure ethyl bromide singularly dangerous, and until we can be sure of the purity of any given sample I think we are scarcely justified in its use for anæsthetic purposes.

Complications.

Muscular spasm may be so pronounced as to interfere with respiration.

Excitement instead of insensibility may appear.

Persistent vomiting has been recorded as following its employment. Persistent nausea also occurs even when vomiting does not occur.

Heart failure may occur. Various degrees of faintness and collapse not infrequently follow its use (Silk).

In no case is it safe to continue the administration of this anæsthetic for more than forty minutes. (Dr. Laurence Turnbull).

Treatment.—The directions given elsewhere (Chap. X.) apply to the recovery of the apparently dead from ethyl bromide. Thus, artificial respiration must be resorted to at once, and the mouth and pharynx cleared of secretion without delay.

Amyl nitrite may be tried.

CHAPTER VII.

Anæsthetic Mixtures.

These are of two classes :—1. Admixtures of members of the alcohol or ethereal series. 2. Alcoholic or ethereal anæsthetics with alkaloids or other bodies.

The following are the best known and most useful members of the first class :—

The A. C. E. Mixture.—Compound of 1 part alcohol, sp. gr. ·838, 2 parts chloroform, sp. gr. 1·497, and 3 parts ether, sp. gr. ·735.

The Vienna Mixture.—1 part of chloroform to 3 of ether.

The Mixture recommended by Linhart : 1 part alcohol, 4 chloroform.

Methylene.—Methylic alcohol 30 per cent. and 70 per cent. chloroform (Regnauld and Villejean).

Billroth's Mixture.—3 parts chloroform, 1 each of alcohol and ether.

The **A. C. E. mixture,** which was originally proposed by Dr. George Harley, is strongly recommended by the Anæsthetic Committee of the Royal Medico-Chirurgical Society of London. They speak of its action as midway between that of chloroform and ether. It has been largely used in England, and although not without objections, is a good substitute in many cases when ether cannot be taken. The main drawback to the employment of this and all other mixtures is that the substances employed in their formation do not

evaporate in the ratio in which the fluids are mixed, and hence it is impossible to be quite sure what percentage vapour of chloroform is being inhaled. To obviate this difficulty, Ellis proposed to blend the vapours of alcohol, chloroform and ether, in a specially constructed apparatus, and so administer a true vapour mixture to the patient. The arrangement he used is too complicated for practical purposes, and his method has never been received with much favour. In three chambers, known weights of the anæsthetics were evaporated; these chambers could at will be made to communicate with a common chamber, and from this the patient was anæsthetised.

Mr. Martindale has proposed an admirable volumetric mixture, the ingredients of which evaporate almost uniformly. It consists of absolute alcohol, sp. gr. ·795, 1 volume, chloroform, sp. gr. 1·498, 2 volumes, pure ether, sp. gr. ·720, 3 volumes.

Method of employment.—This may be given in a Clover's ether-inhaler, a cone, or even by the open method. I find Allis' inhaler also answers well, and recently have employed Krohne's cone fitted with the feather respiration register (p. 116) and have found it very successful and pleasant to manipulate. Junker's inhaler, fitted with the flannel mask, is very convenient for giving the A. C. E. mixture, especially to children. With the open method, much ether vapour escapes into the surrounding air, causing inconvenience and delay in the onset of insensibility, and further rendering the mixture relatively rich in chloroform while deficient in ether. No special directions are needed if the chapters upon chloroform and ether administration have been read. The fact that chloroform is present

in the mixture makes it obligatory that plenty of air be allowed the patient, to effect which the cone or inhaler should frequently be raised from his face. Both respiration and pulse must be carefully noted, as fainting and asphyxial troubles may occur during the employment of the A. C. E. mixture.

After-effects are much the same as those of chloroform or ether. Deaths have occurred during the use of the A. C. E. mixture.

Richardson's mixture consists of 2 parts alcohol, 2 parts chloroform and 3 of ether. Dr. Richardson states that this mixture works very well, and that he has never lost a case during its employment.

The Vienna mixture (1 part chloroform, 3 of ether), stated to have been employed eight thousand times without a casualty, may be given practically in the same way as ether, save that care must be taken that the patient shall respire fresh air at frequent intervals.

Linhart's mixture is administered similarly to chloroform; the same care and watchfulness being necessary, as most of the risks of chloroform are present with its use.

Methylene or "bichloride of methylene"—so called, but which is stated by Regnauld and Villejean to be merely a mixture of methylic alcohol and chloroform similar to Linhart's mixture above given. It consists of methylic alcohol 30 per cent. and chloroform 70 per cent.

The so-called "liquid of Regnauld" consisted of 80 per cent. chloroform, 20 per cent. methylic alcohol. The Glasgow Committee found methylene possessed no definite and constant boiling point, a fact further

corroborating the assertion of the French chemists. It was also pointed out by this committee that the physiological behaviour of this body was identical with that of chloroform. I have found, experimenting upon the frog's heart, that methylene and chloroform affect the heart in precisely the same way and give identical cardiograms. But, in explaining the diverse results at which various observers have arrived, we must remember that although the boiling points of methylic alcohol and chloroform are not very wide apart, yet the constituents of this mixture evaporate at varying temperatures, so that at the end of the dose pure chloroform is given up, while at the beginning only a small percentage of it is present in the evaporating alcohol. It is more agreeable than ether, possessing the fragrant smell of chloroform. Its safety is probably only that of diluted chloroform, and many deaths have followed its use.

Dr. Richardson, the first who introduced methylene into English practice, writing in the *Asclepiad* (1884), adhered to his original statements in favour of methylene. He holds that although many samples are mere mixtures, yet pure bichloride of methylene is anæsthetic. This is absolutely denied by the French chemists cited above, who state that the pure substance (bichloride of methylene) is not an anæsthetic, but a powerful convulsant, and proves fatal to animals in a few seconds.

Methods of employment.—Although methylene may be given by the open method, it is more commonly administered from a Junker's inhaler (see description page 113). Methylene acts precisely like chloroform, and its use is fraught with dangers which differ not in

kind, but in degree, from those present when chloroform is used.

Both the respiration and pulse must be sedulously watched, and the utmost vigilance displayed to avoid accumulation of vapour in the lungs. With the use of an inhaler, it is most important to avoid pushing the narcosis too far. When a patient has once become unconscious, the amount of air blown over (Junker's apparatus) should be much lessened, thus he can easily be kept anæsthetic with a very small percentage of methylene vapour. It must, however, be borne in mind that methylene being diluted chloroform, the subject is apt to regain consciousness somewhat more rapidly than during the use of simple chloroform.

The after-effects of methylene are those following the use of chloroform, they are, however, often less severe.

Billroth's mixture (chloroform 3 parts, alcohol and ether each 1 part), is but little known or employed in England. It contains a high percentage of chloroform, and hence needs careful handling. It should be administered either by the open method, or if an inhaler be used, Junker's or the simple flannel cap will answer. In either case the patient must be allowed plenty of fresh air.

Similar dangers are imminent, and precautions needed, as in the administration of chloroform. Deaths have occurred during the use of Billroth's mixture.

Mixture of Chloroform or Ether with Alkaloids, etc.

Chloroform and morphine (Nussbaum).—Nussbaum, of Munich, was the first to employ this mixture method in Germany (1873), although Claude Bernard had studied the method experimentally some years (1869) previously, having had occasion to give morphine to a dog recovering from chloroform. Injections of morphine, gr. $\frac{1}{6}$ to $\frac{1}{2}$, or in some cases more, hypodermically, half an hour before giving an inhalation of chloroform, are stated to possess the following advantages:—Less chloroform is needed, while the stupor is more prolonged. If the morphine be given immediately before, it in some cases prolongs the period of excitement. Drunkards, and persons who show little amenity to chloroform, soon pass under its influence after a dose of morphine. The patient is usually more completely relaxed and passive, the breathing is quieter, and it is stated (Kappeler) that the depressant action upon the heart is diminished.

The stage of excitement is shortened, and cerebral circulation while under morphine is markedly lessened, so that for operations involving the opening of the meninges and the cutting of the brain substance, this combination is most valuable.

Excitable persons about to be anæsthetised will often be calmed by morphine.

Upon the other hand, vomiting is more frequent when morphine is used. Poncet, from a wide experience during the Franco-Prussian war, abandoned the method, owing to the frequency with which prolonged

stupor, and dangerous depression of the temperature occurred after its use.

Morphine in some produces great excitement, and this by the addition of chloroform may be magnified to a very inconvenient extent.

When this combination is employed, it is important to restrict the amount of chloroform given; indeed when the patient is once fairly narcotised, very little more chloroform will be needed unless the operation be a very prolonged one. Care must be exercised that only a weak vapour is used, since the patient will take but little notice of its pungency, and so one of the usual safeguards is lost. Caution must also be displayed in employing this mixture when severe hæmorrhage is likely to take place into the pharynx, as the patient is not easily roused, and the danger of blood entering the lungs is increased.

According to Regnier there is a grave danger, due to the morphine lessening the elimination of the chloroform and so leading to over-dosage. He lost one patient when this method was used, and regards it as rather increasing the patient's chance of mishap from the chloroform. Dastre points out also the liability there is to respiratory failure under its use.

Demarquay has very justly indicated that the chief dangers of this method of mixed anæsthesia lie in want of caution in not limiting the dose; large injections of morphine preceding chloroform administration certainly have a danger of producing asphyxia through paralysis of the respiratory centre.

Morphine, atropine and chloroform (Dastre and Morat).—It was pointed out some years ago that atropine in paralysing the vagus might be a valuable anti-

dote to chloroform, by preventing reflex inhibition of the heart through the par vagum. I have found the addition of gr. $\frac{1}{120}$ of atropine to gr. $\frac{1}{4}$ of morphine to be an advantage, when that last alkaloid is employed synergetically with chloroform.

This plan which goes by the name of the Dastre Morat method in France is said by its inventors to be safer than Nussbaum's method. Aubert, of Lyons, employed it in practice and speaks well of it. The injection is made 15 or 30 minutes before the commencement of the operation. The mixture Dastre recommends is Morph. Hydrochlor. 10 centigrm., Atropin. Sulph. 5 milligrm., Aq. destill. 10 grammes, one cubic centimetre or 1·5 c.c. being injected. The use of atropine in this way is said to lessen the after-sickness, and to abrogate salivation and bronchial secretion.

Morphine and ether.—It has been proposed to exhibit morphine before ether, similarly as before chloroform, but the method possesses disadvantages in its liability to induce prolongation of the stage of excitement. It may induce very violent struggling and increase the after-headache, prostration, and vomiting. Kappeler, who has experimented with this mixed method, states that he has completely failed in several cases in which he attempted to narcotize patients with ether subsequently to hypodermic injections of morphine.

It is not, however, clear whether Kappeler's results should be considered quite so absolute as his statements would lead one to suppose. Certainly in cases at University College Hospital in which the method was employed, no great struggling or inconvenience was observed.

Chloroform and amyl nitrite ("Chloramyl," Sanford).—American physicians have employed this mixture and speak well of it, and Dr. Richardson in this country has lent it his support.

It is claimed that chloroform, when mixed with nitrite of amyl, loses many of its dangers, and is more agreeable to take. The proportions recommended are ʒ ij., to the pound (Sanford), and ♏ xvi. to the ounce (L. B. Balliet). Dr. Sanford states that unless a very pure sample of chloroform is obtained the mixture is liable to become milky and to give unsatisfactory results. He also suggests that when the administration of the mixture is likely to be very much prolonged, that it is well to use less nitrite of amyl in the latter stages of the operation.

Upon the other hand, we are compelled to recognise that such a mixture possesses several undeniable objections. In the first place the sp. gr. of chloroform is 1·497, that of nitrite of amyl, ·877, so no permanent mixture can be maintained, a drawback which even a suggestion to "shake the bottle well before use" does not abrogate. Again, nitrite of amyl cannot, as is asserted, be considered a physiological antagonist of chloroform, for the following reasons:—Nitrite of amyl lowers blood pressure by producing paralysis of either the muscular coatings of the vessels or of the vasomotor ganglia controlling them. After an initial fillip to the heart's action it depresses, and may if pushed even cause syncope. In the lower animals after the use of nitrite of amyl, the heart muscle becomes after a time paralysed. Further, the respiratory centre is depressed, while the motor centres in the spinal cord are paralysed. It would thus appear that so far from nitrite

of amyl opposing the depressant action of chloroform, it probably acts similarly, and by adding it to that narcotic we are still more prejudicing the patient's chances of recovery. If it be urged that successful cases of administration stultify any such theoretical reasoning, the answer lies in a consideration that, firstly, the combination was probably never a mixture and so the patient inhaled chloroform and little if any of the amyl nitrite; and, secondly, that just as we find very many persons whose hearts withstand the stress of chloroform depression, so many would survive the still greater depression of chloroform to which is added amyl nitrite. I cannot find records of any instances in which prolonged anæsthesia was maintained by this mixture. In brief operations it would be at its best; but then it is in lengthy operations that the depressant action of chloroform is to be most feared.

Method of employment.—The method of employing this mixture is similar to that of chloroform.

Chloroform and chloral.—The preliminary giving of chloral was first suggested by Forné; it is said to curtail the period of excitement and to produce an anæsthesia comparable to that which ensues when morphine is used in conjunction with chloroform.

Dose.—Perrin used as large a dose of chloral as gr. 45 for adults (three grammes) before chloroforming.

An alternative plan has been suggested, viz., to divide the dose, giving half by the mouth and half by the rectum. Children of course would require a much smaller dose.

I cannot think the advantages which are alleged for this method in any way counterbalance the dangers which undoubtedly attend its employment. Chloral

acts so markedly upon the heart that it is upon that score alone a deleterious drug to be used with chloroform.

Dastre gives as much as two to five grammes of chloral an hour before administering the chloroform by inhalation. He explains the action of the agents thus:—the chloral behaving as an hypnotic composes the patient to sleep, and the tranquility and lethargy of the patient enable the administrator to maintain true anæsthesia by the use of a small quantity of chloroform.

Other combinations of chloroform, *e.g.*, that of Von Mering (CHLOROFORM one volume, DIMETHYLACETAL two volumes); that of Dr. Wachsmuth (Berlin), who adds one-fifth part of oil of turpentine to his chloroform, have hardly received sufficient trial for any authoritative opinion to be given concerning their use. Von Mering claims that with his combination there is no failure of respiration or heart, and no lowering of blood pressure; while Dr. Wachsmuth states that the addition of turpentine to chloroform does away with any fear of heart failure.

Chloral, morphine and chloroform (Trélat).—In cases in which it is desired to obtain some degree of analgesia without absolute loss of consciousness, Professor Trélat has employed a mixture of four to nine grammes of hydrate of chloral, twenty to forty grammes of syrup of morphine in 120 grammes of water. This is divided into two doses which are swallowed at an interval of fifteen minutes (Dastre).

When sufficiently drowsy the patient is subjected to operation. In cases in which complete anæsthesia is required, chloroform is inhaled after the patient has gone to sleep from the dose. The method may be

deserving of trial in some exceptional cases, but the same objections may be urged against it as apply to the method of Forné.

Cocaine and chloroform (Obalinski).—The plan recommended is to allow the patient to inhale chloroform in the ordinary way until he is slightly under its influence, and then to inject cocaine hypodermically. The dose is given as two to five centigrammes of a three per cent. solution. It is claimed that a very small quantity of chloroform suffices to effect general anæsthesia, and that the after-effects, vomiting, nervous excitement, and "upset" are less liable to occur. It has also been asserted, but I think upon insufficient evidence, that cocaine and chloroform act antagonistically upon the heart, and hence there is less fear of cardiac syncope when they are combined. The extreme uncertainty of cocaine and the alarming symptoms to which it not infrequently gives rise, should, I think, make one very cautious in the employment of Obalinski's method.

Chloral hydrate and ether.—Kappeler used chloral hydrate in forty grain doses (children half this quantity) as a preliminary to the inhalation of ether. The duration of anæsthesia was prolonged and the recovery retarded, while vomiting, headache, and prostration, were more severe than when ether only was employed.

Priestley Smith (Heath's *Dictionary of Surgery*, *Art.* Cataract) gives fifteen to twenty grains of chloral hydrate twenty minutes before administering ether, and finds this practice answers well in operations for cataract.

A death (Lyman) has followed the use of this combination.

Nitrous oxide and ether.—This combination is fully described under "Nitrous Oxide," p. 41. It is the best method of producing general anæsthesia. When complete unconsciousness has been attained by giving nitrous oxide, the duration may be prolonged by allowing the gas to pass through the ether; or by turning off the gas altogether, the patient may be kept anæsthetised by ether for a lengthened period.

Clover's Gas and Ether Apparatus enables one to regulate the supply of gas or ether with a nicety and precision unattained by any other instrument. The dangers and precautions incident to this method are those fully described in the chapters upon Nitrous Oxide Gas and Ether.

CHAPTER VIII.

Anæsthetics in Obstetric Practice.

Whether or not an anæsthetic should be administered in parturition is for the accoucheur to decide. In cases which are considered suitable, it becomes the anæsthetist's duty to render his aid.

Choice of anæsthetics, stage when to be administered, etc.—As a rule chloroform is preferable to ether, unless an operation is to be performed, or unless the patient is greatly depressed by hæmorrhage or shock. The A. C. E. mixture also answers admirably in obstetric practice. Snow advised that chloroform should be withheld until the *os uteri* was fully dilated and well marked expulsive pains had appeared. He, however, made an exception to this rule, when during an earlier stage the pains were very severe.

Spiegelberg, in summing up the advantages of an anæsthetic in obstetric surgery, says chloroform not only allays the pangs of childbirth, but checks bearing-down and diminishes the tension of the abdominal and pelvic muscles as well as that of the uterus. He further extols its use in neuralgia and cramps occurring during parturition.

In normal labour little chloroform is needed; if a very dilute vapour is inhaled the patient sinks into a quiet sleep, and her sensibility to pain is decreased. The uterine contractions are unaffected, but although during the pains the woman may groan and turn over,

yet her complaints are but slight, and as soon as the pain passes off sleep again comes on.

Rules guiding the administration :—

1. Quietude in the room is essential; fresh air should from time to time be admitted, and the patient's posture should be unconstrained.
2. Chloroform should be commenced when the labour is in its second stage if the pains are very severe, but if they are not it is best to wait until the fœtal head is on the perinæum. As a rule the chloroform should not be given during the intervals between the pains, unless the severity of the pains is very great, or it is deemed advisable to induce deep anæsthesia for the performance of an obstetric operation.
3. For nervous women and those who dread pain, also in cases when the perinæum is very rigid, chloroform should be used, as it relaxes the perinæal structures and so is most beneficial.
4. When the patient becomes excited by the chloroform, if it is considered really essential that she should be anæsthetised, it must be pushed to complete narcosis.
5. When the labour is protracted and the patient is to be kept anæsthetic, it is necessary to discontinue the inhalation from time to time, otherwise an injurious accumulation of the drug will take place.
6. When an obstetric operation becomes necessary deep anæsthesia must be obtained (Charpentier).
7. When heart, lung, or kidney disease exists in a parturient, the production of anæsthesia may be dangerous, and its advisability must be settled upon the same general principles which guide us in deciding upon like cases in surgical anæsthesia.

8. It is necessary when the patient is kept semi-narcotised to carefully guard against over-distension of her bladder.
9. It is inexpedient to awaken the patient to consciousness by artificial means, *e.g.*, slapping with a wet towel.
10. When the fœtal head bears on the perinæum, give the anæsthetic more freely, as it relieves the increased pain and also relaxes the maternal passages, and lessens the danger of tearing the perinæum.
11. If the patient is depressed or the pains are sluggish during the administration, an occasional stimulant may be administered.
12. In cases where the anæsthetic appears to interfere with the progress of labour, it may be necessary to suspend its use for a time and re-apply it after an interval, or even to withdraw it altogether. If a meal has been recently partaken, avoid chloroform, the sickness likely to follow will impede delivery.

Objections.—These, although strenuously urged by some, are probably more theoretical than real.

1. Chloroform is said to increase the mortality alike among mothers and children.

Statistics certainly negative this statement. It has been averred that the danger to the parturient is in direct proportion to the amount of pain experienced, and since chloroform minimises this, it lessens the actual danger of childbirth.

2. It is asserted that it protracts the labour.

Unless pushed to the degree of deep narcosis chloroform does not interfere with uterine contractions. In experimental researches upon animals this point has

been fully proved, and has recently been corroborated in a striking manner by Dr. Milne Murray, of Edinburgh.

Deep narcosis renders the voluntary abdominal muscles lax, and so interferes with expulsive efforts. Very deep narcosis also paralyses the uterine muscular tissue. On the other hand a womb, exhausted by frequent and ineffectual contractions, will often under chloroform regain tone and resume vigorous expulsive movements.

3. Rupture of the perinæum is said to follow more commonly when chloroform is used.

I have never seen satisfactory proof of this allegation, and can find no valid reason why such an accident should be associated with the anæsthetic state.

4. Complications are asserted to be more liable to occur when it is used.

This point was carefully investigated by the Chloroform Committee of the Royal Medico-Chirurgical Society, and it was found that chloroform when properly administered does not predispose to inflammation, puerperal convulsion, apoplexy, or other mishap; indeed, as it promotes relaxation of the maternal passages, it is beneficial.

Opinions differ as to whether it predisposes to imperfect contraction of the uterus and so to *post partum* hæmorrhage. This question is greatly influenced, firstly by the degree of narcosis arrived at, and secondly by the length of time allowed to elapse before its use, as well as that during which it is employed. Prolonged use of small doses may be more harmful in this respect than deep narcosis arrived at rapidly and not maintained for more than a few minutes. It is also highly important that the patient's respiration should be free and unhampered by her posture. Lactation is not injuriously affected; the child is in no way injured.

Convalescence is not only not delayed, but is in point of fact actually hastened by the use of chloroform. This statement is made upon good authority, and is probably explained by the fact that by the use of chloroform the nervous system is protected from shock. (Sansom).

Method of exhibition.—When chloroform is employed the open method probably is the best, admitting as it does plenty of air, the countenance being readily seen. A little chloroform may be sprinkled upon a piece of folded lint, or on a towel. Some practitioners let the patient hold a piece of lint or a cup inhaler so that when she grows drowsy the improvised inhaler drops from the hand. Care must be taken that the face does not fall over the chloroformed cloth, or the breathing become impeded by the pillow or bedding.

"When deep anæsthesia is required it is best to have a skilled administrator." (Chloroform Committee).

When chloroform or the A. C. E. mixture is administered by a person who gives himself up solely to this duty, the use of Junker's inhaler fitted with the flannel cap (see p. 114) possesses the advantage that there is less escape of vapour into the room, the air of which keeps purer. When a less elaborate and more portable apparatus is desired, Krohne's cone with respiration indicator is very good, as it allows the administrator to see the breathing is being properly performed, even when the posture of the patient renders it difficult for him to see the thoracic movements.

In the First Stage of Labour, chloroform or the A. C. E. mixture, if required at all, should be given intermittently and in small quantities. As a rule the first stage of narcosis is deep enough. The

patient is conscious, but only slightly alive to painful sensations. If any excitement and disorderly conduct follow, the patient must be allowed to recover her self-control. Some persons need more chloroform than others, so that the administrator must decide each case upon its own merits and further must be guided by his own observations, and not influenced solely by the patient's cry of "Give me some more." Women frequently repeat this phrase when almost unconscious and unaware of preferring any request.

In the Second Stage, chloroform should be given only during the pains, and then merely to slight narcosis, since the woman needs the use of the abdominal muscles. At the stage of labour when the head is traversing the perinæum, deeper narcosis is needed to relax the soft parts, whilst at the last as the head emerges through the vulva, chloroform should be freely administered.

When Instrumental Procedure is requisite deeper narcosis is needful, and especial caution is required in order to prevent the patient being made simply excited and rigid, a condition alike dangerous to the mother and child. In this stage the anæsthetic must be pushed and true anæsthesia obtained.

Obstetric Operations.

For *Turning* and instrumental deliveries, if an anæsthetic is employed, deep anæsthesia is requisite and may either be obtained by chloroform, the A. C. E. mixture or ether. The London Committee approved the first named, but mainly on account of the greater

ease with which it was then exhibited. Since our modern appliances for giving ether are so improved this reason can have no weight. In deep narcosis from chloroform the parturient is placed in the same danger as for any surgical operation. It is sometimes urged against ether that it does not relax the uterine tissue so effectually as chloroform. If this objection is valid it tells also the other way, as hæmorrhage would under such circumstances be less likely to be severe. The ether effect passes off more rapidly.

The **A. C. E.** mixture is largely used in operative obstetric practice and answers remarkably well. It is best given in Junker's inhaler or from Krohne's cone.

For extraction by forceps narcosis sufficiently deep to keep the patient quiet is needed.

Craniotomy.—The narcosis must be deep.

Hour-glass contraction.—Retained placenta. Here complete relaxation is necessary and so the anæsthetic must be pushed.

Puerperal convulsions.—Chloroform is indicated in all cases of convulsions associated with labour. It is, however, contra-indicated in apoplectic seizures.

After Effects.

Vomiting is rare; faintness, excitement, headache have sometimes been manifested, but as a rule few unpleasant results follow the use of chloroform for childbirth.

CHAPTER IX.

Anæsthetics in Special Surgery.

Brain Surgery.—The method which answers best when the brain itself is made the subject of operation, is to administer a dose of morphine, beneath the skin, either one quarter of an hour before the operation, and subsequently to administer chloroform, or to inject the morphine as soon as the chloroform has deadened the patient's sensibility. It is necessary to get the patient completely anæsthetised, but when once this is achieved very little more chloroform is needed.* Ether produces too much vascular excitement in the meninges and brain substance, and so is contra-indicated in these cases.

Anæsthetics in Ophthalmic Practice.

Since the introduction of cocaine, many operations about the eye are performed without the employment of general anæsthesia. The extreme steadiness and immobility needful in these delicate operations require very deep narcosis, and so it is the administrator's duty to push whatever vapour he is using until profound narcosis is obtained. The operator must not be allowed

* I am indebted to my friend and colleague Mr. Victor Horsley, F.R.S., for this method in Brain Surgery; I have employed it for these cases with great success.

to commence his manipulation until the patient is not only absolutely unconscious and flaccid, but shows not the slightest inclination to cough, vomit, or struggle. It must be kept in constant remembrance, that the very salvation of the eye depends upon the unflinching immobility of the person of the patient. The nature of the anæsthetic used is of less importance than is the way in which it is employed.

Anæsthesia for Operations about the Mouth, Jaws, and Respiratory Tract.

Chloroform is preferred (1) because under its use the narcosis is deeper and more prolonged; (2) its vapour is not easily ignited; (3) it can be conveniently given through the nose and so can be given without being an inconvenience to the operator.

In the removal of sequestra from the jaws, excision of epulides, tapping antral abscess, etc., no very deep narcosis is requisite and the patient may be kept sufficiently quiet by the use of chloroform given by the open method.

During the removal of the upper jaw, the patient must be kept deeply under the anæsthetic for the skin incisions, and this may be done by first narcotising by the open method and by subsequently keeping up the supply of chloroform through a tube introduced into the free nostril and fed with chloroformised air from a modified Junker. When the skin flaps and soft parts are freely divided and dissected up, the patient must be allowed to recover sufficiently to cough and so prevent blood entering the larynx, al-

though he must be sufficiently anæsthetic not to struggle. The management of these cases needs constant care and some judgment. The dangers the chloroformist has to guard against are—entrance of blood, teeth, portions of growth, spicules of bone, etc., into the larynx; the patient passing into the second stage of chloroformisation and growing restive, excited and so violent as to interrupt the progress of the anæsthetic. He should see that the hæmorrhage is directed out of the mouth, that the tongue is not allowed to fall back, that the air enters and leaves the glottis freely. If the patient's respiration is embarassed from entrance of blood into the air passages, the tongue must be drawn right out of the mouth, all blood mopped away, and failing relief from this, laryngotomy must be performed and the tube sucked free from clots, etc. Inversion may be needed.

Removal of the lower jaw may often be done almost completely while the patient is under ether, chloroform being administered only just at last when in the course of the operation the mouth is opened. This is an admirable method.

In excision of the tongue.—Chloroform administered through a nasal tube should be relied upon and much the same precautions with regard to hæmorrhage taken, as in anæsthetising for removal of the jaws. When much hæmorrhage occurs, the patient must be guarded from deep narcosis. By the use of Dr. F. Hewitt's gag, p. 114, the nasal tube can be dispensed with.

Staphyloraphy is best performed under chloroform, which is preferably administered through the nostril. Care must be taken that the nasal tube does not get into

the operator's way, and to avoid this possibility, a flexible catheter should be used. The hæmorrhage being, as a rule, slight and easily controlled, there is no particular fear of blood trickling down the trachea, and further, as quietness is very desirable in the patient, full surgical narcosis should be maintained. However, with careful management and with frequent interruption of the operation, ether or the A. C. E. mixture may be used. Warrington Haward, to whose powerful advocacy the ether propaganda owes so much, speaks highly of ether in staphyloraphy.

Operations on the respiratory tract, laryngotomy or tracheotomy is usually performed when the patient is under chloroform as the rapid movements under ether interfere with the surgeon.

Excision of the larynx, thyrotomy requiring a preliminary tracheotomy, may be performed, chloroform being given by sprinkling it on a flannel stretched across a funnel, connected with a Hahn's tube, or by directing a catheter over the outlet of the Hahn's tube, and pumping through it chloroformed air from a Junker's inhaler. An alternative is given below.

Rectal Etherisation in Oral Surgery.

My experience of this method is so far so favourable that I should say for removal of the tongue, the jaws, and for staphyloraphy, especially for excision of the larynx, the rectal etherisation is far more convenient for the operator, and more effectual in the anæsthesia it produces than the plans named above in which chloroform is used. The operation can be proceeded

with without a break, and the after-effects to the patients appear as a rule to be less troublesome and less lasting than when the anæsthetic is given by the air passages. In cases in which much blood is likely to be thrown into the buccal cavity, careful watch will have to be taken that it is efficiently sponged out, and does not enter the windpipe. If the anæsthetist is engaged in watching the apparatus at the foot of the operating table, another observer should be stationed at the head to watch this point closely.

In all these cases the inverted posture of Langenbeck may be usefully employed. The method, however, admirable as it is, is certainly not free from dangers peculiar to itself.

Removal of Post-Nasal Adenoids.

Growths in the post-nasal region, when removed through the mouth, give rise to troublesome bleeding. Chloroform, preferred by many surgeons, possesses the disadvantage that the patient remains longer under its influence, and so it is less easy to avoid blood entering the air passages. The additional time is by some deemed an advantage, as it permits of longer manipulation in the mouth. I have found that when it is undesirable to use chloroform, the A. C. E. mixture in succession to gas answers fairly well in these cases. It does not excite as much hæmorrhage as ether, and the patient can, if necessary, be again and again anæsthetised, after emptying his mouth of blood, until the operation is complete. By this method there is not much fear of blood being sucked into the larynx.

Ether possesses the disadvantage of producing much congestion, and so increases to an annoying degree the hæmorrhage incident upon operations for the removal of post nasal growths. Still, if properly managed, ether answers very well for these cases. Of course where the cautery is used in the nasal passages, ether must not be used.

Anæsthetics in Dental Surgery.

The operations for which an anæsthetic is usually needed are :—

Extraction of teeth.

Lancing the gums, and tapping the antrum.

Extirpation of the dental pulp.

Filling when the dentine is abnormally sensitive.

In tooth extraction, nitrous oxide gas—alone, or with ether after the manner introduced and advocated by Clover—is the safest and most convenient anæsthetic.

The administrator stands to the left side of the patient and carefully fixes his prop (gag)* either on the side opposite that from which the teeth are to be drawn, or between the central incisors—thus allowing room on each side. The patient is then anæsthetised (see section "Nitrous Oxide"), and when quite unconscious, the face-piece is withdrawn, and the patient's head steadied and moved into the most convenient posture for the dentist. Care has to be taken that the tooth, or a fragment from a broken forceps, does not fall back into the larynx, and that the tongue is not pushed back by the operator and the patient's breathing impeded.

* In this case great care must be taken to avoid the teeth being loosened or forced out of their sockets by the prop.

As a rule, it is inadvisable to administer gas twice to the same patient at one sitting, but if such a thing is done warning of probable after-headache should be given.

Where prolonged anæsthesia is required, ether may be given, and the ordinary precautions taken as for etherisation in general surgery. Chloroform should never be given to a patient sitting upright in a dental chair. If it is deemed wise to employ that agent, the patient should be seen at his own home, and in bed, and the anæsthetic administered with the usual caution.

For special dangers of anæsthetics in dental surgery see Nitrous Oxide, under accident, p. 57, and Accidents of Anæsthesia, Chap. X.

Thoracic Surgery.

In the surgical treatment of empyema some difficulty frequently arises in the choice of the anæsthetic. Chloroform has in a good many instances caused dangerous and even fatal results from syncope, while ether sets up severe cough and respiratory distress. The A. C. E. mixture when it can be borne answers well, but must be given in a very dilute vapour; even then it is liable to provoke distressing cough. This state of things is rendered worse by the lateral posture which the exigencies of the operation may require. It is sometimes a good plan in very severe cases, *i.e.*, when grave fears exist, owing to the condition of the heart and lungs, to push the anæsthetic to only the first stage, as far as possible maintaining a state of analgesia, and always stopping short of true anæsthesia. To combat these difficulties I have employed the method of rectal

etherisation (q. v.) in thoracic surgery and have been pleased with the results especially in the case of children. When the empyema communicates with a bronchus great care must be taken that the patient does not become sufficiently deeply narcotised to hinder free coughing up of the pus in his lungs. Any tendency to cyanosis should be accepted as a signal to lessen the depth of the narcosis, and provided care has been taken in the initial etherisation this is easily effected in the rectal method.

Anæsthesia in Abdominal Surgery.

Complete relaxation of the recti and other abdominal muscles is imperative; great quietude and freedom from hurried respiration, coughing, and vomiting, are also necessary for operations upon the abdominal parietes or viscera. To ensure these points, chloroform, the A. C. E. mixture, or methylene, are most suitable. During the incision through the parietes, the patient must be kept fully under the anæsthetic, subsequently a lesser degree of narcotism is needed until the final skin sutures are put in, when deeper anæsthesia will again be requisite. Great care must be taken, however, that the patient is not allowed to recover sufficiently for the supervention of vomiting. In cases in which a large tumour or collection of fluid or gas is removed from the abdomen, and the heart—previously displaced—is allowed suddenly to right itself, there is especial danger of syncope, and precaution against this must be taken.

Rectal Surgery.

All operations about the anus and rectum are not only very painful, but excite reflex straining and spasm. In anæsthetising for such operations, profound narcosis is needful. The combination of gas and ether in most cases answers well, although it is necessary to give enough ether to induce absolute muscular flaccidity, snoring respiration, and widely dilated pupils—and further, to maintain deep narcosis to the end of the operation.

CHAPTER X.

The Accidents of Anæsthesia, and How to Treat Them.

I. Those connected with Respiration.

Foreign bodies may become loose in the mouth, and either get sucked into the larynx and thence enter the trachea, or become impacted, and set up laryngeal spasm.

False teeth.—Small plates are especially dangerous, whilst obturators and pivots may also become sources of peril. During operation, teeth or pieces chipped off teeth may fall back, and even portions of epitheliomatous or other growth, blood clot, vomited undigested solid food, gags, portions of snapped off forceps, and bits of sponge, may obstruct breathing. When the tongue is partially removed, the stump is liable to fall back and cover the glottis, and similarly after removal of a portion of the lower jaw, the whole tongue may be carried back by its own weight. This may also occur in deep narcosis, even when the jaw is intact. The finger inserted in the mouth during tooth extraction, often pushes the tongue right back, and unless this is noticed and remedied, complete occlusion of the air-way occurs.

Precautions.—Remove all loose bodies from the mouth before operation. Let the patient avoid any solid food on the day of operation. Never operate

again until the first tooth extracted is known to be *out of the mouth;* and be careful that the forceps are freed from the tooth just removed, before employing it again. Gags and sponges must be securely tied to a long string. When possible, the head should be placed on its side, to obviate the effect of the weight of the tongue in carrying it back, and also to facilitate the expulsion of blood. Sometimes a Carter's oral spoon held in the mouth during tooth extraction prevents teeth flying back and being drawn into the larynx.

Vomited matters.—When through the exigencies of the case or through inadvertence, food has been taken within a few hours of the administration of an anæsthetic vomiting is pretty sure to occur, either when the operation is proceeding or as the patient is commencing to regain consciousness. There is great danger lest vomited matters be drawn back into the larynx, leading to asphyxia.*

Respiration may also be **hampered** by the posture of the patient, by pressure upon his chest from instruments, assistants leaning upon him, or by tight bandaging. When placed prone or upon the side, feeble people, those who are fat or emphysematous, or who

* The following case illustrates this danger. A hospital patient requiring a minor operation was instructed to abstain from food and present himself in the evening for the house surgeon to operate. The operation was performed—the patient being skilfully anæsthetised by a resident, but during recovery he vomited, and large masses of undigested meat were taken from the mouth. Asphyxia being imminent laryngotomy was performed, but the patient died, and the necropsy showed a mass of meat had entered the trachea, and lay at its bifurcation occluding the bronchi. It transpired the man had in spite of explicit directions to the contrary partaken of a heavy meat dinner just before coming to the hospital.

have fluid in their chests—one lung being more or less hampered, must be carefully watched, as the mechanical interference with breathing in these cases has caused fatal accidents.

All general anæsthetics eventually **paralyse** the **respiratory centre** in the medulla oblongata, and so cause cessation of breathing; but some act more rapidly, and provoke spasm of the glottis by the impact of their too strong and pungent vapour upon its delicate mucous membrane. In this way no air enters the lungs, although irregular thoracic movements persist. Spasm of the larynx certainly may occur from ether or chloroform vapour, and, it is stated, from nitrous oxide gas. As a rule the spasm passes rapidly off, being relieved by the admission of air, but it may be sufficiently severe to need laryngotomy. Chloroform also acts upon the larynx in another way whereby the air-passage becomes occluded; namely, by the closure of the arytæno-epiglottidean folds. In this case respiratory movements persist although no air enters the chest.

Patients may be actually asphyxiated by the administrator excluding all air; and this may occur with any inhaler unless care is taken and the colour of the face watched.

Treatment.—The foreign body, if still free in the mouth, should be dislodged by bending the head forward and sweeping the buccal and pharyngeal cavities with the finger. The tongue should not be pulled forward, otherwise the tooth, or whatever it is, will enter the trachea. Should the finger feel the body fixed, its removal must be attempted with œsophageal forceps or with a snare. A slap on the back often

helps the expulsion of the offending substance. Inversion should also be practised, although if the body has already passed the larynx there is danger of its impaction in it giving rise to spasm. Should this occur, or should suffocation be imminent from other reasons, the windpipe must at once be opened as follows :—

The operator feels with his finger for the cricoid cartilage, and makes his incision through the skin and subcutaneous structures for a distance of two and a half inches vertically downwards making the cricoid cartilage the centre of this incision. The assistant draws open the wound with blunt hooks, taking care to pull equally on the two sides, as it is all important that the surgeon should have the middle line well defined for him. Vertical incisions are then made until the deeper structures are divided. The fascia uniting the edges of the sterno-thyroid muscles has to be sought and divided. This done, some veins, the thyroid plexus, come into view, and may be held aside with hooks, but should they be large, clamp forceps may be used to secure them before section, and they can later on be tied at leisure. The isthmus of the thyroid body may present and hide the trachea, but after dividing its fascia, it can readily be hooked down out of the way. The trachea reached, it is well cleaned with a blunt director and fixed by means of a sharp hook introduced between the rings to the side of the middle line, and with its point looking upward. The trachea is then freely opened by introducing the knife *from below*, and slitting upwards two or three of the tracheal rings, even the cricoid cartilage may be divided, then the aperture held freely open by means of blunt hooks. Succussion, or better, tickling the tracheal mucous membrane with

a feather will induce violent expiratory efforts, and may provoke expulsion of the foreign body by coughing. Further measures, such as the introduction of fine forceps, snares and so forth, are matters hardly within my province to describe. The main object of tracheotomy in these cases is to ensure an air-way should the laryngeal space be closed by spasm, excited by the foreign body either impacted or coughed against it. The operation itself greatly increases a chance of the patient's coughing up the object, because the artificial opening is insensitive and offers an unobstructive outlet, whereas the sensitive larynx closes as soon as touched, and so effectually prevents the coughing out of the foreign body. After the foreign body has been removed a small dossil of wet lint should be placed over the opening.

When mechanical impediment to respiration is not due to a foreign body in the air passages, the tongue must be drawn forward with forceps, until it protrudes well out of the mouth, while at the same time the head is thrown back to straighten the respiratory tract. This treatment will usually be effectual when the tongue or larynx is the cause of non-entrance of air.

When **spasm** of the **larynx** results from administering an anæsthetic, and persists after drawing forwards the tongue and hooking up the larynx, laryngotomy must at once be performed. No formal operation is needful, the surgeon at once incising the crico-thyroid membrane and maintaining open the aperture so made. It is suggested by some that inhaling chloroform relaxes the spasm, but it is of course useless to adopt such measures if the rima is quite occluded, as no vapour will enter, and valuable time is being lost.

If, after the upper air-ways have been cleared and rendered patent by the manœuvres above cited, the breathing still remains unsatisfactory, artificial respiration must be at once practised by one of the following methods.

Sylvester's Method.*

The tongue being drawn forcibly out of the mouth, and the air-ways seen to be clear of obstruction, the head is to hang back, with the neck extended, and the tongue held firmly out of the mouth. The operator stands behind the patient and grasps the arms *near* the axillæ in such a way as to evert them and render the pectorales majores tense. He first presses the arms into the sides so as to compress the thorax and expel air, whilst at the same time an assistant should make pressure upon the abdomen to prevent the increased intra-thoracic pressure from forcing down the diaphragm. Next, he firmly drags the arms away from the sides, everting them and lifting the patient as the arms become about 45° beyond the head; finally, he carries the arms back to a line with the head. He pauses to allow air to rush freely into the lungs, and then brings the arms down to the sides as before. This process he repeats twelve or sixteen times in one minute. The way the arms are grasped is important. When they are held below the elbows, it is not possible to open out the chest as effectively as when the plan above indicated is followed.

* The method described is modified by the introduction of the essential features of the plans proposed by Pacini and Bain.

The diagrams given below illustrate this method of inducing artificial respiration.

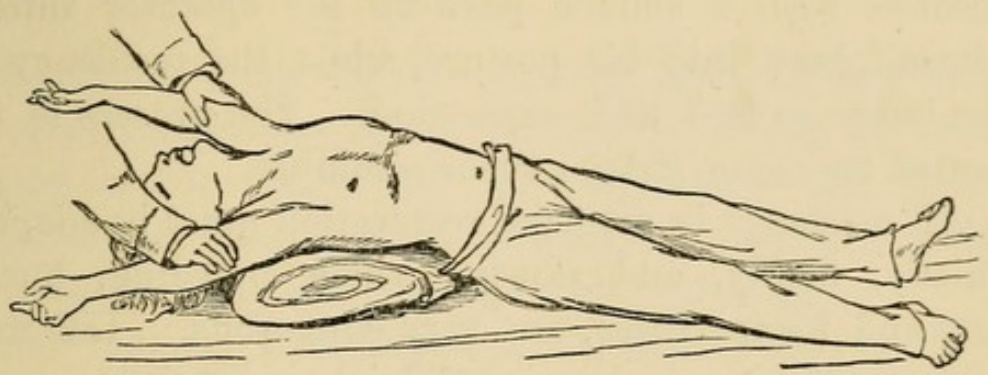

FIG. 27.—Artificial Respiration—Inspiration.

FIG. 28.—Artificial Respiration—Expiration.

HOWARD'S METHOD

Can be usefully employed, supplementally to Sylvester's. It is also of value when the patient's chest is rigid. Dr. Howard insists strongly upon the full extension of the head upon the trunk that the air-ways may be thoroughly straightened out. The patient is between the operator's knees. The latter, who faces him, applies his hands so as to grasp the free margin of the thorax, his thumbs resting upon the xyphoid cartilage. The patient's arms are drawn above his head. The operator presses upwards and inwards towards the diaphragm, gradually bending over the

patient so that all the weight of his body aids in compressing the thorax. After steady pressure for some seconds with a sudden push-up the operator throws himself back into his posture, while the resiliency of the lungs causes their expansion. The process is repeated twelve or sixteen times a minute.

All measures in artificial respiration must be adopted quietly, firmly, and slowly; since crowding, hurry, fuss and inexpertness, are very dangerous. Life may be restored after an hour's artificial respiration.

II. Accidents connected with the Heart and Blood-Vessels.

Syncope may occur as the result of fright, or be caused by sudden impact of a strong vapour upon the air-passages. This occurs in the early stages of the administration, and is shown by pallor of countenance and failure of pulse.

Treatment.—The patient should at once be placed supine, the legs and arms raised, and the head dropped below the level of the trunk; all clothing loosened; smelling salts, liq. ammoniæ fort. (with caution), or burnt feathers be put to the nostrils; and the præcordium rubbed with a warm hand. Sulphuric ether may be hypodermically injected over the heart, and nitrite of amyl capsules be smashed and the patient made to inhale the vapour. If the breathing flag, artificial respiration must be at once practised. An enema of brandy—℥ ss. in ℥ ii. of warm beef-tea or gruel or starch—may be tried. When the patient has recovered sufficiently to swallow, hot strong coffee with a teaspoonful of Cognac should be given. The most stringent

injunctions must be laid down that the horizontal posture be maintained until the heart has quite recovered itself.

Syncope from shock occurring later on may arise from prolonged operation, or loss of blood, or overtaxing of the heart due to respiratory difficulties. Chloroform, given over a lengthened period, also depresses the heart and may determine syncope.

The TREATMENT rehearsed above applies also to these cases; in them it is usually more common to find a *gradual heart-failure* occurring, and giving warning of trouble. Respiration also is especially liable to flag at the same time as the heart fails. It is especially necessary to have resort to artificial respiration early, both on these accounts and because that measure even by itself will frequently steady the heart and restore its rhythm. In all syncopal attacks, while the above measures are being adopted, an assistant should pour cold water over the face and chest, and dash the latter with a towel-end, wrung out in ice-cold water.

Apoplectic seizures.—Besides ceasing from all interference and placing the patient supine, little can be done, and directions would not be in place in the present manual.

Epileptic seizures.—The patient should be laid down, his tongue be guarded from being bitten, and his clothing loosened, the only interference justified is to be directed towards restraining the patient from doing himself any injury.

Hysterical seizures should be treated in a similar way to that indicated above (epileptic seizures).

CHAPTER XI.

Local Anæsthesia.

It has been sought to obtain local anæsthesia without disturbance of the mental faculties, and this object has been consummated with partial success in three ways.

(1) By drugs painted and injected at the situation desired to be rendered anæsthetic. (2) By cold. (3) By electricity.

The most usual means of producing local anæsthesia by drugs is the use of cocaine. This, the active principle of the leaves of *Erythroxylon Coca*, a plant cultivated in Bolivia, Peru, the Andes, and Argentina, has, since 1880, come into use for producing local insensibility to pain. It is employed commonly in two ways: *a*, as a paint over mucous or cutaneous surfaces, and *b*, by subcutaneous injection.

Physical Properties, Preparations, etc.

The *Erythroxylon Coca* (cuca) leaves have been known for very many years as a stimulant, and cocaine was first isolated by Gardeke (1855) who called it erythroxyline. It was rediscovered in 1857 by S. R. Percy of New York, who, besides isolating the active principle of erythroxyline, described the property it possessed of deadening the sensibility of the tongue; Niemann in 1860 also noticed its anæsthetic properties. Lossen two years later recognised the true composition of the sub-

stance and gave it the formula $C_{17}H_{21}NO_4$. It was not until Karl Koller, in 1884, induced Dr. Brettauer to demonstrate the anæsthetic properties of the hydrochlorate of the alkaloid before the Ophthalmological Congress meeting in Heidelberg that it became generally recognised as a local analgesic.

The alkaloid cocaine ($C_{17}H_{21}NO_4$) has a bitter taste; forms crystals; is with difficulty soluble in water (1 in 700 or more), more so in alcohol (1 in 20), freely so in chloroform or ether, also in melted vaseline, castor oil, &c. Pure cocaine, or the hydrochlorate, gives no coloration, or a very faint evanescent yellow one, with concentrated cold sulphuric acid. It may readily be recognised by its crystals, which are colourless monoclinic prisms. Cocaine readily undergoes chemical changes in its composition, so that solutions for use should be made fresh as required. With benzoic, citric, hydrobromic, sulphuric, tannic, oleic, and hydrochloric acids, cocaine forms salts, respectively, the benzoate, citrate, hydrobromate, sulphate, tannate, oleate,* hydrochlorate, of cocaine, which possess the advantage of being easily soluble in water, and so readily employed for hypodermic injection. Aqueous solutions of these salts should not be kept any length of time, as they are liable to become contaminated by the growth of a fungus which occasions deleterious effects upon the patient. The addition of boric acid, carbolic acid, or chloroform has been suggested to prevent such fungoid growth, but these cannot be relied upon to promote the object in view.

Cocaine acts as a general anæsthetic when so overwhelming a dose is taken as to bring the animal taking

* A saturated solution of cocaine in oleic acid.

it to the point of death. Its true action is that of an analgesic and this is due not to the vaso-motor constriction which it establishes, but to its influence upon the sensory nerve endings. If an area is rendered anæmic and analgesic by cocaine, the subsequent injection of pilocarpine will abrogate the anæmia while the analgesia remains unaffected. Arloing has shown the same thing by dividing the sympathetic of a rabbit on one side, the animal having been previously cocainised, hypervascularity could thus be seen to exist simultaneously with analgesia.

The HYDROCHLORATE is the salt which in solution is most commonly used; it forms acicular or lamellar crystals. It is soluble in half its weight of water, but freely taken up by glycerine or spirit, and unlike cocaine is insoluble in ether or fats. It is liable to grow fungi. The proposed addition of boric or other antiseptics seems, as in the case of cocaine itself, useless as a means of checking the production of fungus.

PHYSIOLOGICAL ACTION OF COCAINE UPON THE HEART AND BLOOD VESSELS.

It is a much disputed point what action cocaine exercises upon the lowest organisms, ferments, infusoria, &c., but it would seem to behave as a true anæsthetic, producing temporary arrest of function in plants and arrest of movement in the lower forms of animal existence without destroying life; if, of course, the dose employed be not excessive (Charpentier).

In **cold-blooded** animals cocaine, whether applied to the heart itself, circulated through the detached

ventricle, or injected into the circulation, slows the rhythm, and depresses the beat, finally arresting the heart in diastole. Its depressant action upon the heart is shown by the accompanying cardiogram (Fig. 27). It was taken while the detached heart of a frog was perfused with a competent fluid containing cocaine (1 in 2000) in a Roy's tonometer.

Cocaine also interferes with cardiac innervation, decreasing in a very marked degree the excitability, for while it abolishes "make" contractions, "break" contractions persist. Although both auricles and ventricles are influenced, the latter are more interfered with, and cease to beat before auricular rhythm is arrested (Van Anrep).

The blood-vessels are but little, if at all, affected by cocaine unless it be applied locally as a paint, and in this case it is doubtful how far the action is really characteristic of the drug.

In **warm-blooded** animals, an initial increase in rapidity of the heart's beat occurs, the heart's action is weakened, but usually recovers and is said to survive the cessation of respiration (Van Anrep). Vagal inhibition is also much depressed and even lost; blood pressure is greatly lowered, though this is preceded by an initial and transient increase of pressure.

Cocaine does, however, produce a very marked depressing action upon the human heart. Many persons after even small doses become pallid and complain of extreme faintness, while the heart's action grows weak and irregular, the radial pulse becoming almost indistinguishable. Blood pressure is at first lowered but subsequently increased. Cocaine in large doses (and we must remember that what constitutes a large dose

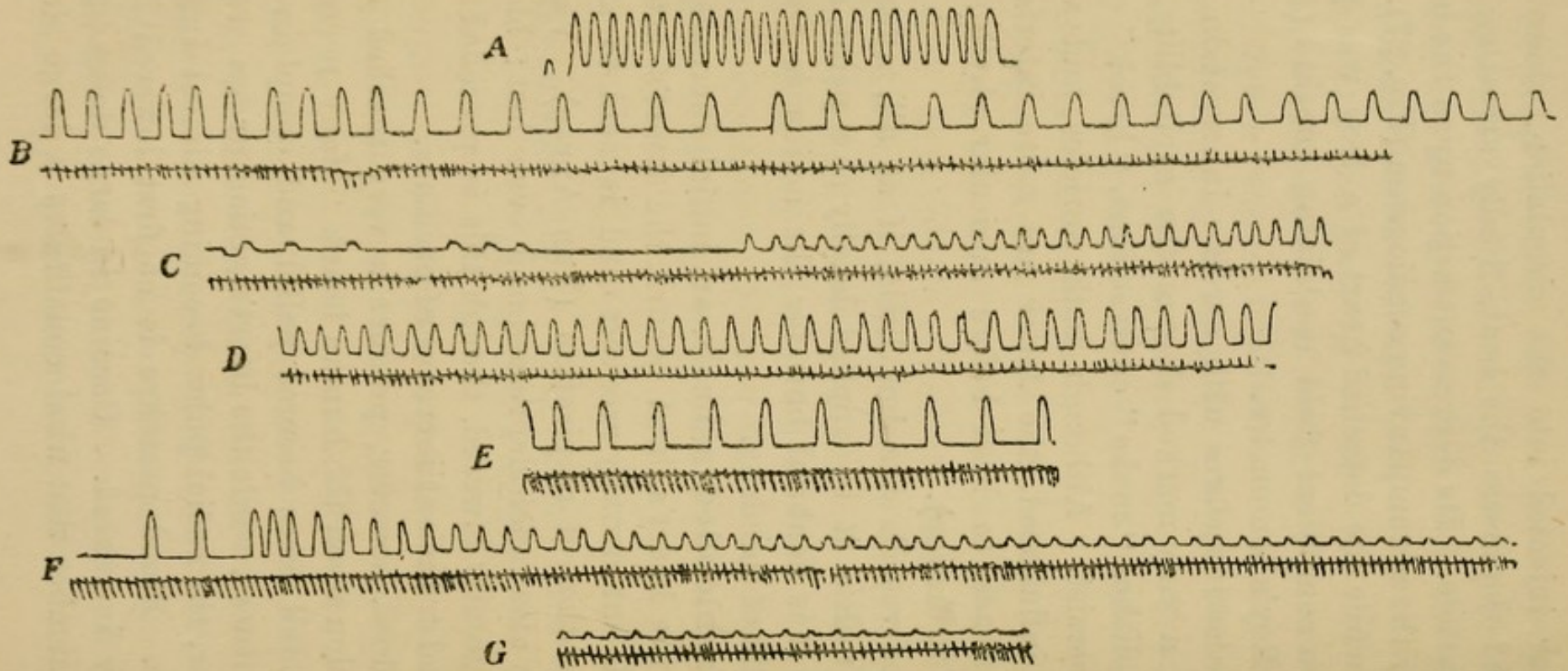

FIG. 29.—Cardiograms of frog's heart (effect of cocaine). A. Normal trace. B. After addition of cocaine. C. Cocaine removed, nutrient fluid recirculated. D. E. Recovery to normal. F. Cocaine again circulated. G. Extreme heart failure, no recovery.

varies greatly among different individuals) renders respirations more rapid, irregular and shallow, and finally will asphyxiate by stopping respiration altogether. In human beings, marked dyspnœa and breathlessness may follow its use.

Convulsions and epileptiform seizures, due, it is said (Durdufi), to vasomotor irritation producing anæmia of the brain, occur after toxic doses. Death, according to Mosso, occurs from tetanic contraction of the diaphragm.

The nervous system is much affected by cocaine. The peripheral nerves of sense become anæsthetic over the area into which cocaine has been injected, the anæsthesia extending just so far as the drug traverses the tissues. Dastre very aptly terms cocaine the "curare" of the sense nerves. Painting over the skin may, if it be sufficiently thin to permit of absorption, lead to a like result but in lesser degree, since but slight absorption occurs by cutaneous surfaces. The motor nerves are usually only affected by large doses, but in some persons comparatively small doses have induced paresis or paralysis lasting for hours or even days. Ptyalism occurs leading to dryness of the mouth and fauces. Peristalsis is increased and vomiting and borborygmi follow its use. The other secretions of the alimentary tract are lessened. The urea and phosphoric acid excretion is increased by it (Fleischer). Cocaine increases destruction of tissue and by a constant repetition of this process leads finally to physiological ruin. Mydriasis and proptosis are usual among warm-blooded animals. Upon warm-blooded animals cocaine produces great hyperexcitation of the muscular system and marked agi-

tation, a large dose may at first simulate strychnine in its action, causing muscular tremblings, convulsive movements and spasms.

Although the mind at first will remain clear, there is usually a tendency to garrulity, followed by great anxiety and feelings of unaccountable distress. Languor, muscular weakness, and lassitude, will then take possession of the patient, who becomes haunted by most fantastic hallucinations. Some persons simply experience slight elation, or it may be drowsiness, but loquacity is the most usual symptom.

Cocaine would appear to produce an hyperexcitability of the spinal cord evincing itself in muscular tremblings and twitchings (Dastre); a similar condition of the medulla accounts for the vaso-motor and respiratory disturbance, while (Richet) an increased excitability in the cortex brings about convulsions, &c. In fine the effect on the nervous system may be summed up in the words of Dastre, who says that while the drug paralyses the terminations of the sensory nerves, it excites all other parts—nerve trunks, spinal cord, medulla, encephalon and sympathetic chain.

Cocaine produces at first a slight rise in body temperature.

It is eliminated by the kidneys, and often produces albuminuria or glycosuria, accounted for by Van Anrep as the result of the partial paralysis of respiration, which the drug occasions.

No attempt has been made to describe at all fully the symptoms which characterise poisoning by cocaine. These are bizarre to a degree, and may be grouped as (1) more or less heart failure with a remarkable lowering of blood pressure, paling of the skin and mucous

membranes; (2) great dyspnœic distress from failure of respiration; (3) impairment of mental faculties and even unconsciousness, or in some cases catalepsy. Convulsions may occur, or a loss of movement in various groups of muscles. While such symptoms usually occur only after the injection of a considerable dose of cocaine, they may follow the use of quite a small quantity. Retention of urine, protracted insomnia, and prolonged anorexia are also recorded (Kümmer).

Methods of Employment.

1. Instillation into the eye.
2. Painting over mucous surfaces.
3. Subcutaneous injections.

Whatever method be adopted, it should be remembered that a dose of one grain will in a large number of persons produce unpleasant if not dangerous symptoms, half a grain is a safer dose, though even this may in many people give rise to trouble.

As a paint, 20 per cent. solution is used, weaker preparations being of little value over cutaneous surfaces. Several coats are necessary, and even then as a rule anæsthesia will not extend much deeper than the true skin.

When employed for mucous surfaces, especially if there be any likelihood that some of the solution may be swallowed, a dilution to 10 per cent. should be adopted. In laryngoscopic examination Semon uses a 20 per cent. solution, painting the pharynx with it, and this he finds will enable the patient to submit tranquilly to prolonged and painful laryngoscopy.

In ophthalmic practice it is well to instil a few drops

of a 4 per cent. solution into the conjunctiva, repeating the instillation two or three times at brief intervals, and then waiting from five to ten minutes before operating. If the manipulation takes long, it will be necessary to repeat the process from time to time.

Cocaine is also employed as a spray in an atomiser, a 4 per cent. solution being used.

Most marked effects, both local and constitutional, follow the use of cocaine when injected hypodermically. Used in this way, its action is more rapid and more persistent than when applied as a paint or an ointment. A 10 or 20 per cent. solution is usually employed, and from 2 to 5 minims injected at the site of operation. As the effect may pass off before surgical interference has been completed, it will often be necessary to inject a second or third dose during the operation. Great care must be taken to avoid the injection entering a vein, as it is probable that many of the deaths following the use of cocaine have resulted from this accident. From five to ten minutes must be allowed to elapse after injection before the knife is inserted.

Another and useful method of administration suitable for eye work is the placing of an easily soluble cocaine tablet (B.P., 1885) in the oculo-facial fold of the conjunctiva.

A convenient and very admirable means of using cocaine for a throat spray is the atomiser figured below, invented by W. J. Miller.

Dr. Leonard Corning, of New York, proposes yet another method of using cocaine. He first marks out with crayon the superficial veins, to obviate a possibility of puncturing them, and next exsanguinates the limb with an elastic bandage and Esmarch's cord. He

then injects superficially three to five drops of a 1 or 2 per cent. solution of cocaine hydrochlorate immediately above the cord. After waiting until the skin is anæsthetic, he injects the deeper tissues with a solution of the same strength, making twenty or more punctures according to the area to be rendered insensitive. Dr. Corning then applies a tourniquet at the upper limit of the anæsthetic zone, and after a few minutes operates.

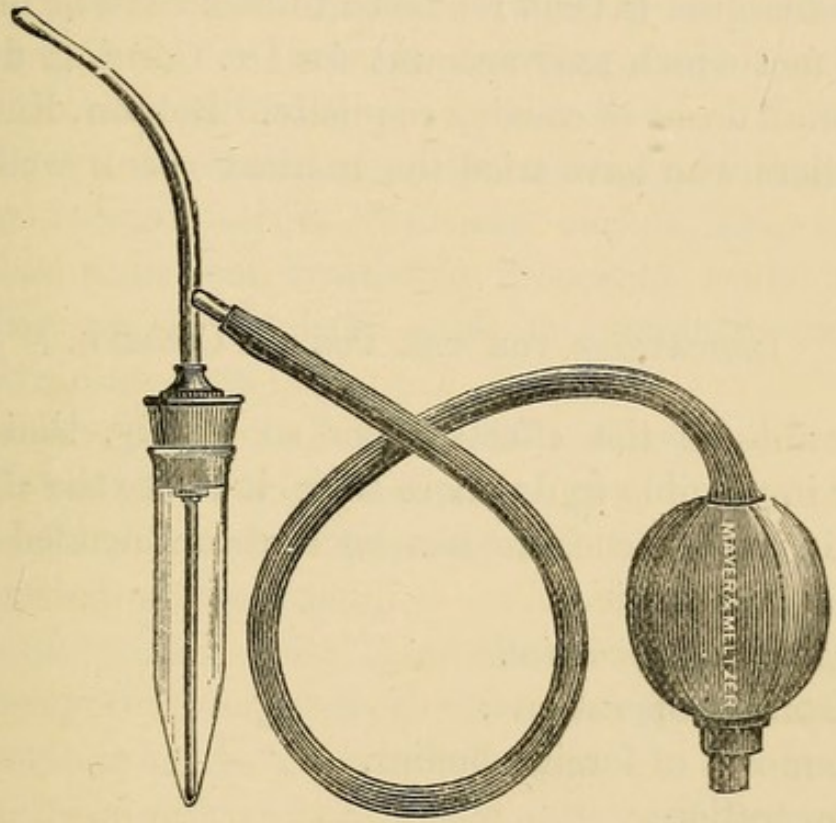

Fig. 30.—Miller's Atomiser.

This elaborate procedure is based upon the theory that by checking the venous return, he prevents a deportation of the anæsthetic from the area of injection, while dilution of the drug by blood is also lessened.

In other words it is assumed that cocaine, instead of being rapidly absorbed into the circulation, is by this method able slowly to permeate the tissues and exert its paralysing action upon the peripheral nerve endings.

Dr. Corning also employs specially constructed rings and hæmostatic clamps, to effect the same "incarceration of the anæsthetic." The method may prove serviceable when cocaine is used, but, as we have indicated, the employment of frequent and numerous injections of the drug are not devoid of danger. In estimating the value of this theory also, due regard must be had to the consideration that a limb surrounded by tight cords or a tourniquet is thus rendered to some extent insensitive, a fact which may account for Dr. Corning finding only small doses of cocaine requisite. Robson, Kümmer and others who have tried the method speak well of it.

Indications for the use of Cocaine.

Accounts of the effects differ so widely, that it is wholly impossible to do more than indicate the class of cases in which cocaine has been recommended as an efficient anæsthetic.

In ophthalmic practice.

Cataract operations.
Removal of foreign bodies.
Laceration.
Iridectomy.
Iridodesis.
Sclerotomy.
Slitting up the canaliculi.

To this list some surgeons add tenotomy for strabismus, and extirpation of the eyeball.

Many minor eye operations have been purposely omitted. Even in the above named cases, cocaine must not be too implicitly trusted, for it fails with

some individuals, and no means exist which enable us to determine beforehand when it will succeed or fail. Panophthalmitis has followed its use for eye operations. When employed for extirpation of the globe or tenotomy, instillation is not sufficient, and subconjunctival injection is necessary. In many cases patients complain that the division of the deeper structures causes much pain in spite of cocaine. The presence of glaucoma is a contra-indication to the use of cocaine, indeed according to Javal its constant use may cause a glaucomatous condition.

Although advocated for operations undertaken to remove foreign bodies from the cornea, &c., cocaine possesses a serious drawback, inasmuch as it induces flaccidity of the eyeball, and so seriously impedes operative measures.

Operations about the Larynx, Pharynx, etc.—

Ulceration of epiglottis, scraping.

Removal of polyps from larynx.

Cutting off the uvula.

Catheterising of the Eustachian tubes.

Removal of polyps from the nose or ear.

Cauterising the nasal meatuses.

Excision of the Tongue has been attempted, but without uniform success.

Abscesses, boils, and carbuncles may be opened, and many of the small operations classed under minor surgery performed, after the injection of cocaine.

Operation on the Urino-generative Tract.—The injection of a few drops of a two per cent. solution into the urethra is said to render catheterisation painless, but this is only true when no stricture exists. In like manner the operations of lithotrity and litholapaxy may

be undertaken after an injection of cocaine, a stronger solution (five per cent.) in these cases will better answer the purpose.

In Dental Surgery.

The adjustment of clamps and separators.

The introduction of wedges.

The application of ligatures for the rubber.

The manipulation of deep cervical edges of cavities, whether for excavating, filling, trimming or polishing.

The removal of tartar in pyorrhœa alveolaris.

The modelling of sensitive and irritable mucous membranes. For this purpose a paint of a 10 per cent. solution is used, or a spray of 2 or 4 per cent. according to the degree of sensibility manifested by the parts.

For lancing and excising gum-tissue.

For the relief of pain after extraction, though cocaine is usually inadequate to accomplish this.

For anæsthetising pulps before extirpation.

For obtunding sensitive dentine (results are not upon the whole satisfactory).

Many observers have come to the conclusion that cocaine is a failure when employed to effect painless tooth extraction ; small doses are inadequate, and larger ones too frequently give rise to constitutional derangement, which is always prejudicial and often alarming. As a rule, a grain is needed to anæsthetise sufficiently to permit of extraction, and ten minutes must be allowed to elapse before applying the forceps. Many patients are greatly terrified by the pricking of the hypodermic syringe. It is best to inject by three punctures, one on the lingual, and two on the labial aspect

of the tooth. One of these being before, and one behind the prominent ridge on the buccal alveolus, they will correspond to the roots of the tooth to be extracted.

Messrs. Cunningham and Hern (*Odont. Trans.*, vol. xix.) have published some carefully noted cases in which cocaine used for dental purposes has given rise to very unsatisfactory if not alarming results.

Major Operations.

A few surgeons have undertaken section of bones, clamping of hæmorrhoids, circumcision, &c., but the successes recorded are not such as to justify the use of cocaine in these operations, unless under most exceptional circumstances. In all these cases, repeated and large doses of cocaine have to be injected, and therefore we cannot be sure that most disastrous constitutional effects may not follow. We have moreover to remember, that a conscious patient is always more or less a terrified one, and so not in a favourable frame of mind for surgical proceedings.

Accidents and After-Effects attending the use of Cocaine, with their Treatment.

Severe headache, palpitation, failure of the heart, with repeated attacks of fainting, præcordial pain, and sensation of stifling, and inability to obtain sufficient air, may be experienced even after small doses.

Tingling, formication, muscular weakness, vertigo, and muscular inco-ordination, cold sweats, utter pros-

tration, and extreme drowsiness, are also not uncommon symptoms. Muscular movements almost amounting to convulsions may occur, and in some persons persistent pendulous oscillations of the head follow the use of cocaine, greatly disturbing the operations (dental), which it was sought to achieve.

Nausea and vomiting sometimes occur, together with cramping pains in the abdomen.

These untoward symptoms may last several hours, or pass off in less than one; they may be slight, or so serious as to cause the greatest alarm.

The most usual *after-effects* are persistent nausea, headache, anorexia, sleeplessness, derangement of digestion, and great mental depression.

Treatment.—A careful watch being kept over the patient, any signs of heart failure or insufficient respiration must be at once treated. The patient is to be placed on his back, his arms and legs raised, his head hanging below the level of his body, and all clothing loosened about the neck, chest, and waist, while cold air is admitted. If he can swallow, a teaspoonful of sal volatile in half a wineglass of water should be given in sips. Strong smelling salts should be sniffed, the præcordium and front of the chest dashed with a wet cold towel, and sinapisms put to the calves of the legs and nape of the neck. If he cannot swallow, brandy should be rubbed with a finger over the tongue, the inside of lips and mouth. Subsequently, small doses—half a teaspoonful of brandy—should be given every ten minutes until pallor disappears. Nitrite of amyl in capsules, or three drops on a handkerchief, may be held to the nose.

Warm tea and hot coffee give a patient comfort after

the syncope has passed off, and will also relieve headache.

As a rule, absolute quiet in the prone position, with sal volatile, will bring a patient round without the aid of alcoholic stimulants and the more heroic treatment detailed above.

Should respiration become greatly hampered, artificial means should be at once adopted to maintain breathing.

Cocaine has no distinct *antidote*, although marked physiological antagonism exists between this substance and morphine. Skinner has suggested the use of atropine, Mosso that of chloral, to counteract the convulsive properties of cocaine.

Several fatal cases of cocaine poisoning have occurred. In the case of Professor Colomnine's patient 23 gr. proved fatal, this dose having been injected into the rectum in order to allow of scraping an ulcer. In another case death resulted from ʒ j. of a 20 per. cent. solution introduced into the urethra as a preliminary to internal urethrotomy. Swabbing out the larynx with a two per cent. solution has also proved fatal (Dr. W. H. Long quoted by Dr. J. B. Mattison). This patient was aged 33 and had nearly died previously as a result of the application of a 4 per cent. solution to his larynx. Dr. Mattison, of Brooklyn, has also reported fifty cases in which death seemed imminent, and in several cases actually followed the use of even small doses. These cases comprise those of persons for whom cocaine sprays, injections, painting of mucous surfaces, instillations in the conjunctiva, had been used, also of stuffing cocaine-moistened pledgets into carious teeth.

Brucine, and a substance called **drumine,** have

been suggested as local anæsthetics, but the former is little used, while drumine has been shown to be oxalate of lime prepared from a euphorbiaceous plant and to be devoid of anæsthetic properties.

Other Methods for producing Local Anæsthesia.

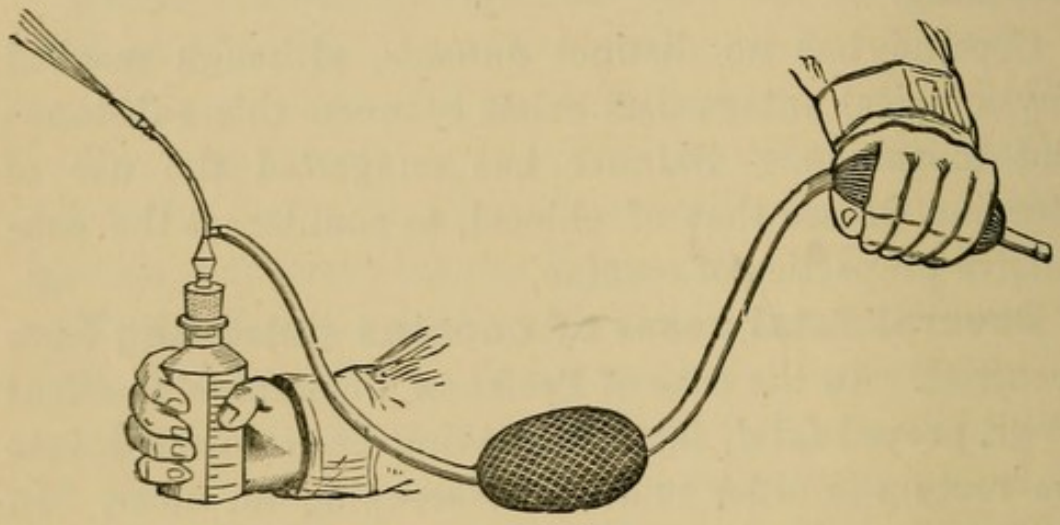

Fig. 31.—Dr. Richardson's Ether Spray.

Ether Spray (Dr. B. W. Richardson).—The woodcut explains the simple mechanism of this useful contrivance. A bottle containing specially prepared ether,* is traversed by an air current propelled by a hand ball so valved as to admit, but not allow the escape of air save by its traversing the ether. The second ball which is covered with net, acts as a reservoir. Air forced into the ether atomises it through a delicate tube, causing it to escape in a fine spray. Ether impinging upon the skin or mucous membrane causes so rapid an evaporation from its surface, that its heat is abstracted

* Richardson recommends anhydrous ether, sp. gr. 0·720, mixed with an equal part of hydride of amyl (Rhigolene).

with sufficient rapidity to numb the part, thus paralysing the terminations of the sensory nerves.

The anæsthesia is confined to the skin and is very transient. Recovery of sensation when the spray ceases to work, is often accompanied with very painful smarting and tingling. The great drawback of the method is that the instruments and skin get thickly coated with ice which obscures the parts, rendering the use of the knife almost impossible. Further, under ether spray it is difficult to see and secure blood-vessels, and painful to do this when the anæsthesia has passed off. Unless care be taken, the skin may be so much frozen that a slough like that of frost-bite will follow.

Chloride of Methyl (CH_3Cl).—Another method of rendering tissue insensitive by refrigeration is that obtained by allowing the liquid chloride of methyl to drop upon the skin or mucous membrane. It possesses a boiling point of $-23°$ C., is capable of being kept in the liquid state in metal bottles under a high pressure. There is some slight danger in using it, namely, that unless the action is kept carefully under control, and this is not easy, there may be severe injury to the vitality of the tissue subjected to its influence.

Alcohol has been used to produce local anæsthesia. It possesses the property of removing sensation to pain, while tactile sense persists. Alcohol is cooled by placing it in ice and salt, to ten degrees or so, below freezing point, and the part to be numbed is then placed in it. The use of alcohol for anæsthetic purposes is not advisable except as a make-shift.

Carbolic acid painted over the skin possesses some benumbing power, but its effect does not penetrate at all deeply, and is disadvantageous inasmuch as the tissue touched is damaged by the caustic action of the acid.

Faradic currents directed for some minutes through an area of skin or mucous membrane, are held by a few to produce anæsthesia. At one time this method was in vogue among dentists; it has now fallen into disuse. A recent attempt has been made to revive this plan, an improved apparatus being employed, but the success achieved seems to have been so slight as to make it hardly necessary to particularise its features.

Rhigolene, a product of the distillation of petroleum, was introduced by Richardson, who employed it instead of ether in his atomising spray. Rhigolene has a sp. gr. of ·625; it is one of the most volatile substances known, and so needs to be kept in strong, well-stoppered bottles.

The uses and precautions described under the head, "local anæsthesia—Ether" apply to rhigolene.

Bisulphide of carbon, although an effectual local anæsthetic, when used from a spray or by irrigation, possesses the insuperable disadvantages of having a disgusting odour and of being a potent poison.

CHAPTER XII.

Medico-Legal Aspects of the Administration of Anæsthetics.

The administration of an anæsthetic to a patient who is not a minor, against his will, constitutes an assault. When a patient has voluntarily submitted himself to be anæsthetised, he may, under the influence of terror, during an early stage of the proceedings attempt to prevent further narcosis; he is then not sufficiently guided by his reason, and the administrator is bound in the patient's interest to take his own course.

The anæsthetist, like any other medical man, is liable to prosecution for malpraxis; it then rests with him to prove that whatever steps he took were adopted after due consideration and because he believed them to be the best he could follow for the benefit of his patient. Such questions as the following might arise:—Did the anæsthetist undertake a duty which knowledge, skill, and experience had qualified him to fulfil? Did he employ the most suitable agent according to his view of the exigencies of the case? and did he administer it with due skill and after the most approved method? Did he possess himself of all necessary facts with regard to the patient's bodily condition? and did he make due allowance for these in the treatment which he pursued? And, in the event of an accident of any kind, did he adopt the right and appropriate treatment

indicated in such an emergency? and was this done with due promptitude?

Anæsthetics have been employed to assist in the perpetration of various crimes upon the person narcotised. Thus, an anæsthetic may be given, it is alleged, without the consent of a person; or when given with his or her consent to effect a lawful procedure, advantage may be taken of the anæsthetised person's helpless condition to perpetrate a crime.

Can an anæsthetic be administered without consent?

Firstly, can this be done whilst a person is awake and in full possession of his senses? Formerly many cases came into the law courts in which the complainant alleged that a handkerchief saturated with chloroform was waved before his face and unconsciousness followed *immediately*. This we now know to be an impossibility; a period of time varying from two to twelve or more minutes must elapse before an individual succumbs to chloroform, and during this time fresh supplies of the anæsthetic would be needed. Further, chloroform in most cases produces so much excitement, that one person would find it a difficult matter to keep the victim sufficiently still to complete the anæsthesia, and would hardly do so without much noise and disarrangement of the victim's clothing. Further, unless food is avoided before the anæsthetic is given, vomiting is very liable to occur, and with it a return to consciousness.

It is often alleged by the supposed victim that he, or she, was conscious of what was transpiring, but was powerless alike to speak or resist. Such statements must be received with the utmost caution. It is true that Péan records cases in which patients, though ren-

dered analgesic by ether, retained their consciousness as to what was in course of proceeding. Cases like Péan's must be so exceptional that one is tempted to believe the anæsthetic was administered very imperfectly, and that faith in the assurance of the surgeon did the rest. Snow also admits the possibility of persons imperfectly chloroformed being conscious and yet powerless to resist. In attempts at criminal violence under an anæsthetic administered without the victim's consent—fear, excitement, and struggles, would all be against the possibility of arriving at loss of voluntary power without deep narcosis. It is very doubtful whether a person, be he an expert or not, could narcotise a waking adult against his will unless there existed a very unusual disproportion between the strength of the two individuals. In the case of R. *v.* Snarey, the prosecutrix alleged that she had been rendered insensible instantly by something being held over her face upon an handkerchief, and that in that condition she had been violated. This contention could not in a present state of knowledge be admitted by experts. However, in a parallel case, that of White *v.* Howarth, the prosecutrix made a similar assertion, and added that she was aware of what was going on but was unable to resist.

Although the time required to thoroughly anæsthetise a patient is longer when chloroform is used, than when ether is employed, yet, from the highly irritating nature of ether vapour it is less easy to administer to an unwilling patient than chloroform. And further, it requires the use of some apparatus entirely excluding air, and is hence less easy to manipulate by non-experts. In general it may be affirmed, that if chloro-

form can only be used for criminal purposes with difficulty, with ether such attempts would prove still less easy.

Can a Person be Anæsthetised during Sleep?

Dolbeau made careful experiments with reference to this subject, and his conclusions are certainly consonant with the experience of most skilled anæsthetists.

He first attempted to anæsthetise four persons during sleep. Three were awakened in the process. In his second series of cases four persons out of six awakened, and in his third series only three persons awakened out of nine to whom he administered chloroform while sleeping. Dr. Turnbull asserts that either chloroform or ether may be given during sleep without awakening the subject of the experiment. I have no doubt that chloroform may in many cases be so administered, but am less sure about ether; in either case certain conditions must be present to ensure success. Only the greatest care, skill, and familiarity with the anæsthetic used would suffice, and then we must predicate the subject to be a sound sleeper. But it is highly improbable that a novice in anæsthetics would succeed in such an attempt.

A further question arises, upon which evidence may be sought, and that is whether in the event of his escaping capture, it is possible to prove the person attempting to administer an anæsthetic with criminal intent was one skilled in its use. To determine this offers some difficulties. The presence of apparatus, the method in which lint or a handkerchief is folded,

or blistering of the lips and nose from allowing the chloroform to drop upon the face, may offer a clue. If ether be employed we may be sure that the person using it possessed some knowledge, and had resort to an apparatus, since ether given by the open method seldom if ever carries the patient beyond a stage of delirious excitement producing bellicose struggles such as would effectually prevent the accomplishment of any criminal design.

Anæsthetics have been given to assist in the committal of ROBBERY, RAPE and MUTILATION. What has been said above leaves little to add with regard to robbery.

ATTEMPTED RAPE UNDER ANÆSTHETICS.

Many cases have now been reported in which the prosecutrix has affirmed that a dentist or surgeon has violated her person while she was under the influence of an anæsthetic. So frequent are such charges that the greatest care should be taken on the part of an operator in order to ensure the presence of a third person, at least within ear-shot, and preferably within sight of the administration. No administrator of an anæsthetic is safe from having such a charge preferred against him, and if he and his supposed victim are alone, it is simply a case of word against word. Further, the woman may be enceinte at the time of the alleged rape, and may subsequently give birth to an infant whose parentage she may find it convenient to fasten upon the medical man.

But it is not only designing bad women who bring such charges. Modest, virtuous, and refined gentle-

women have been prosecutrices in these cases. The cause for this remarkable and deplorable state of things is fortunately not far to seek. Chloroform, ether, nitrous oxide gas, cocaine, and possibly also the other carbon compounds employed in producing anæsthesia, possess the property of exciting sexual emotions, and in many cases produce erotic hallucinations. It is undoubted that in certain persons sexual orgasm may occur during the induction of anæsthesia. Women, especially when suffering from ovarian or uterine irritation, are prone to such hallucination, and it is almost impossible to convince them after their recovery to consciousness that the subjective sexual sensation is not of objective existence. It is stated that women at their menstrual periods are more prone to erotic hallucinations than at other times, a fact which may be borne in mind. A case cited by Dr. Richardson will illustrate this statement. A young lady had chloroform administered to her by the doctor in the presence of a dentist and of the young lady's mother and father. After the tooth had been extracted, and the patient became conscious, she steadfastly affirmed that she had been criminally assaulted by the dentist, and to this statement she adhered although the four persons present in the room strove to disabuse her mind.

In considering the evidence in such cases, the following points need especial attention :—

Nature of the anæsthetic.—Chloroform, ether, and the other members of the carbon anæsthetic series, certainly render persons wholly unable to protect themselves from any personal ill-usage. The body of the anæsthetised patient is, however, rendered utterly flaccid, and is a dead weight. If then there is any question of

moving the body, as for example, from a dental chair, and again back into the chair, it must be remembered that such an undertaking would be exceedingly difficult for one individual however strong, and could hardly be accomplished without causing much disarrangement of clothing.

On the other hand, if the offence was alleged to have been committed when the patient was under the influence of nitrous oxide gas, it would have to be borne in mind that the effect of this gas is to produce first muscular rigidity and subsequently violent jactitation. Further, unconsciousness only persists for about half a minute, or in exceptional cases a trifle longer, and the patient regains her senses with control over her muscles all at once. This being so it is exceedingly improbable that even a premeditated and skilfully planned attempt at violation would be successful if made under nitrous oxide gas.

A caution is needed about admitting the evidence of a person only just recovered from an anæsthetic. The following case illustrates this:—A dentist appealed to a friend to extract a tooth. Under gas he struggled so violently that the operation was not performed, but as he came to, he reproached his friend most bitterly, telling him he had felt the whole pain of the extraction and was even then suffering torture.

Death under an Anæsthetic.

It becomes requisite to decide whether the death was suicidal, accidental, or due to an anæsthetic given by a second person, and then whether that individual was an expert or not. Persons frequently employ chloro-

form as an anodyne, and many deaths have resulted from the stopper coming out of the bottle, the contents escaping upon the patient's pillow. The presence of a phial near the corpse might point to self-administration. Ether is not used similarly, and is not selected by suicides. One death from nitrous oxide gas is recorded from America. A dentist whilst under the influence of drink, placed himself in his chair and turning on the gas held the face-piece over his mouth and nose. In the morning he was found dead and the gasometer empty.

It is important to carefully search for evidence as to *how* the anæsthetic was administered, as this may determine whether it was done *secundum artem* or unskilfully.

The enquiry into a death supposed to be from an anæsthetic commences with the question—was it due to the narcotic, or to hæmorrhage, shock, exhaustion, or some other mischance following surgical interference. The mode of death due to chloroform, ether, and other agents is described under the heading *chloroform*, &c.

The CHOICE of the ANÆSTHETIC would have to be JUSTIFIED; thus were chloroform given for a simple tooth extraction in lieu of the safer agent nitrous oxide gas, and were the patient to succumb, the administrator could with reason be severely censured for subjecting his patient to such an unnecessary danger.

All anæsthetics are dangerous. In the hands of one skilled in their use this danger is minimised; but whatever may be individual uses and opinions, the general consensus of belief places anæsthetics in the following order of safety :—nitrous oxide gas when used for short

operations; ether; chloroform. Other substances are not used sufficiently often to make statistics reliable, but the following table gives a rough estimate of their danger.*

TABLE SHOWING DEATH-RATE UNDER THE VARIOUS ANÆSTHETIC BODIES.

	Deaths.	Administrations.
Chloroform (Coles, Virginia) ...	53	152,260
,, (Richardson)	1	2500 to 3000
,, Baudens (during Crimean War)	1	10,000
,, War of Secession ...	1	11,448
,, Lawrie (Hyderabad)	0	45,000
,, Juilliard (Geneva) ...	161	524,507
Ether (Andrews)†	1	23,204
,, Juilliard (Geneva)	1	14,987
,, Lee (Chicago)	4	92,816
Nitrous oxide gas	1	100,100
Amylene*	2	238
Hydrobromic ether*	2	(?)
A.C.E. Mixture, No. not ascertainable‡		
Methylene mixture	1	5000

It must be added that Scotland presents a series of statistics much more favourable to chloroform; thus out of 36,500 administrations at the Edinburgh Infir-

* No great stress can be laid upon such figures, as in many cases a death occurred very early in the career of an anæsthetic, and this rendered further trials of it inadvisable.

† Probably too low an estimate.

‡ Richardson states erroneously that no death has occurred under A.C.E. mixture. Dr. Reeve, of Dayton, Ohio, reports 3 deaths.

mary during ten years, only one death has been recorded. Inquiries recently made have revealed that several deaths from chloroform have occurred at the various surgical centres of Scotland, so that the above estimate can no longer be taken as a reliable statement of the death-rate from chloroform.

Dr. McEwen gives his own results at Glasgow (computed, not recorded) as 11,886 cases of anæsthetics, 500 of which were ether cases. He makes various deductions from his total and regards 10,000 with one death as his chloroform record. Sir George Macleod mentions 15,000 cases with one death, and Dr. Buchanan 9,000 with one death. This gives the total of 34,000 with 3 deaths, or 1 in 11,000 about, for three leading Scotch surgeons.

Questions of responsibility when the patient dies under an anæsthetic may involve those as to whether the most suitable anæsthetic was given him. Sometimes a patient refuses one anæsthetic, preferring another; here the administrator clearly cannot shirk responsibility, but must give that agent which he deems best, without regard to the whim of the patient. In the converse case, when death occurs during the administration of an anæsthetic which the patient declined to take until persuaded, cajoled, or cheated into so doing, the anæsthetist would have to show that his special knowledge guided him in making his selection, which although it led to a fatal result, was in point of fact, the best he could do for the patient. In the employment of a new or untried anæsthetic, very grave responsibility would rest with the administrator unless he very fully and clearly explained the possible results, and obtained the patient's consent to the experiment.

A question which we have not yet considered arises—who in the eye of the law is qualified to administer an anæsthetic? At present some uncertainty exists upon the point, owing to discretionary power being left to the operator to assume the so-called responsibility of the anæsthetic. Thus butlers, coachmen, dispensers, and various unqualified persons are frequently permitted to give the anæsthetic, or as the phrase is, "keep it going," while the surgeon besides operating is supposed to exercise a general supervision over the administrator's proceedings. If any accident happens, the certificate is duly signed by the surgeon, and the coroner's court admits the principal's evidence. It cannot be doubted that to give any individual an anæsthetic subjecting him to a minimum of danger is all one person can do, and can only be accomplished by those specially instructed and experienced in anæsthetics.

Were an action for damages raised upon a death occurring under the above named circumstances, there is little doubt that the persons proceeded against would be heavily mulcted, since nothing short of the utmost emergency could justify the proceeding.

Recently an action for malpraxis was taken out in a Colonial court against a medical man who lost a patient whilst he was administering chloroform. The question rested upon whether the anæsthetic was rightly and skilfully given, which being taken as proved, the court decided the case in favour of the medical man.

How far dentists practising with or without the L.D.S. diploma are legally justified in administering anæsthetics is a moot point. Many hold that the L.D.S. confers a right to the administration of nitrous oxide gas, but no other form of anæsthetic. In the

United Kingdom no trial case has, I believe, been contested. The ground for this affirmation that licentiates in dental surgery possess such a right has no legal basis, but has grown out of the belief that the use of nitrous oxide gas is part and parcel of the dentist's business, and that so he has a right to employ it. This, however, applies with equal force to all registered dental practitioners. Probably the issue would hinge, in the present ambiguous condition of the law, rather upon the previous experience and recognised skill of the person administering the anæsthetic, than upon bare qualification. Thus, could it be shown that a registered practitioner, after two or three thousand successful administrations, met with an accident, in spite of all due care and precaution, he would probably be in a better position than would a well qualified practitioner, who met with a fatality presumably through mal-adroitness, if it were shown that he had never obtained a practical experience in anæsthetising.

In any case a person would be open to grave censure, if not liable for malpraxis, were he to undertake the administration of an anæsthetic, and operate single-handed, unless it could be shown that to do so was a necessity, no help being accessible.

It has been made a subject of much debate with whom rests the responsibility of the choice of the anæsthetic, the surgeon who operates, or the anæsthetist who gives the chloroform or ether, &c.? Clearly this must depend entirely upon the understanding which exists between the two. If the anæsthetist is called in as an expert to decide what anæsthetic is best for any given patient, his must be the whole responsibility; while if he is present simply as an

assistant to the surgeon to give in the best possible way an anæsthetic which is named by the latter, his responsibility can extend only so far as the actual administration is concerned. If the two disagree the surgeon insisting upon an anæsthetic which the anæsthetist conscientiously believes will jeopardise the patient's life, the surgeon cannot cover the anæsthetist, and the latter has but one course to adopt, namely, to retire from the case. As, however, the experience of the surgeon will probably equal that of his colleague, and as the patient is his, it is a grave step for any anæsthetist to adopt, and could only be justified in most extreme cases.

Death from Nitrous Oxide Gas.

The deaths which have occurred when the patient had inhaled or was inhaling the gas, cannot be imputed to any specific action it exercised. In some cases heart failure occurred upon the patients, resuming consciousness *before the operation was completed*, and in others respiration was interfered with by gags slipping and setting up laryngeal spasm. In a recent case death occurred in an elderly lady who wore extremely tight corsets, whose heart was diseased and whose stomach contained food. The gas was also administered twice. Unquestionably there is danger if the patient is allowed to feel pain, especially in operations upon the fifth pair of nerves, but little if any when the gas is given fully and the operator warned to desist before consciousness returns.

The P.M. appearances are simply those of death from syncope, or death from asphyxia.

Death from Ether.

If viewed before death, the individual will be found to be lethargic or comatose, breathing slowly, deeply, and with stertor, the skin pale and cold and covered with clammy sweat. The exposed mucous membranes will be purplish; the face livid; the pulse quick, soft, small, and compressible. Complete muscular relaxation gives the body a flaccid doughy feel. The eye is fixed and glassy, and usually smeared with a thick film of mucus, the pupil is dilated and insensitive to light. The body temperature is depressed several degrees below normal.

If the vapour has been inhaled, a much smaller dose is needed than when ether is swallowed. The effects given above may be brought on in from three to five minutes. Six drachms to an ounce are necessary to produce narcotism when swallowed.

Post-mortem appearances.—If examined within twenty-four hours after death, the brain, lungs, liver, spleen or kidneys, upon being cut give a strong ethereal smell. The blood is dark and thick, although still fluid. The lungs are congested posteriorly and filled with aërated spumous fluid in front (Taylor). The bronchial mucous membrane is reddened from injection throughout its entire extent. The cerebral and spinal vessels are found congested, and the meninges stained.

Ether when swallowed has not caused death in the human subject (Taylor). Orfila, experimenting upon dogs, found the mucous membrane of the stomach of a blacky-red colour, acutely inflamed by a lethal dose of ether.

The duodenum was also red and inflamed, the heart contained black blood which was partly coagulated.

The detection of ether by analysis.—Ether in liquid is distilled from the stomach contents and led through a glass tube containing asbestos moistened by a mixture of sulphuric acid and saturated solution of bichromate of potash. The asbestos turns green.

Its odour is also characteristic; ether burns with a smoky yellow flame; it is only slightly soluble in water.

The tissues.—In recent examinations the odour is characteristic. Since but little ether is absorbed by the blood, and of this little some is converted into aldehyde (Taylor), it is almost impossible to separate ether from it or the solid tissues by distillation.

Death from Poisoning by Chloroform

May occur through inhaling the vapour or drinking the fluid. If examined before death the individual will be comatose, breathing stertorously with slow, shallow respirations. The skin will be cold and blanched, the face livid, the lips ashen in hue, the pulse imperceptible, and the pupils may be widely dilated, but insensitive to light. Muscular flaccidity is present, but epileptiform convulsions often occur.

Post-mortem appearances.—In cases of death from chloroform the appearances reported vary very much, and this is probably due to the confusion present in the minds of many persons concerning the connexion of cause and effect. Thus death from asphyxia, fear, shock, and so on, are attributed to chloroform; and further, the autopsies are seldom made soon enough

to be of any value, while sufficient note is seldom taken of the stage in which death occurred. We should expect the cadaveric appearances presented in the first stage to differ widely from those found in the last stage, and yet in but few records have I been able to find any information bearing directly upon this point.

In the earlier stage chloroform congests the vessels of the brain and cord, and so this condition, although inconstant, is sometimes found.

The lungs are usually deeply congested, the heart empty, flaccid, or containing a little fluid blood. In some cases the right heart is full, even to distension, of dark fluid blood (asphyxia). The blood remains fluid, it is very dark and is said occasionally to contain bubbles of gas (Taylor). Snow, analysing thirty-four cases, describes visceral engorgement, but in some instances he found the lungs normal. Casper denies that any of the features pictured above are pathognomonic of chloroform poisoning. When the drug is swallowed it produces gastro-enteritis, and pathological appearances resulting from this would be seen post-mortem.

Detection of chloroform.—The odour very soon passes off. Dr. Taylor failed to detect any in the blood half an hour after administration. Analysis of the blood also fails to reveal any evidence after half an hour.

Analysis of the tissues.—The substance supposed to contain chloroform is placed in a flask, one end of which is in a hot-water bath, the other communicating with a tubulure which is heated by a flame. The bath is raised to 160° while the tube is heated to redness. Chloroform vapour driven off by the heat of the water bath is split up as it traverses the tube,

chlorine and hydrochloric acid being set free. The vapour reddens blue litmus, precipitates solutions of nitrate of silver, and liberates iodine from iodide of potassium which is tested in the usual way with starch paper.

Self-Indulgence in Anæsthetics.

A "habit" has been unhappily created for most forms of anæsthetics. Thus, some persons become addicted to self-administration of chloroform; others to that of ether; others again to that of chloral; while cocaine also has its victims. It is not within the scope of the present work to describe the proper modes of treating the slaves of such unfortunate habits, but merely to draw attention to them, that medico-legal questions arising out of such depraved practices may receive due notice. Nitrous oxide gas, although presenting greater difficulties to self-administration, has yet led some weakly principled persons to practise self-induction of anæsthesia by its aid.

The possibility of the subject of an inquiry—in cases of supposed suicide or murder by anæsthetics—being an habitué of one of them, should not be allowed to drop out of mind.

Insanity following the Administration of Anæsthetics.

Among persons predisposed to insanity the administration of anæsthetics may, in certain rare cases, determine an attack of mania. "It is the fact of the temporary disturbance of function, and not the means by which this is produced, which is of most impor-

tance" (Savage). It is stated upon the high authority of Dr. Savage that chloroform, ether, nitrous oxide gas, and indeed any anæsthetic, is capable of so interfering with brain functions, that the delirium of commencing narcosis may become reproduced upon the patient's recovering from the sway of the anæsthetic, and may either persist as intractable mania or pass off after expending its violence in a sharp but transient maniacal seizure. This liability was also noted in 1865 by various speakers at the meeting of the Superintendents of American Institutions for the Insane, at least as far as chloroform and ether were concerned. The possibility of such a result ensuing upon the administration of an anæsthetic to a person either highly neurotic or coming from a family in which insanity has been developed, should be borne in mind when such individuals are examined with a view to ascertain their fitness for anæsthetisation.

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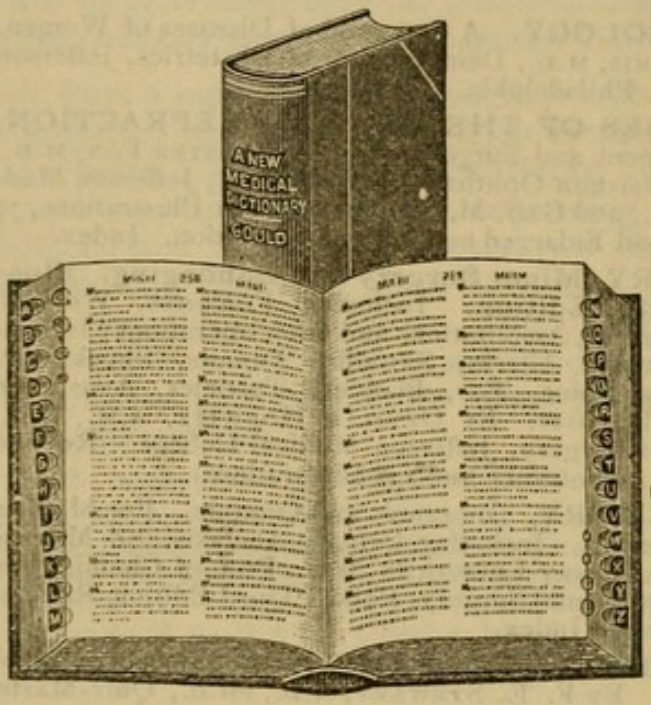

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