A guide to anaesthetics for the student and general practitioner / by Thomas D. Luke.

GUIDE TO ANÆSTHETICS

Luke

SECOND EDITION

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FOR THE

Student and General Practitioner.

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WILLIAM GREEN & SONS

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GUIDE TO ANÆSTHETICS

FOR THE

Student and General Practitioner

BY

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WITH 45 ILLUSTRATIONS

SECOND EDITION

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Dedicated

TO THE

STUDENTS OF THE EDINBURGH

MEDICAL SCHOOL.

PREFACE TO THE SECOND EDITION.

THE advent of ethyl chloride as a general anæsthetic has necessitated an almost complete re-writing and re-casting of several portions of this little book to bring it up to date. During the past two years this drug has made enormous strides in this country, and bids fair in a few years to be the most frequently employed anæsthetic which we possess. It has almost completely displaced nitrous oxide as far as general surgery is concerned, although this anæsthetic will probably continue to be employed in dentistry.

Throughout the preparation of this edition I have had the benefit of valuable practical advice and suggestions from my colleague Dr. Daniell, and to him, also, I am indebted for kindly taking the photographs from which a number of the illustrations have been prepared. To Mr. W. J. Stuart, I am greatly indebted for the trouble which he has taken in revising the proof sheets. My thanks are also due to Messrs. Down Bros., Arnold & Son, Barth & Co., and others, for kindly lending electros for purposes of illustration.

While the book has not been enlarged to any extent, my endeavour has been within a comparatively small compass to give a fairly comprehensive account of the practice of anæsthetics at the present day, such as I trust may be intelligible and serviceable to the general practitioner and student.

THOMAS D. LUKE.

EDINBURGH, *October*, 1904.

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GUIDE TO ANÆSTHETICS.

CHAPTER I.

INTRODUCTORY.

THERE are few subjects to which a student gives less attention during his curriculum than that of anæsthetics. As Sir Frederick Treves has said: "There is a widespread impression that to give chloroform is a minor act—that the power comes with the granting of the diploma—and the significance of the procedure is sometimes emphasised by the remark, 'Well, if a man cannot give chloroform, what can he do?'"

From some of our schools men are sent out year after year, absolutely ignorant of the elementary principles of anæsthetic administration, or, at the most, with a very imperfect knowledge of one anæsthetic—usually chloroform. Can we wonder that the mortality under anæsthetics at the present time is a very heavy one? For this state of matters the councils of some of our universities and licensing bodies are responsible. Two of these, however, have recently made it compulsory for students desirous of their diploma to present a certificate showing that they have received proper instruction in the use of the various anæsthetic agents, and it is to be hoped that very soon some of the older and long established bodies will follow their good example.

No one anæsthetic can possibly be universally adopted if the best results are to be obtained; and while fully alive to the difficulty of men in general practice, long past their student days, rendering themselves familiar with the use of inhalers for ether and other comparatively safe anæsthetics, we cannot help feeling that, in certain parts of Great Britain, chloroform could frequently be replaced by one of these safer agents, with advantage to both doctor and patient, and that the greatly increasing mortality from anæsthetics is largely

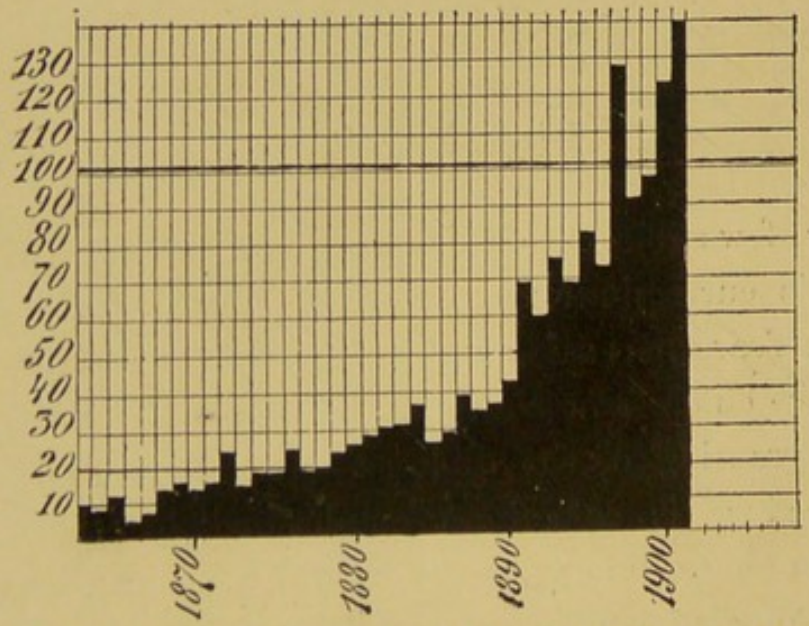


FIG. 1.—DIAGRAM of the annual numbers of "deaths from anæsthetics" in England in the years 1863 to 1901, constructed from the returns of the Registrar-General.

due to the indiscriminate, not to say reckless use of this invaluable but lethal agent. It has been recently pointed out that the anæsthetic mortality has more than doubled during the last ten or twelve years.

In regard to this striking diagram, Professor Waller says,* "the unsifted figures of such returns are not, I am aware, unimpeachable scientific evidence of the number of deaths caused by anæsthetics.

* *Lancet*, 28th November, 1903.

"The numbers may be too high or too low; they may include cases not caused by anæsthetics, but that have occurred from other causes during anæsthesia; or they may fail to include cases of death really caused by anæsthetics, but certified, and quite honestly certified, as caused by that disease for which the services of the surgeon and the anæsthetist have been invoked. I think, however, that the returns are sufficiently voluminous to be amenable to the 'law of large numbers,' and to justify us in regarding the actual figures, inclusive of their plus and minus errors, as fairly representative of the state of the case as regards the death-rate from anæsthetics in past years. The figures are at least arranged by an unprejudiced machinery, and I cannot but regard as disingenuous the assertion that such figures are worthless, and the demand for their detailed analysis. Detailed analysis is impossible, and, even if possible, would be misleading, for if faults of commission might be detected, faults of omission might be beyond correction."

Ether and chloroform have, since their introduction, been rivals for the surgeon's favour, and each in its turn has taken the premier place, at different periods, almost all over the world. Chloroform has nearly always been more popular in tropical countries and in Scotland—the land of its birth. Endless, and often not very profitable discussions have taken place as to which was the better anæsthetic, and after about half a century of such controversy, we have fairly come to the conclusion that each anæsthetic has its place, that the man who is familiar with the use of both is in a better position to obtain good results than he who is only acquainted with one, and that in regard to all anæsthetics much more depends on the skill and experience of the administrator than on the nature of the anæsthetic or inhaler used.

The position of the general practitioner as regards the administration of anæsthetics has been admirably summed up in the following words * :—

"If medical men were well educated in the theory and practice of anæsthesia, they would recognise for themselves that, for nose and throat operations, associated with severe hæmorrhage, for cases where the breathing is embarrassed by aneurism or tumour, or for prolonged abdominal operations, the administration of the anæsthetic should be intrusted to those who have given more than ordinary time and attention to the subject. The satisfactory administration of anæsthetics in many cases of disease—*e.g.*, empyema, is fraught with risk. Safety to the patient and comfort to the operator can only be insured by long experience, caution, and skill. It is quite impossible to suppose that all medical men can be educated to such a high pitch of excellence. They should, however, be enabled during their hospital career to attain a sufficient knowledge to fit them to estimate the limit of their own capabilities, and to know when a given case is difficult or dangerous.

"In districts remote from large cities, it is the duty of every man bravely to encounter difficult and dangerous cases, and do his best by them.

"If once the young practitioner grasps the fact that every case of anæsthesia is a study in itself, in the selection of the appropriate agent for safety and for the operator's convenience, fully appreciating that every case has its peculiar risks and after dangers, he will continue to improve as years advance. At all events, his medical teachers will have done their duty by equipping him as well as possible for one of the most important after duties of his professional life."

* Mr. Marmaduke Shield in *Practitioner*, October, 1896.

THE RELATIVE MORTALITY UNDER THE VARIOUS ANÆSTHETICS.

The safest anæsthetic of which we know at the present day is nitrous oxide, the death-rate of which is given (by Buxton) as 1 in 100,000, but we can only regard this as a nominal death-rate, for it must be considerably less. We are safe in saying that this anæsthetic has been administered on many million occasions, and only thirty-five deaths have been recorded during the past half century. We find that the death-rate of ethyl chloride is about 1 in 12,000 ; ether, 1 in 10,000 ; ACE * and CE mixtures, 1 in 7500 ; chloroform, at least 1 in 1000.

Looking at these figures, an immediate deduction is to be drawn, which should be applied in practice, with the object of reducing the excessive number of fatalities which, as we have shown, at present occur under anæsthetics. This obvious deduction is that some of the known anæsthetic agents are less likely than others to act in a toxic manner on the human organism, and we are surely bound to use the safest anæsthetic which we possibly can for any given operation, taking all the circumstances of the case into consideration.

This should certainly be made a working principle, and a few instances will illustrate this point. We have no right whatever to give chloroform to a patient who puts himself trustingly into our hands for the extraction of a few teeth, if nitrous oxide gas, or ethyl chloride and ether, are available. Similarly, if a patient is to be curetted, and there is no contra-indication to ether, we are in duty bound to administer this anæsthetic, or at any rate CE mixture, in preference to pure chloroform. At the same time, unreasonable or unreasoning bias is to be avoided, and if an operation

* ACE is a mixture of alcohol, 1 part ; chloroform, 1 part ; ether, 1 part. CE is a mixture of chloroform, 1 part, and ether, 2 parts.

on the brain or about the face is to be performed, we are equally bound to administer chloroform, as in this case *the immediate necessities of the operation* must be foremost in our mind, and the high death-rate from chloroform must not make us frightened to use it, where there is such a clear indication.

Summary of the History of Anæsthetics.

1798 Sir Humphry Davy cut a wisdom tooth under nitrous oxide.

1842 Dr. Crawford W. Long, Georgia, U.S.A., gave ether with success for some surgical operations.

1844 Horace Wells, Hertford, Connect., gave nitrous oxide for dental extractions, and attempted publicly to demonstrate its action, but the demonstration was a failure.

1846 Mr. W. T. G. Morton (dentist), pupil of Wells, on Jackson's suggestion, used ether with success for dental extractions, and, on 17th October of same year, for a surgical operation at the Massachusetts General Hospital—Dr. Collins operating. The first operation under ether in an English Hospital took place at University College Hospital, on 21st December of this year, Mr. Squire giving the ether, and Mr. Liston operating.

1847 Sir J. Y. Simpson employed ether for first time in midwifery practice on 19th January; later in same year he introduced the use of chloroform, $CHCl_3$, for anæsthetic purposes.

1848 28th Jan.—Hannah Greener, the first victim to chloroform, died, Sir James Simpson himself being the chloroformist.

1858 Dr. John Snow's classical work "On Chloroform and Other Anæsthetics" appeared.

1868 Dr. Evans demonstrated the value of nitrous oxide at the London Dental Hospital.

1877 Dr. Clover invented his portable regulating inhaler —the most valuable anæsthetic mechanism ever introduced.

1879 Glasgow Committee of British Medical Association met, and condemned the use of chloroform.

1889 The first Hyderabad Commission met.

1890 The second Hyderabad Commission met, and concluded that "chloroform was a comparatively safe body, used properly."

1901 The British Medical Association Committee published a fresh report, again condemning the indiscriminate use of chloroform.

1902–3 The introduction into general use in the United Kingdom of ethyl chloride as a general anæsthetic.

CHAPTER II.

THE CHOICE OF AN ANÆSTHETIC.

It is a remarkable fact that an individual whose health has become somewhat impaired by disease is often a better subject for an anæsthetic than one who enjoys robust health.

Among the laity there is a wide-spread impression that, if "the heart is sound," all must go well, whereas, in about 90 per cent. of the fatalities from chloroform, at the post-mortem examination the heart is found to be perfectly normal. An immense amount depends on the nervous disposition and temperament of the patient, and the amount of alcohol, tobacco, &c., he is accustomed to use.

A healthy, vigorous, male adult is by no means the best subject for anæsthesia in many cases. Although his heart and lungs may be in excellent condition, and able to stand almost any strain which may be put upon them, yet he will not pass so easily into the anæsthetic sleep as a less robust patient, owing to the more frequent occurrence of struggling and excitement, which will interfere with the respiratory rhythm.

Anæmic people usually take anæsthetics quietly, and are better anæsthetised with ether than with chloroform, *ceteris paribus*, as their blood pressure readily becomes unduly depressed by chloroform. When giving ether by a closed inhaler, however, care must be taken not to accentuate the air limitation which will be badly borne.

Fat people also nearly always give trouble when the

method used involves any air limitation; and to fully anæsthetise a fat, short-necked person by means of a Clover's inhaler, without producing undue secretion of mucus and saliva, with considerable cyanosis, is well-nigh impossible. For this type of patient, therefore, CE or chloroform, given with plenty of air, is indicated.

Edentulous people sometimes give trouble by sucking in their lips in a valve-like manner and so obstructing the air-way. This necessitates the separation of the gums and lips by the fingers and the insertion of a corner of a towel or a small dental prop.

To the various organic diseases which indicate one anæsthetic and contra-indicate another it is only possible to allude very briefly.

Cardiac Valvular Disease.—Patients suffering from organic cardiac disease, generally speaking, take chloroform or mixtures containing it quite well, often better than ether, but the greatest possible care in inducing and maintaining perfect anæsthesia is necessary. In many such cases there is a marked tendency to syncope, particularly in the stage of recovery and vomiting.

In **Cardiac Myasthenia** with myocardial degeneration of a fatty nature, or in simple atrophy, ether or CE mixture is strongly indicated, chloroform and nitrous oxide strongly contra-indicated. Grave responsibility is incurred in casually sending such patients to a dentist for extraction of a tooth under nitrous oxide. The majority of fatal accidents under this ordinarily very safe anæsthetic have occurred under such circumstances.

The existence of **Active Bronchitis,** and marked tendency to bronchial affections, contra-indicates ether. Tubercular

disease of the lung, with tendency to hæmoptysis, does also; but the majority of asthmatics are not affected adversely by inhaling ether.

In conditions of **Renal Inadequacy** both chloroform and ether must be used with great caution; for ether congests the kidney unduly, aggravating the albuminuria, while chloroform often increases the degenerative changes in the kidney substance, so that a long anæsthesia of any kind should be avoided if possible.

Insanity contra-indicates both nitrous oxide and ether, while mental aberration is not unknown after the inhalation of chloroform. Ether is, however, much more prone to induce marked cerebral excitement.

During **Pregnancy** chloroform and CE mixture may be given at any time, with ordinary precautions. Nitrous oxide, if carefully administered so as to avoid clonic contractions, may be used up to the eighth month.

Women, if anæsthetised during the menstrual flow, are more prone to excitement and hysterical symptoms.

In **Goitre**, angina Ludovici, and any condition involving much constriction of the air passages with dyspnœa, great care is necessary to use no anæsthetic or method of administration which will in any way hamper the breathing or cause cyanosis.

Several deaths have occurred under nitrous oxide administered to such cases. A light anæsthesia under CE is best; but with goitre the general anæsthesia is frequently so hazardous, that many surgeons prefer to operate entirely under local anæsthetics.*

* Kocher has done over 2000 operations for goitre with local anæsthesia only.

In many cases the choice of the anæsthetic requires the gravest consideration, for it is obvious that some of the pathological conditions mentioned may co-exist, and then we may have a contra-indication for both ether and chloroform—*e.g.*, glycosuria with a bronchitic tendency. In such cases all the circumstances must be taken into consideration, and the anæsthetic which we consider least objectionable employed.

Nature of Operation.

Cases suitable for Ethyl Chloride.

(1.) Extraction of teeth.
(2.) Opening superficial abscesses.
(3.) Tenotomies.
(4.) Removal of aural polypi.
(5.) Passive movements of stiff joints.
(6.) Avulsion of toe nail or finger nail.
(7.) Removal of external piles.
(8.) Scraping patches of lupus.
(9.) Application of cautery.
(10.) Removal of drainage tube or dressing from sinus, &c.
(11.) Turbinectomy.
(12.) Removal of post-nasal adenoids.

Cases suitable for Ether (which may be preceded by N_2O or Ethyl Chloride, with advantage in most cases).

(1.) Operations on extremities, such as amputations, osteotomy, reduction of dislocations, and excisions especially of large joints.
(2.) Operations on rectum for piles, fistulæ, stricture or excision.
(3.) Operations on the genito-urinary organs; lithotomy, urethrotomy, castration, amputation of penis,

operations for varicocele; nephrotomy, and nephrectomy.

(4.) Many simple hernia operations and colostomies.

(5.) Excision of breast—partial or complete.

(6.) Most ovariotomies, amputation of cervix, vaginal and most supra-vaginal hysterectomies, and all curettings.

(7.) In all conditions of collapse—*e.g.*, after railway

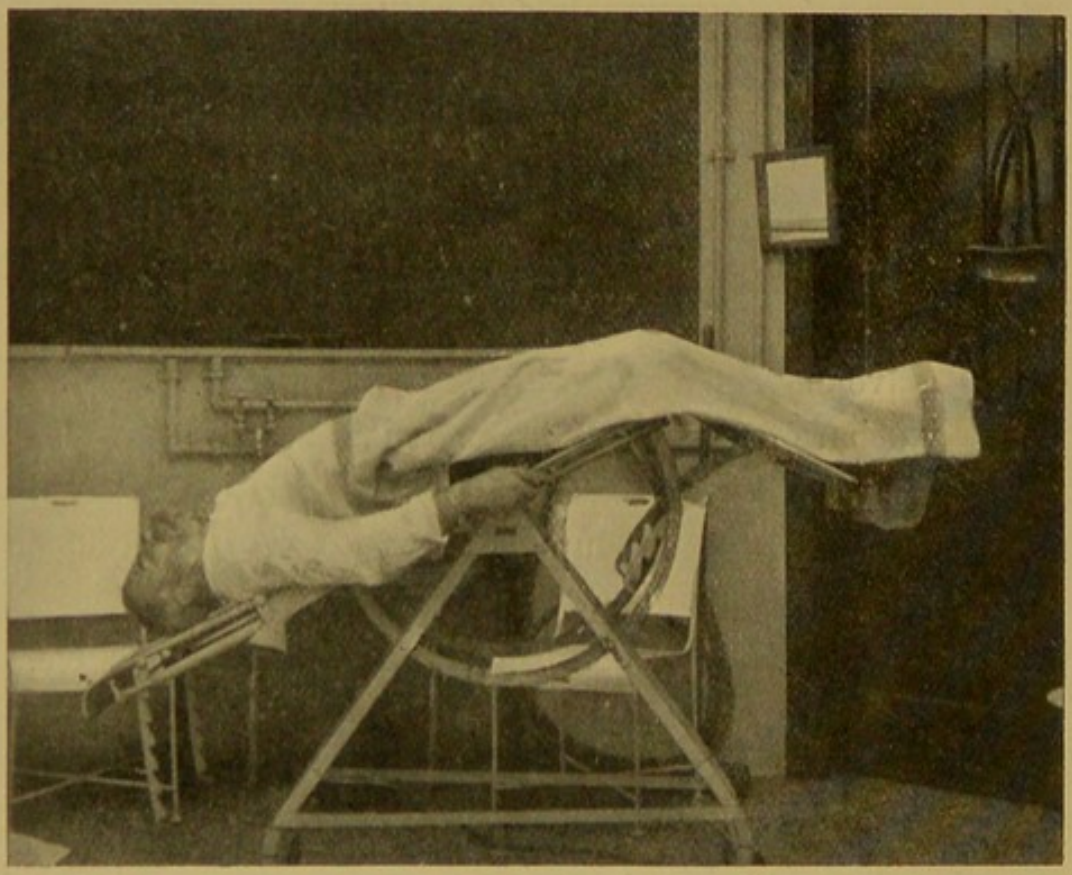


FIG. 2.—THE TRENDELENBERG POSITION.

smashes, gunshot wounds, strangulated herniæ, and ruptured viscera, and where the patient's vitality is extremely low from cachexia, debauchery, or chronic inanition.

(8.) In all dental extractions of a prolonged kind, for which the period of anæsthesia provided by nitrous oxide and ethyl chloride is too brief.

Cases suitable for Chloroform.

(1.) Operations on the neck—*e.g.*, plastic operations and removal of tubercular glands.

(2.) Intracranial operations.

(3.) Excision of tongue, inferior and superior maxillæ.

(4.) Abdominal operations, when preferred by the surgeon, where the exaggerated Trendelenberg position

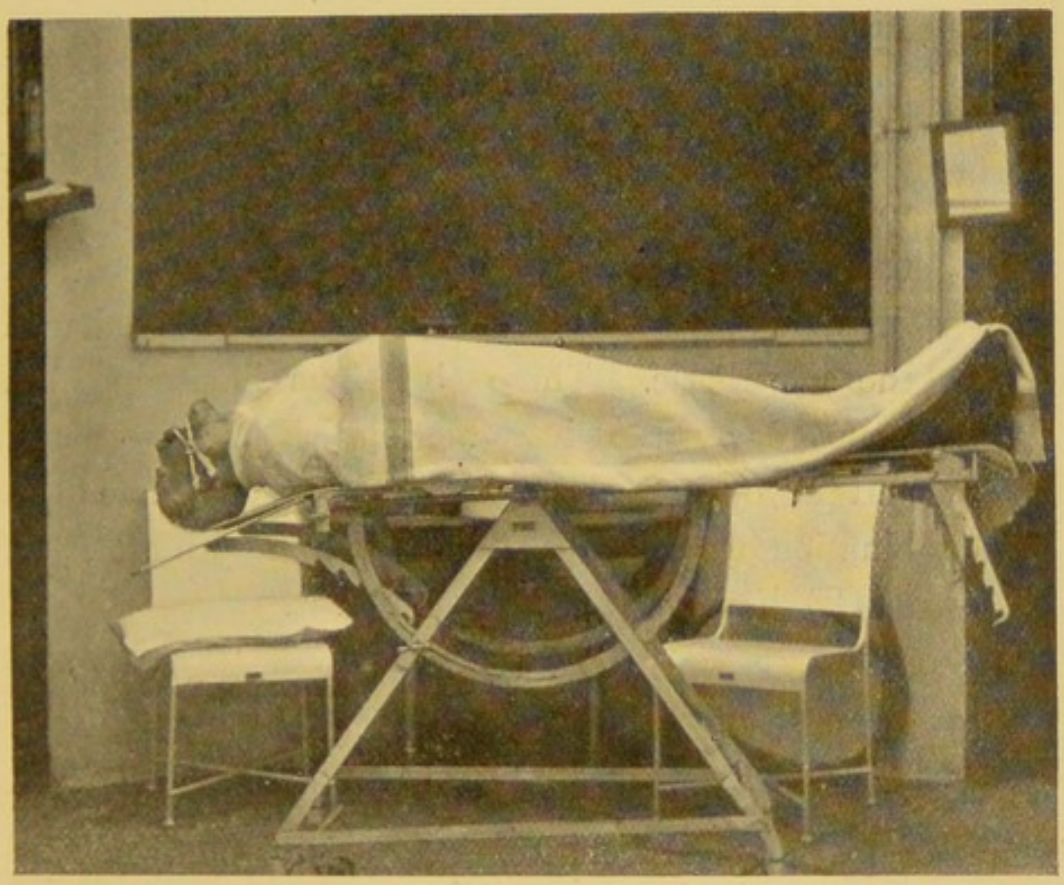


FIG. 3.—ANNANDALE'S POSITION FOR THROAT OPERATIONS.*

is used, or the patient breathes too vigorously under ether.

Kocher† remarks that in his opinion "for operations

* This is more commonly known as Rose's position—but attention was first drawn to its value in throat operations by Mr. Annandale in *Lancet*, 28th November, 1879.

† "Operative Surgery." Second Edition. Translated by H. J. Stiles, 1903.

exceeding one hour in duration ether should be used, *ceteris paribus.*" This, coming from a surgeon of such high repute and large experience, carries great weight, though it is not in accordance with our own practice.

(5.) In cases of labour, generally speaking, chloroform is most convenient, as the patients usually have vigorous circulations and temporarily hypertrophied hearts, and so bear it well. Fatalities are exceedingly rare, and, when they occur, are usually due to gross carelessness, or due, perhaps, to the administration of the anæsthetic being handed over to the nurse. Simpson objected to ether for this purpose, owing to the amount needed, and further, owing to the persistence of the odour of the anæsthetic. These objections have since been removed by the introduction of proper inhalers, and in operative midwifery ether or some combination of this anæsthetic with chloroform, such as CE, has much to recommend it.

The choice of the anæsthetic, therefore, must depend upon :—

(1.) The condition of the patient and the presence or absence of pathological conditions to which we have already referred.

(2.) The nature of the operation.

(3.) The skill of the administrator.

(4.) The wish of the operator, which, with all due consideration of the patient's condition, &c., should be paramount, for it is obviously unfair to the surgeon and undesirable for the patient that the former should feel for one moment that he is embarrassed in his work in any way.

Further, it may be desirable to commence with one anæsthetic and continue to maintain anæsthesia with another. Many deaths from anæsthetics are due to persistence in the use of an anæsthetic which, *to the initiated,* is obviously unsuitable for the patient.

The Age of the Patient.

Under 5 years. — Either pure ether, or CE on a Schimmelbusch mask, is to be recommended. Young children are as readily anæsthetised with ether as with chloroform, and it is well to remember that to young infants chloroform is a powerful, protoplasmic poison, which may produce marked degenerative changes after the anæsthetic effect has disappeared.* Further, "false anæsthesia" is less common with CE than with chloroform.

From 5 to 15. — CE mixture may be used with confidence, and will give best results.

From 15 to 70 and over.—If there be no respiratory trouble or other contra-indication, ether may be used as the routine anæsthetic. CE is also an excellent anæsthetic here.

* See H. J. Stiles, *Scott. Med. and Surg. Journal*, August, 1904.

CHAPTER III.

NITROUS OXIDE, N_2O, PROTOXIDE OF NITROGEN.

(Popular Name "Laughing Gas.")

NITROUS oxide gas is a colourless body possessing a rather sweet taste and odour, and a specific gravity of 1·527. It is neutral in reaction, and consists of nitrogen and oxygen in chemical combination, and so differs from atmospheric air, which is a simple mechanical mixture of these gases.

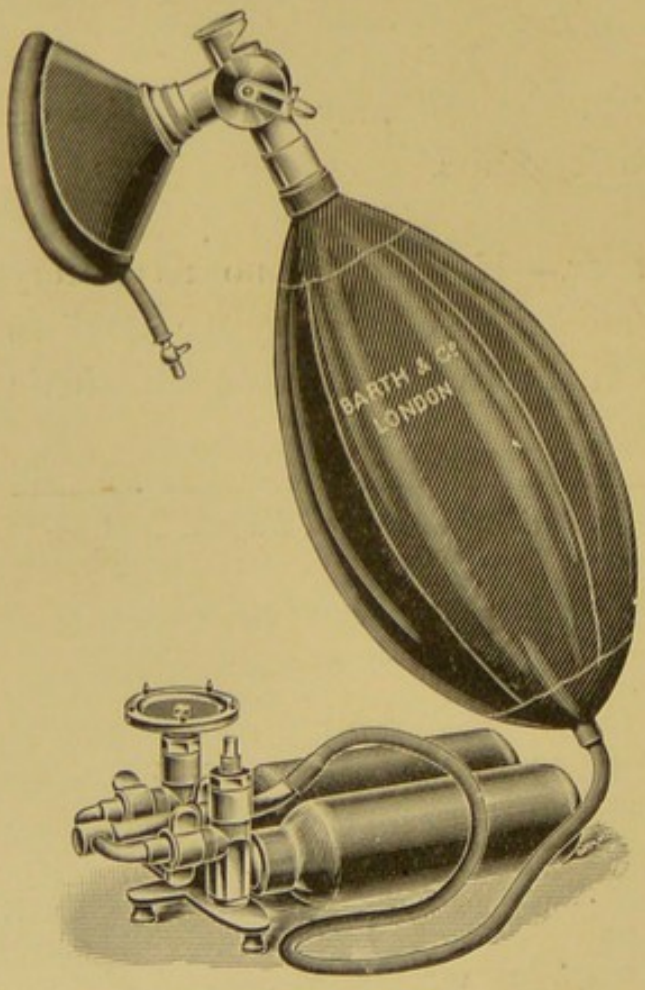


FIG. 4.—BARTH'S NITROUS OXIDE APPARATUS.

The Apparatus for administering is a very simple one. It consists of a face-piece and a three-gallon bag of rubber, joined by a three-way stop-cock and connected by a tube with two steel gas cylinders.

Gas cylinders are of two kinds—

(1) Angle pattern, and (2) Ordinary pattern.

The former is the most convenient kind, as it can readily be turned on and off with the foot when on a stand by one manipulation, and leakage is less apt to occur. These cylinders have to be very strongly made to stand the enormous pressure of the liquefied gas, and are rather costly, but are let out on hire by the makers of nitrous oxide.

They are made in 25, 50, 100 and 500 gallon sizes, but for general purposes the 50 and 100 gallon sizes are most convenient.

FIG. 5.
ORDINARY.

FIG. 6.
ANGLE.

NITROUS OXIDE CYLINDERS.

Formerly dentists used a gasometer for nitrous oxide, but this is seldom used at the present day. The actual technique of the administration with it was even simpler than with the modern apparatus, but the gasometer was more expensive, apt to leak and get out of order, and was the reverse of portable.

Technique of the Administration.—The patient should be seated on a dental chair or an easy chair with a high back; the head must be neither hyper-extended nor flexed, but so placed that it is in the same vertical axis as the spinal

column. The person administering the gas should stand on the patient's left side behind the chair, and it will be found most convenient for him to turn on the gas with the left foot.

Care must be taken that there is sufficient gas available at the start to complete the operation. Each cylinder is marked with a gross and net weight, so that the amount of gas contained in each can at any time be readily ascertained. The foot key should be given a turn round before starting, to see if it is working easily, as the tap sometimes gets stiff and a spanner is needed to move it.

A little gas should then be allowed to flow through the bag to free it of air, and then it should be filled about two-thirds full. The valves, which, if not used frequently, are apt to become dry and curled up, may be tested by breathing through the face-piece a few times.

The dentist having inserted a mouth prop, the face-piece should be gently but firmly and accurately applied to the patient's face. Leakage of air is very apt to occur at the upper part of the face, at the junction of the frontal and nasal portions of the face. Waving of the fringe in the fair sex indicates this, and it is best arrested by pressing in the sides of the upper part of the face-piece against the nose. The patient should not be told to take long breaths, but simply to breathe as usual —quietly and naturally.

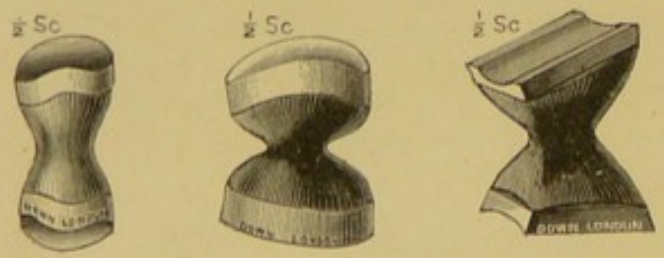


FIG. 7.—MOUTH PROPS.

In the early part of the administration the indicator is kept at "valves," but, after about six to eight breaths, should be turned on to "no valves," and to and fro breathing be

allowed. Throughout the administration the bag is kept moderately distended with gas.

The available anæsthesia may be somewhat lengthened by giving a breath of air to every five respirations during the induction of anæsthesia.

Nitrous oxide anæsthesia is divided into three stages, just like the anæsthesia of chloroform or ether, but the change from one to the other is so rapid that they are not easy to differentiate; neither are they of any great practical importance, beyond the fact that it is necessary to be familiar with the signs and symptoms of the third stage, when the patient is in a condition of true anæsthesia, and the operation may be commenced.

After the first breath or two of gas the patient has a strong inclination to take a deep inspiration, and has a marked feeling of expansion or exhilaration. Consciousness is soon lost, and vivid dreams are common, rendered very unpleasant if the operation is begun too soon.

Signs of Full Anæsthesia. — The patient's breathing becomes deep and stertorous; the complexion is markedly cyanosed, clonic muscular contractions commencing in the orbicularis palpebrarum and extending to the limbs, constituting the phenomenon known as *jactitation.* The pupils are dilated; the conjunctiva insensitive; the pulse full and bounding; the eye-balls rotate from side to side or become fixed, while the features are often considerably distorted and unpleasant to look at.

The average time to induce anæsthesia is . 56 seconds.
The average duration of anæsthesia, . 39 seconds.

How does Nitrous Oxide act?

Let it be understood at once that, although the appearance of a patient deeply under the influence of nitrous oxide

may be highly suggestive of asphyxia, the condition is actually quite different, and N_2O is by no means an asphyxiant.

The late Sir George Johnson actually contended that it merely produced "a beneficial asphyxia"! That it really displaced oxygen from the blood, and when the tissues reached a certain point of cellular asphyxia, they lost their power of receiving and conveying stimuli.

It is hardly necessary to say that an anæsthesia so produced would be fraught with danger, and we know on the contrary that nitrous oxide is by far the safest anæsthetic yet discovered. H. C. Wood, of Philadelphia, declared it to be an asphyxiant. Paul Bert, while recognising that the gas had a specific action on the tissues in producing insensibility, considered that the anæsthesia was yet accompanied by asphyxial phenomena due to air exclusion which he considered essential. Later, he found that anæsthesia could be produced even when air and oxygen were mixed with the gas. Since then the united researches of Dr. Dudley Buxton, Dr. F. W. Hewitt, and Mr. Bellamy Gardner have clearly demonstrated that—

(1.) Nitrous oxide enters into loose combination with hæmoglobin in the red blood corpuscles, and probably is so conveyed to the cells of the nerve centres.

(2.) It exerts a specific effect on the central nervous system.

(3.) The phenomena of N_2O anæsthesia are totally distinct from those occurring in asphyxia.

(4.) The effect of nitrous oxide on the circulation, more especially on the heart, is stimulating, except in so far

as the introduction of any gas into the pulmonary circulation, if we exclude oxygen, increases friction, and so interferes in some degree with the circulation.

(5.) A mixture of air and N_2O with a proportion not exceeding 30 per cent. of air, or a mixture of N_2O and oxygen with not more than 12 per cent. of the latter, will produce an agreeable and efficient anæsthesia.

After-Effects of Nitrous Oxide.

The after-effects of nitrous oxide are, as a rule, exceedingly slight and transient; indeed, there is no known anæsthetic which produces less constitutional disturbance.

Slight headache and vertigo, accompanied by a feeling of lassitude and depression, are occasionally seen. If at all marked, some impurity in the gas may be suspected, or the administration may have been faultily conducted, and too much CO_2 administered along with the nitrous oxide from re-breathing, or some blood may have been swallowed. If the patient has had a meal within the last two hours, these symptoms are more prone to occur, and may be accompanied by nausea and even active vomiting.

Accordingly, it is well before administering to inquire when the last meal was taken. Pallor and faintness are due usually to stomachic disturbance and threatened vomiting, rather than to any direct circulatory disturbance.

Two administrations at a sitting can rarely be carried out without causing a good deal of after-discomfort and headache, and should therefore not be undertaken unless the patient lives at a distance, and it is especially desirable to complete the extraction at one sitting.

Ethyl Chloride or Chlorethyl.*

(*Chem. form.* C_2H_5Cl.)

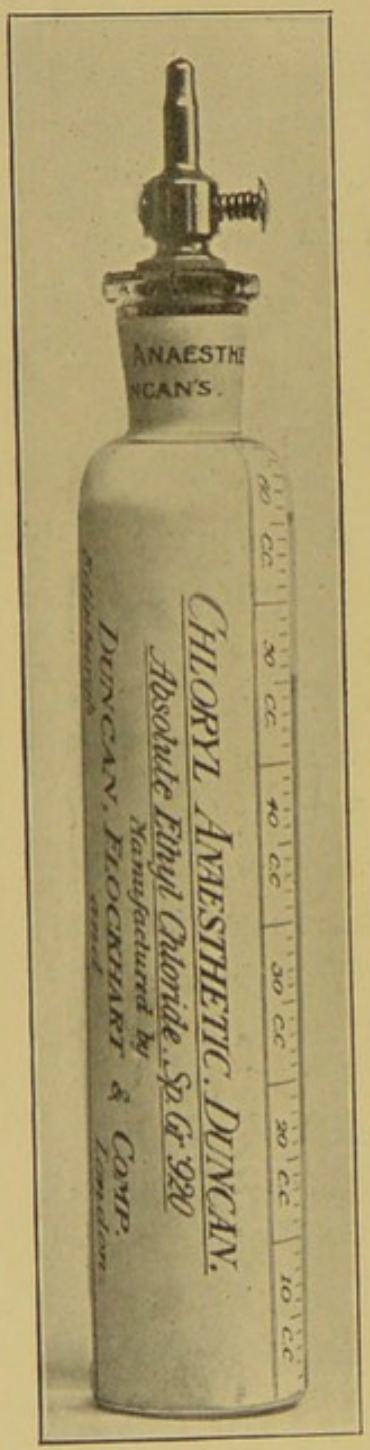


Fig. 8.—An ethyl chloride cylinder.

Ethyl chloride has been favourably known for many years as a local anæsthetic, but since 1896, when Carlson discovered that it possessed general anæsthetic properties, it has been steadily growing in favour in this capacity on the Continent, and during the past two years has been very extensively used in our own country, where it has practically displaced nitrous oxide in general surgery.

The drug is a colourless, highly-volatile liquid, with a not unpleasant but rather penetrating odour. It evaporates at all ordinary temperatures without leaving a residue; it is very combustible, and burns with a green flame, setting free hydrochloric acid. It keeps well, when not unduly exposed to light, and has no tendency to undergo chemical changes and form poisonous by-products.

It is put up in flasks containing from 50 to 60 cubic centimetres or about one and a half fluid ounces; these are fitted with patent spring stoppers of various patterns, not all of which are satisfactory.

* Ethyl Chloride must not be confused with Ethidene Dichloride, C_2H_4Ch, a very different and much less safe anæsthetic agent, never used at the present time.

The Apparatus.—A certain amount of anæsthesia can be induced by simply spraying the drug on to a handkerchief formed into a cone, or on to the inside of a Blake inhaler. If this is done, it is best to measure out 5 c.c. (about 75 minims) into a minim measure and throw it at once on to the inhaler, as freezing is less likely to occur. Such a method answers for emergencies or where a better inhaler is not available, but for reliable and the best results an inhaler such as we now figure is necessary.

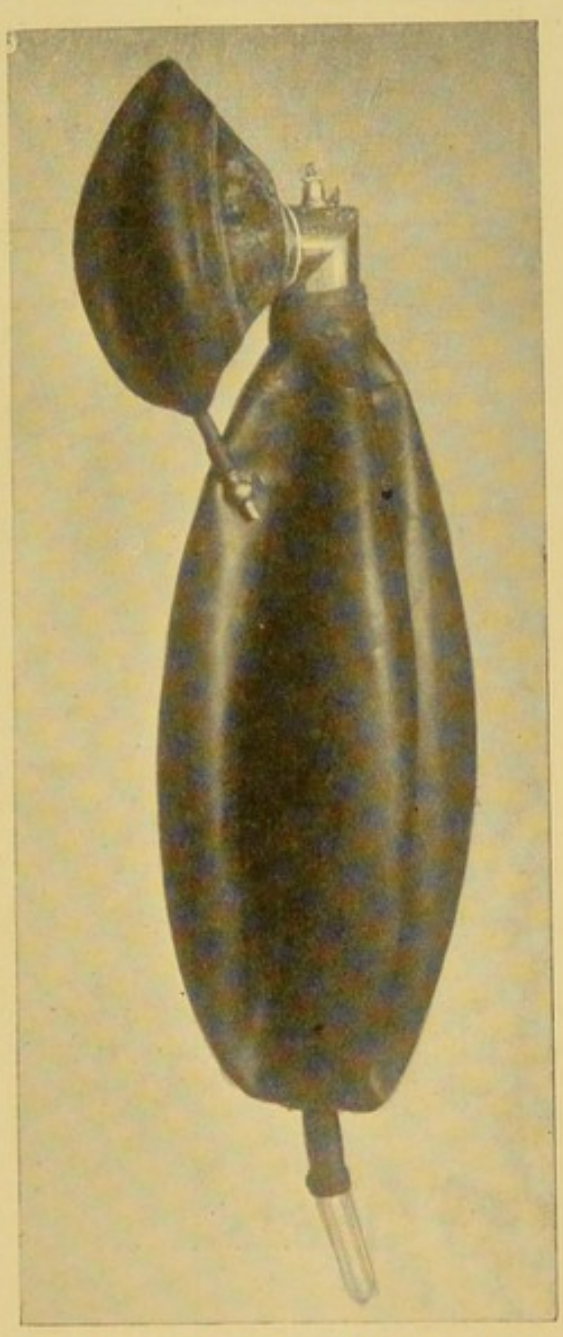


FIG. 9.—AUTHOR'S ETHYL CHLORIDE INHALER.

The essential parts for any apparatus which will produce satisfactory and reliable anæsthesia by means of ethyl chloride are in brief the following:—

(1.) A one-gallon rubber bag, preferably with a wide mouth.

(2.) A face-piece such as is used for ether or nitrous oxide.

(3.) An angle junction tube for the two.

Such an apparatus can be readily formed from the parts of a Clover's or Hewitt's inhaler. From the former the inhaler figured above was prepared, the only addition being a simple tube for introducing the ethyl chloride, which passes

down the lumen of the vertical arm of the angle junction tube. This modification can be made in the Clover apparatus at a very trifling cost. It is best to avoid the use of any lint or cotton-wool along with this inhaler, as this is quite useless and wasteful of the anæsthetic. There is some little difficulty, and especially for the inexperienced, in measuring

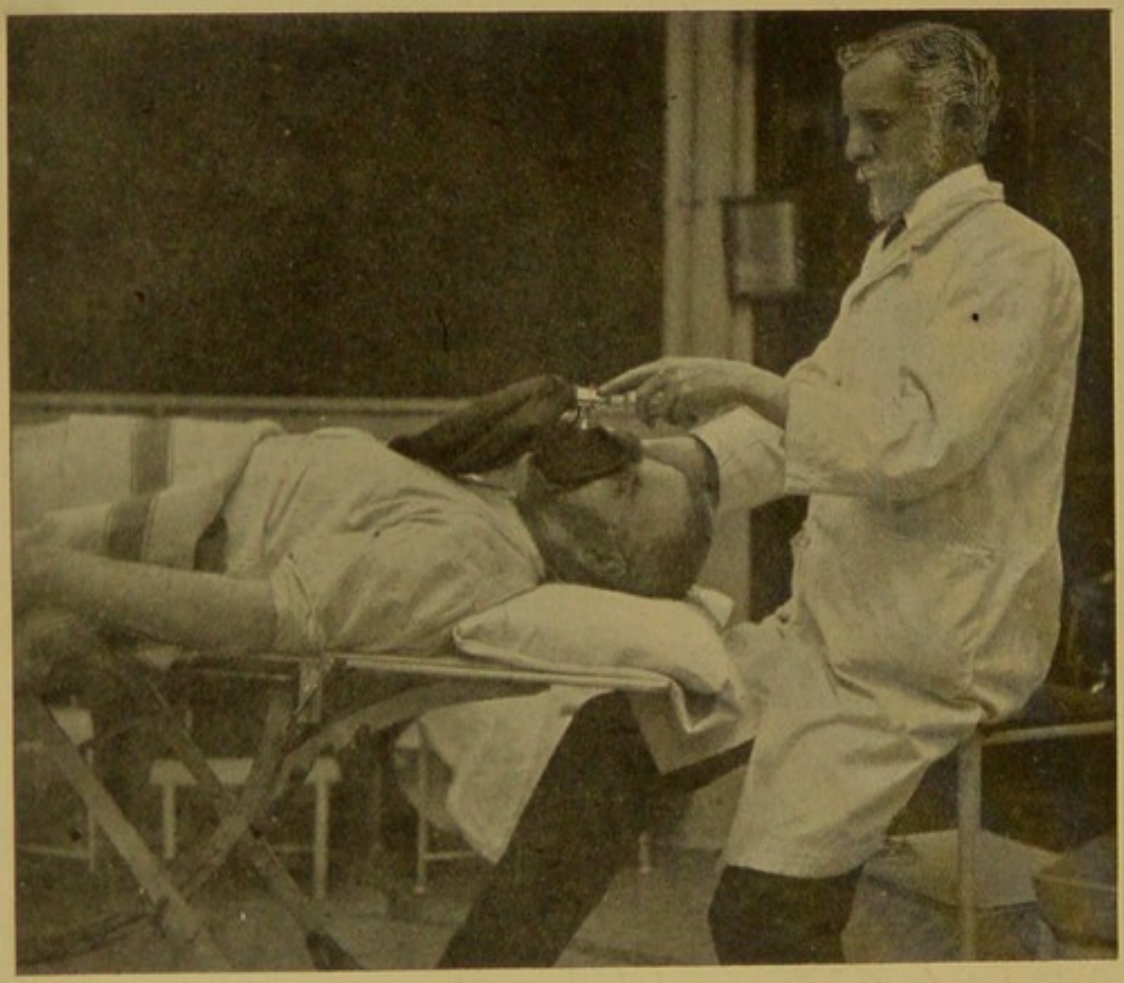


FIG. 10.—THE ADMINISTRATION OF ETHYL CHLORIDE.

the exact amount of ethyl chloride when it is introduced directly from the original cylinder.* In view of this, the

* To meet this difficulty, an admirable little contrivance, "The Automatic Indicator," has just been invented by Mr. Vernon Knowles. It is a scale *set* at each administration, and enables one to tell at a glance how much ethyl chloride has been used. It can be obtained from the Dental Manufacturing Co., London.

manufacturers of the drug have placed capsules on the market, containing 3 c.c. and 5 c.c. respectively, and hence there can be no difficulty in administering an exact quantity. The small capsule will be quite enough for a young child, while the larger size, properly administered to an adult, will induce an anæsthesia of from two to three minutes duration, if required.

The Administration.—Whenever possible, the drug should not be administered until a period of two hours has elapsed since the last meal, as sickness is then less liable to occur. The clothing of the patient should be loosened, the collar or anything tight around the neck being removed.

The patient may be seated in a dental or other chair with perfect safety, but, if more convenient for the performance of the operation, he may be placed on a couch. After having inquired as to the existence of artificial teeth (which, if present, must be removed), the inhaler—without any anæsthetic in it—is carefully adapted to the patient's face, and he is asked to take two or three breaths to and from it.

After he has been got to breathe freely and comfortably, the ethyl chloride should be introduced. It is best to do this somewhat gradually, as otherwise the vapour in the bag becomes suddenly very pungent, and the patient holds his breath. Although good anæsthesia may be soon obtained, the patient will complain afterwards, in many cases, that "it was very choky."

It is well to take the exact time to a second when the ethyl chloride is introduced into the bag, and it will be found that signs of complete anæsthesia are present before the lapse of ninety seconds in the very large majority of cases; if

not, it is more than probable that some air leakage has been going on.

The signs of ANÆSTHESIA are the following :—

Regular, automatic breathing, rapidly deepening to stertor ; fixity of the eye-balls ; loss of the conjunctival reflex ; dilated pupils, and varying relaxation of the muscular system. The *masseter*, however, is the one muscle which is seldom fully relaxed, and sometimes takes part in the spasm which, during deep anæsthesia, we often notice in the muscles of the extremities. The pulse is full and increased in rapidity, and the face sometimes flushes considerably.

Unless a long anæsthesia is required, it will be best not to push the administration to the production of marked stertor and spasm of the muscles.

The average time required for induction of anæsthesia is 50·9 secs., and the average available anæsthesia 71·3 secs. (according to M'Cardie) ; but they both vary, and can be made to vary greatly according to the requirements of each individual case.

The After-Effects of Ethyl Chloride.—Headache and nausea are somewhat common, unfortunately, and the frequency of their occurrence is the only thing which prevents this almost ideal anæsthetic from completely displacing nitrous oxide in both dental and general surgery. Untoward effects such as these are far less common after a brief anæsthesia than after a prolonged one where stertor has been produced. Further, they seem slightly less frequent when nitrous oxide is used along with the ethyl chloride. Sickness is less frequent when the patient has been properly prepared, and when the hour of administration is in the morning.

Ethyl Bromide.

($C_2H_5Br.$)

Ethyl bromide has been used in this country chiefly by Dr. Brown Kelly of Glasgow, for adenoid operations. It is neither so pleasant an anæsthetic nor as safe as ethyl chloride, but, properly administered, affords a good anæsthesia of one minute or more, and is thus well adapted for a brief operation, such as removing adenoids or tonsils. It has the advantage over ethyl chloride that, with it, no special inhaler is necessary, as it is best given on a towel or napkin held close over the patient's face, all air being practically excluded for the time being.

It is undesirable to repeat the administration at a sitting, as can be readily done with ethyl chloride, and care should be taken to keep the drug * in a carefully stoppered bottle in a cool place. The dose is from $1\frac{1}{2}$ to $3\frac{1}{2}$ drachms, according to the age of the patient.

Signs of Anæsthesia.

In fifty to seventy seconds from the commencement, stertorous breathing ensues. This may be allowed to continue for ten seconds before stopping the inhalation, if a fairly long anæsthesia is wanted. Sometimes the breathing will only become deep and regular, as in profound sleep. The limbs become relaxed, and the corneal reflex is abolished. Voluntary movements cease. If these symptoms do not ensue in less than ninety seconds, and if there are at that period rigidity and irregular breathing, then the drug has been improperly given and too much air admitted.

* Dr. Inglis Clarke says, if properly prepared, ethyl bromide is a very stable drug.

Colour.—The face gets somewhat congested or even dusky. Pallor is rare.

The eyes often remain open. The conjunctiva becomes congested, and the pupils dilate widely.

The pulse may remain normal or become somewhat lowered in tension and irregular, in some cases rapid and increased in tension, as with nitrous oxide.

Muscular System.—Spasmodic contractions and movements of the limbs (jactitation), as under nitrous oxide, are common. Spasm of the masseter is frequently troublesome, and necessitates the insertion of a mouth wedge or Mason's Gag before commencing the inhalation.

After-Effects.—Vomiting occurs in about 55 per cent. of cases. This may be merely a transient retching, but is often more severe.

"Somnoforme" is merely a mechanical mixture of ethyl chloride 60 per cent., methyl chloride 35 per cent., and ethyl bromide 5 per cent. After a careful trial and comparison with plain ethyl chloride, it is difficult to see any advantage in this much vaunted compound to compensate for the very considerable extra cost.

The presence of methyl chloride gives the mixture a somewhat unpleasant odour, and the breath of patients who have inhaled this mixture not uncommonly smells of garlic, due to decomposition products of ethyl bromide.

CHAPTER IV.

ETHER.

(Syns.—Sulphuric Ether, Anhydrous Ether $(C_2H_5)_2O$.)

Ether is a colourless, very volatile liquid, with a peculiarly strong odour and hot taste; it is highly inflammable, burns with a white flame, and contains about 8 per cent. of spirit. It has a specific gravity of ·715 to ·725. The varieties used for anæsthetic purposes are ethylic ether, prepared entirely from ethyl alcohol, and what is called "pure anæsthetic ether," which is carefully prepared from methylated alcohol, from which the wood spirit has been removed. Unless the source is a reliable one, however, and this is quite certain, it is better to employ ethylic ether. Crude methylated ether, such as is used for disinfecting and cleansing the skin prior to an operation, is inadmissible as an inhalant.

The Administration.

Three methods are employed, two of these being almost the same:—

(1) The Open Method. (2) The Semi-open Method.
(3) The Close Method.

(1.) **The Open Method.** — The most simple way of administering ether by the open method is on a towel or Schimmelbusch mask, but the latter is only suitable

for children; while the former, if used for more than a very short period, renders the room unbearable to the surgeon and other occupants from the rapid evaporation of the anæsthetic, and the patient is exposed to a considerable risk of an attack of genuine ether bronchitis or pneumonia.

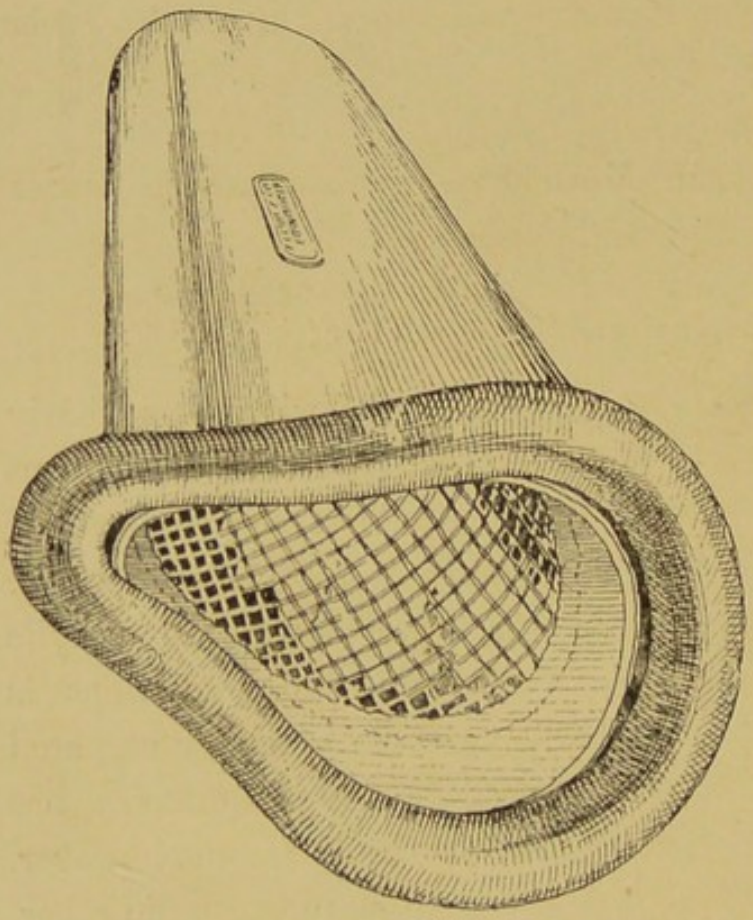


FIG. 11.—BLAKE'S INHALER (modified by the author), fitted with face pad for ether administration.

Open etherisation is therefore not used to any extent in this country at the present day, for the amount of ether required is unduly large, while the risk of subsequent bronchial troubles is so great as to make ether, so administered, ultimately almost as dangerous as chloroform. It is quite a common and a good practice, however, when administering chloroform, for the anæsthetist to give

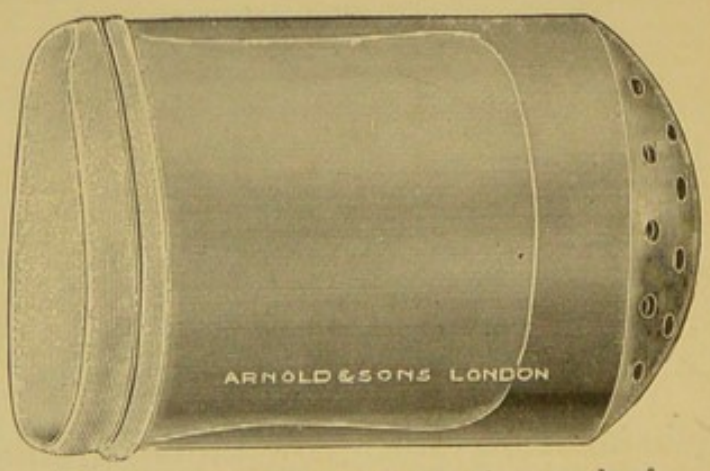


FIG. 12.—RENDLE'S MASK (only those made of celluloid or metal are admissible).

the patient a little ether on a towel for a moment or two from time to time, when the pulse is flagging. This is much preferable as a prophylactic measure to waiting until the patient has collapsed, and then injecting ether hypodermically.

(2.) **The Semi-open Method.** — The apparatus most commonly used for this purpose are the following :—

1. Blake's Inhaler (somewhat modified by the author).
2. Rendle's Mask (only those made of celluloid or metal are admissible).

Of these the modified Blake inhaler is, all things considered, the best and most generally useful, and is largely employed in America. It consists of a truncated pyriform cone, of tin plate or German silver, about 7 ins. long ; the upper aperture is about 2 ins. × 1 in., and the lower about 4 ins. × 3 ins., and is fitted with a pneumatic rubber face-pad, so that, if used for administering ether the air supply can be somewhat controlled ; but, on the other hand, if the inhaler is being used for CE, this pad can be easily removed and more free air supply allowed. Inside this larger cone is placed a smaller complete cone of stiff wire-gauze, rendered more rigid by a circular metal band at the base ; on to this cone, before inserting it, is wound some narrow domette bandage, only as much being put on as will leave the apex of the cone uncovered. This domette bandage acts as the vehicle for the ether (just as the sponge does in Silk's cone). The inhaler is really very much like an Ormsby without the bag, and, when using it for an average type of patient, very little more ether is necessary than is used with an Ormsby, or even a Clover, to keep up a satisfactory degree of anæsthesia, seven to eight ounces an hour being usually necessary. One great advantage of this

apparatus is that it can be completely sterilised—by boiling if necessary—before and after using it; and the face-piece can be soaked in 1-20 carbolic lotion. Silk's metal inhaler can be treated in the same way, but Rendle's (celluloid) cannot be, of course, while the leather Rendle and the "Hyderabad cone" are simply germ carriers, which it is next to impossible to satisfactorily disinfect.

Technique of Semi-open Etherisation.—The administration of ether by the semi-open method is extremely simple, the only difficulty being to get the patient nicely under in a reasonable time, and without undue struggling. To the expert this will present no difficulty with the majority of patients, but when an inexperienced practitioner is going to etherise a patient in this manner (and it may be remarked that as regards safety he could use no better method), he will find it advisable, in order to save time and avoid struggling and annoyance on the part of the patient, to render the latter unconscious in the first place by the preliminary use of a little ethyl chloride or CE, and then induce full anæsthesia and maintain it by means of the ether. For this sequence of anæsthetics Blake's inhaler *without* the face-pad is well adapted.

If the anæsthesia is to be conducted with ether alone, a drachm or two should be placed within the inhaler, and the latter held at such a distance from the patient's face as to avoid coughing and holding of the breath, and then gradually approximated as the patient gets accustomed to the vapour. If too strong a vapour is employed, spasm of the larnyx and a sense of choking are produced, which may become unbearable; while if the ether is applied too sparingly, the induction of the anæsthesia will be unduly protracted, and the patient may get excited and

troublesome. It is of great importance to gain the confidence of the patient, and get him to realise that, disagreeable as the proceeding is, it is for his good; and, while beginning with a dilute vapour, to gradually and progressively increase the strength as soon as the patient gets dazed and is losing consciousness.

The respiratory rhythm is always more or less interfered with by swallowing movements and temporary closure of the larynx, but by degrees the larynx gets accustomed to the vapour, its reflex is subdued, and the breathing grows regular.

(3.) **The Close Method.**—Until quite recently either Clover's or Ormsby's inhalers were almost exclusively used for administering ether by this method, but a few years ago Dr. Hewitt brought out his improved wide-bore Clover inhaler, which is the best apparatus of the kind obtainable.

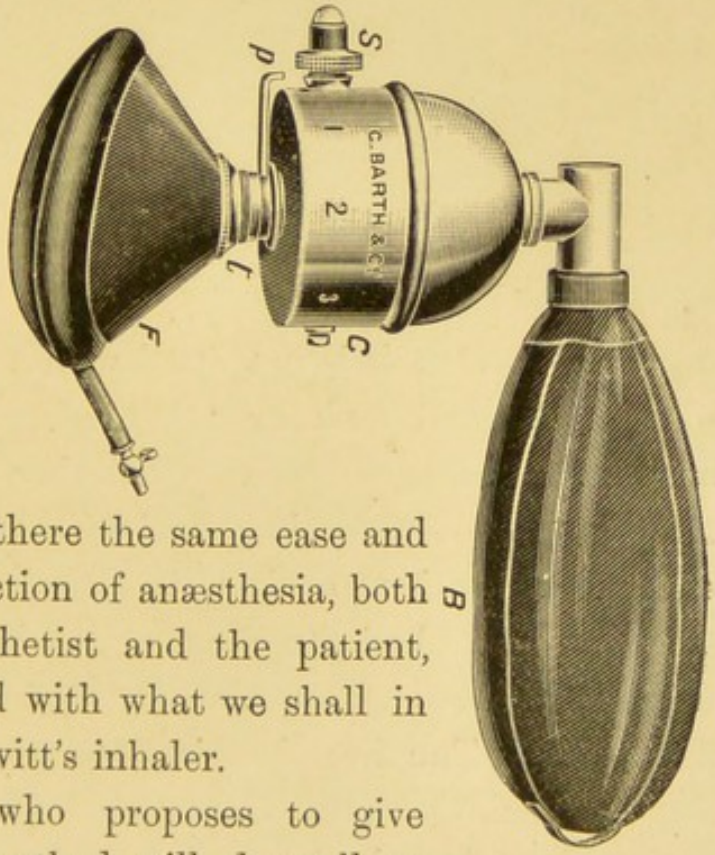


FIG. 13.—CLOVER'S INHALER.

With no other are there the same ease and comfort in the production of anæsthesia, both as regards the anæsthetist and the patient, which are experienced with what we shall in future refer to as Hewitt's inhaler.

The practitioner who proposes to give ether by the close method will do well to use it and no other, for it is in several ways superior to the ordinary Clover, and costs very little more. It is scarcely possible too strongly to

condemn the cheap ether inhalers, as a rule "made in Germany," and sold in a flimsy leatherette case for about half the price of a good inhaler. They are, as a rule, very badly constructed, and only calculated to make the inexperienced think that the administration of ether is an extremely difficult and tedious matter. As will be seen from the diagram, Hewitt's inhaler is somewhat different in shape from the ordinary Clover; it is not fitted with a circular water-jacket, but has a small tank or "thermofore" on one side which answers the same purpose. There is a much larger opening than in a Clover for introducing the ether, which can be effected without removing the inhaler from the patient's face, and instead of the chamber revolving on the shaft, this latter is revolved within the chamber by means of a handle fixed to it. The face-piece is an exceedingly well-made one, and is attached to the ether reservoir by screwing it on to a thread. There is thus no risk of the face-piece becoming detached when a patient struggles violently, as sometimes occurs with the old pattern Clover. But the most important improvement, undoubtedly, is the wider bore of the shaft,

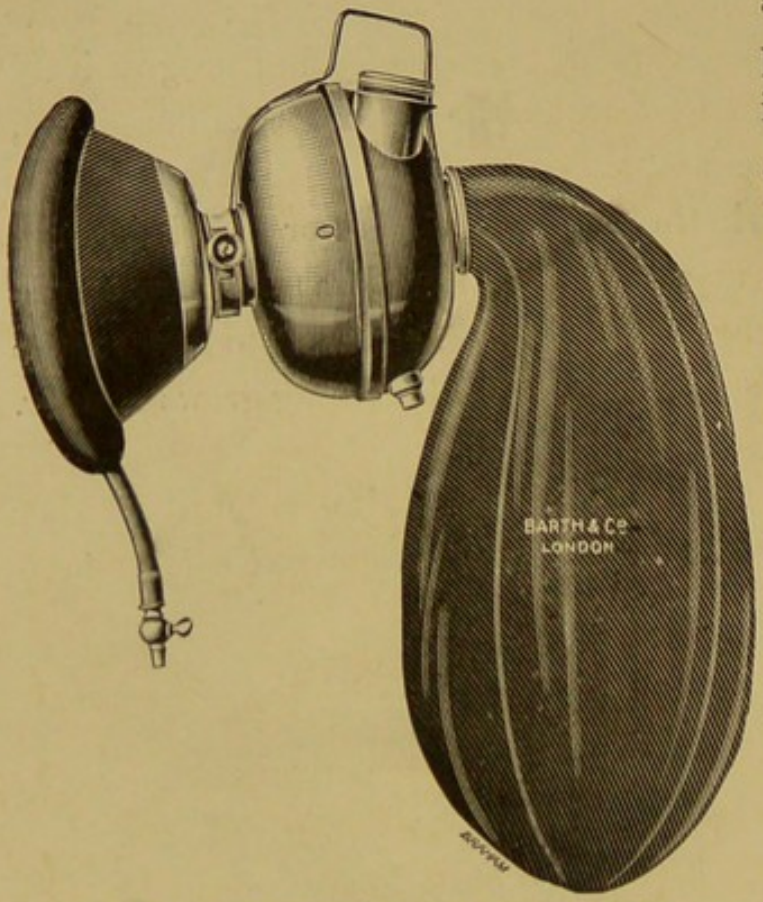


FIG. 14.—HEWITT'S WIDE-BORE INHALER.

which enables the patient to breathe with greater ease and freedom, doing away with much of the somewhat suffocating

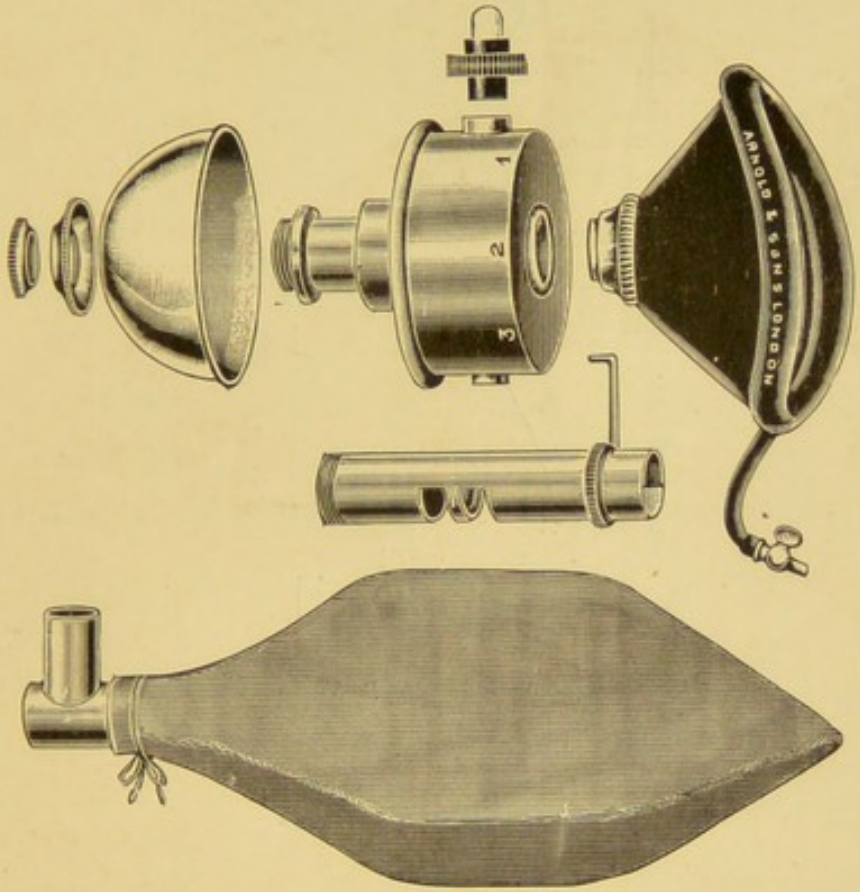


FIG. 15.—CLOVER'S INHALER IN SEPARATE PIECES.

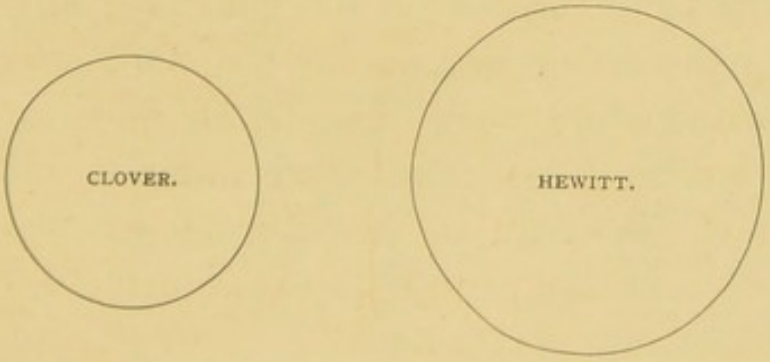
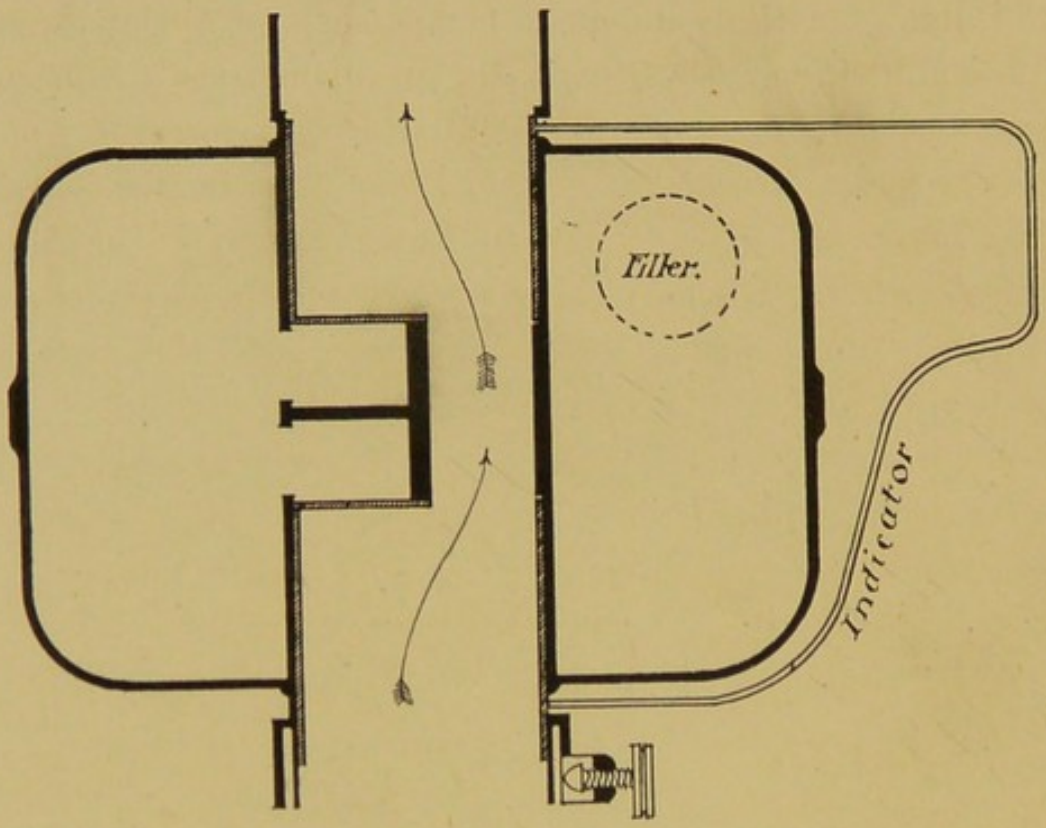
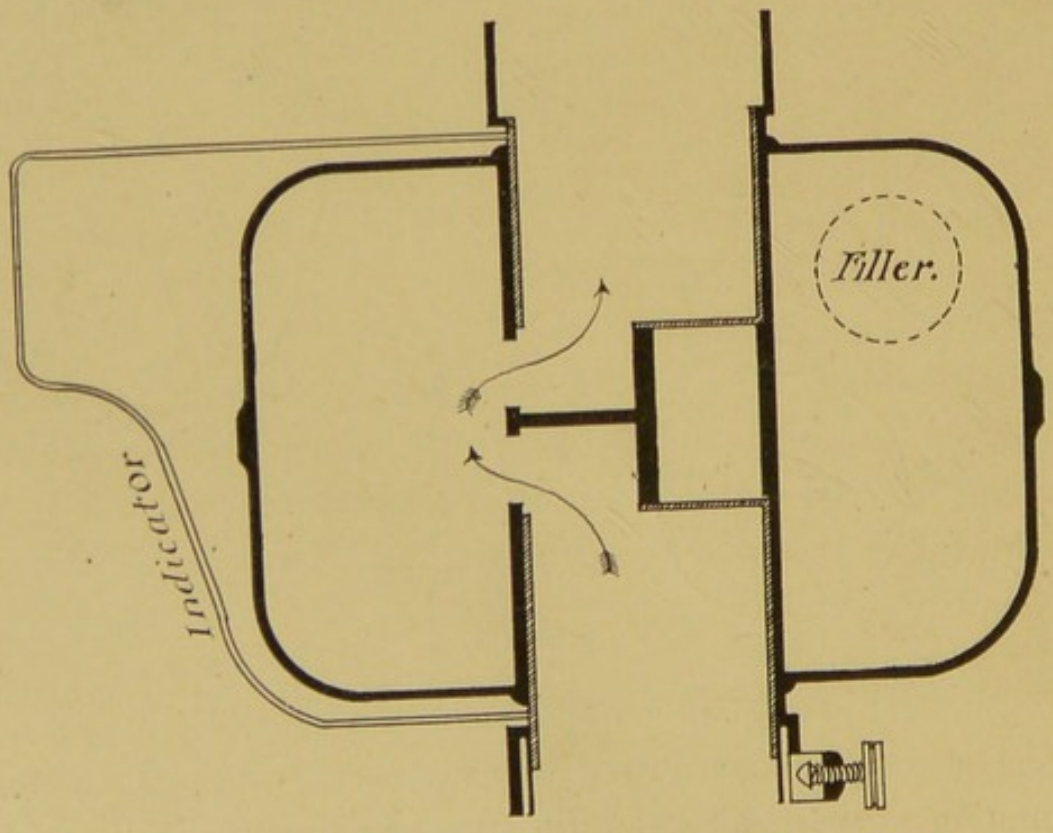


FIG. 16.—COMPARATIVE SIZE OF THE BORES.

sensation experienced with a Clover, and hastening the induction of anæsthesia.



A.—INDICATOR AT O.



B.—INDICATOR AT F. (FULL ETHER).

FIG. 17.—CROSS SECTIONS OF THE CHAMBER OF HEWITT'S INHALER.

When the index stands at O, the slots in the shaft and the casement of the shaft are in diametrically opposite positions, and no ether can pass out of the reservoir; at 1 they partially overlap, at 2 they do so to a further degree, while at F or full, as shown in Fig. 17 *B*, they completely coincide, and ether is passing freely from the chamber into the shaft and thence into the bag and the patient's lungs.

A great deal of importance must be attached to the construction of a face-piece, which should be so designed as to adapt itself closely around the patient's face, and not allow any leakage of air at the junction of the nose and the internal canthus. It should not be oval or circular as regards its shape on cross section, but narrow at the top and broad at the base; looked at from the side the cushion should form an arc of a large circle and not be simply vertical.

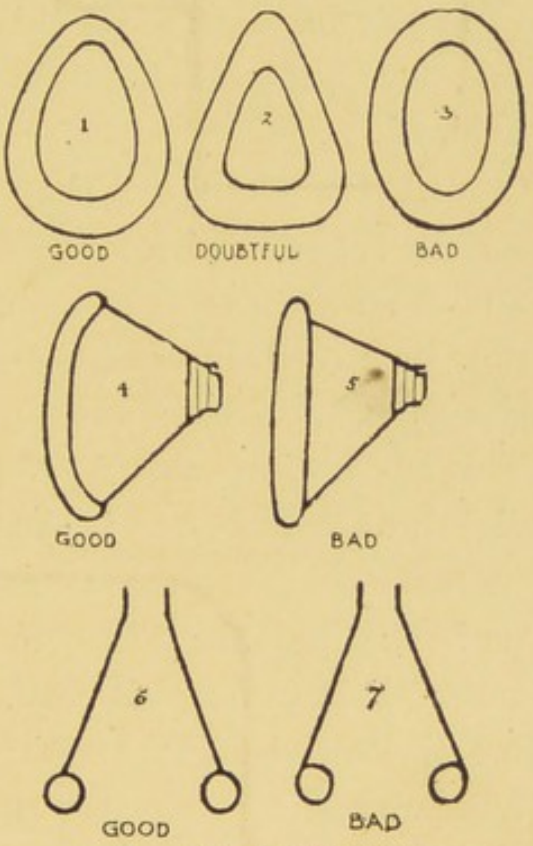


FIG. 18.—FACE-PIECES.

The accompanying diagrams will show the features of a good type of face-piece better than they can be described.

RULES FOR USING CLOVER'S OR HEWITT'S INHALER.

I. If the inhaler has recently been used for another operation, thoroughly cleanse the face-piece with 1 to 20 carbolic and warm water and dry carefully.

II. Pour out any ether left in the chamber from the previous administration.

III. Pour an ounce and a half of ether into the filling tube, replace the stopper, and see that the index points to O.

IV. Adjust your face-piece to the shaft, and blow through the apparatus to remove any traces of ether vapour present in the shaft of the apparatus.

V. Carefully adapt the face-piece to the patient's face, ask him to blow out, give him a breath of air, get him to expire again, and repeat this until your bag is three-fourths full, but on no account blow up the bag with your own expirations.

VI. Having allowed the patient to breathe backwards and forwards two or three times, carefully turn the indicator on about an eighth of an inch. The patient's face should be now turned on its side, so that any saliva which is secreted lies on that side and may later be removed with a towel. This is *most* important. Now turn on your indicator another eighth of an inch, and if the patient does not hold his breath increase this. If the ether be turned on too quickly, the patient will hold his breath and cough and retch; and sneezing is sometimes seen. If the patient does hold his breath, turn back the reservoir till his breathing is again regular. The respiratory rhythm is nearly always interfered with to a slight extent by swallowing or temporary holding of the breath; but, after about a minute and a half, the breathing becomes regular and deeper—probably simultaneously with the loss of consciousness. The administrator should now turn on the ether more freely than before, but not so rapidly as to excite the heart; not in jerks, but slowly and progressively. No fresh air having yet been admitted, the patient will probably look rather dusky.

VII. Do not give any fresh air until there is a distinct

indication for it. Disregard moderate duskiness or lividity unless associated with impaired respiration or circulation; if the breathing is stertorous along with lividity, air must certainly be admitted. Healthy, vigorous patients more commonly become quickly dusky than patients in a condition of asthenia from prolonged illness. If the air be too early admitted when the patient is dusky, he will very probably come round enough to hold his breath, set his teeth, or start coughing, and give the administrator trouble. When the patient is once thoroughly under, generally from three to four minutes from the commencement, an inspiration of air may be allowed, the administrator taking care to catch the next expiration in the bag. The more vigorous the patient, the more necessary is it to be careful as to the amount of air admitted, if anæsthesia is to be secured without struggling or excitement. When dealing with feeble patients and those who are gravely ill, speed in securing anæsthesia must yield to regard for the patient's colour.

VIII. Roughly speaking, a breath of air may be given in every five inspirations, but the more air the patient gets, the more ether he will require to keep him anæsthetised. I have latterly found that it is quite possible, once having got the patient well anæsthetised, to keep him so when the bag is removed and ether turned on to full, re-application of the bag being only necessary if the patient shows signs of lightening anæsthesia.

IX. If the patient shows symptoms of excitement and commences struggling, the inhaler must be closely applied and ether pushed. The asphyxial element, which is so dangerous under chloroform at any stage, is without any considerable risk when we are giving ether; the only point being that the more air deprivation the patient is subjected to during the operation, the more likely he will be to suffer

from severe after-sickness and headache. In persons with feeble circulation and elderly people with possibly atheromatous arteries, the administrator should avoid any prolonged suspension of breathing, and not run any risk of putting too great a strain on the disordered circulatory apparatus.

X. In dealing with children and women not of a robust type, it will be often sufficient to keep the index at some point between one and three ; but, on the other hand, with strongly built alcoholic males, it will often require the closest application of the inhaler to keep the patient relaxed and passive.

XI. Generally speaking, the initial ounce and a half of ether will last fifteen minutes, but in patients of stalwart build, in robust health, it will be well to add another ounce prior to the commencement of the operation.

XII. In cold weather, warm the chamber of the inhaler before a fire for five or six minutes, or immerse it in *hot* water.

If Blake's inhaler be used, the metal part may be similarly warmed, while, instead of a bandage, a hollow cone sponge carefully wrung out of hot water by twisting it in a towel may be used. This causes the ether to evaporate more readily.

These details, trifling as they may seem, will often make all the difference between good and bad anæsthesia.

Ether is now so generally taking the place of chloroform for the routine production of anæsthesia that the phenomena attending its inhalation are worthy of careful consideration and study. To administer successfully, some amount of training is essential. With proper attention to a few guiding principles, and with a little practice, the administrator will find he is able to materially lessen any disadvantages ether may have as an anæsthetic, and, without danger to his patient or

anxiety to himself, produce by its means a most satisfactory anæsthesia for surgical operations. Ether anæsthesia is as safe as profound surgical anæsthesia can reasonably be expected to be, although there is an amount of respiratory activity frequently caused, not seen in chloroform, and although the air-passages are more often temporarily occluded than when that anæsthetic is employed. The most important point concerning the use of this valuable agent is that, when once a deep narcosis has been produced, the administrator may feel assured that he will receive sufficient warning, should untimely symptoms occur, to meet them with deliberation and success. When chloroform is being used, patients not infrequently pass into a condition of some danger with little or no warning to the administrator. Under ether, healthy patients may be raised into a sitting posture; may be subjected to a slight operation before they are very deeply anæsthetised; their air supply may be so restricted that considerable cyanosis is occasioned; and yet the circulation will not show that liability to sudden fluctuations and depressions so commonly seen under chloroform. Moreover, the breathing under ether is usually quite obvious and audible, and any alteration in rhythm or character may be at once noticed; the inaudible and sometimes shallow respiration met with under chloroform is almost unknown under ether.

Owing to the rapidity with which patients become anæsthetised by ether under ordinary circumstances with a closed inhaler like Clover's, we do not now have such an opportunity of studying the so-called stages of the inhalation. They do not differ to any marked extent from those of chloroform anæsthesia.

First Stage.—Swallowing, cough, and some holding of the

breath are rather more common than with chloroform, except when the administration of the ether is preceded by nitrous oxide. The pulse is considerably accelerated, and the pupils are large and very mobile. The patient rapidly gets into a state of analgesia, in which, though perhaps conscious to some extent of his surroundings, he will not experience pain from the infliction of an injury.* A tooth, for example, may be painlessly extracted during this stage, the patient being aware, however, that something is being done, and even talking very distinctly. Simple incisions may be made, sutures and drainage tube may be removed, and various other brief operations and manipulations carried out without suffering to the patient.

If the ether be pushed no further than the height of this stage, the patient is in his usual condition in about ten minutes, and will probably suffer from no after-sickness, but may go about his business as if nothing had been done.

Second Stage.—The patient becomes abruptly unconscious; memory, volition, and intelligence are abolished; questions may be answered, but the answers will be nonsensical. Struggling, shouting, and singing may be met with in robust patients. If the patient struggles, his movements must be just passively resisted. He must have no sense of antagonism, and strapping to the table or mechanical restraint of any kind is most undesirable. During this stage we sometimes see the phenomenon known as "Ether tremor." In my own experience it has occurred in somewhat less than two per cent. of cases. It is speedily put an end to by deepening the anæsthesia. The patient's face is

* Known in the United States as "Primary Anæsthesia," and largely utilised for minor surgical operations.

flushed, his conjunctiva injected, and perspiration, especially over the face, is commonly seen. The pulse remains quickened and robust in quality. The breathing is inclined to be somewhat hampered during this stage, owing to a tendency to general muscular spasm. As the anæsthesia deepens, however, the breathing becomes regular, and commencing stertor may be detected.

With a close inhaler the first two stages are passed over, and the third stage of deep anæsthesia reached, in three to four minutes.

Third Stage.—In this stage we have the typical signs of true surgical anæsthesia. The cornea is insensitive to touch. Muscular relaxation is present, and the extremities are flaccid. The breathing becomes regular and somewhat stertorous; the stertor, along with the duskiness which will often accompany it, is speedily relieved by allowing some breaths of air.

The operator, if unaccustomed to ether, not uncommonly remarks on the blueness of the patient's blood on making his incision, but this is speedily eliminated by a few breaths of air.

The pupils differ from chloroform pupils in some respects. Their size varies from $3\frac{1}{2}$ to $4\frac{1}{2}$ mm., and they sluggishly respond to light. No great reliance can be placed on the pupils as land marks until the anæsthesia has been established for a little time. The administrator need not be alarmed by an extremely dilated pupil if the patient's colour be good, for, in certain cases, it is impossible to obtain a very deep anæsthesia without this.

The pulse is full, bounding, and regular; and incised parts are often very vascular, the surgeon not uncommonly remarking on the free hæmorrhage. The pulse has somewhat

slowed down from the earlier stages. Some patients perspire very profusely.

Difficulties and Complications during Ether Anæsthesia.

During the administration of ether, complications and fatalities occur much in the same manner as with chloroform, but we find the possibilities and occurrence of fatalities are much less numerous.

The complications which we most frequently have to encounter are the following :—

(1.) Overdose by pushing the anæsthetic too far. The respiration will show signs of commencing failure ; the conjunctiva will be insensitive to touch ; the pupil more or less dilated ; the colour dusky rather than pale ; the eyelids slightly separated, but the pulse often remarkably good considering the respiratory depression. However failure of respiration may arise, *the circulation of the patient at the moment when breathing ceases is sufficiently satisfactory for remedial measures to be almost invariably successful.* In other words, when the breathing ceases from excess of ether in a healthy patient, the pulse is still beating at the wrist. Simultaneous cessation of breathing and pulse, occurring sometimes from too rapid administration of a large quantity of chloroform, is unknown with ether anæsthesia in moderately healthy persons.

(2.) Respiratory embarrassment leading to failure may occur independently of an overdose, especially during early anæsthesia, often passing away as soon as the anæsthesia is deep. It may be due

to masseteric spasm, swelling of the tongue, and a varying degree of laryngeal spasm. Florid vigorous subjects may clench their teeth and hold their breath, necessitating the insertion of a mouth wedge or Mason's gag. Respiratory embarrassment from these causes, unless it has existed for a considerable period, is always unattended by cardiac depression.

(3.) Failure of circulation independent of overdose is practically unknown apart from some pre-existing condition of a pathological nature, such as goitre, grave cardiac disease, the occurrence of profuse hæmorrhage, or severe surgical shock.

(4.) Foreign bodies, blood and vomitus, may pass into the larynx and trachea, just as in chloroform.

(5.) Apoplexy has been recorded, but is extremely rare. The administrator should take this possibility into account, however, in dealing with a patient of advanced years with brittle atheromatous arteries.

The rules guiding the administrator as to the depth of anæsthesia in ether differ a little from those in chloroform. The proper level of anæsthesia will vary entirely according to the nature of the operation. Abdominal sections, operations on the genito-urinary tract, or in the region of the rectum, especially where dilatation of the sphincter is requisite, call for profound anæsthesia. Some patients seem to have peculiarly irritable vomiting centres, and in dealing with these, particularly during operations on the abdomen and the region of the neck, deeper anæsthesia will be necessary to completely paralyse this centre. The administrator is, as in the case of chloroform, guided by—

(1.) The respiration.
(2.) The occurrence of swallowing movements.
(3.) The lid reflex.
(4.) The size of the pupils, and their mobility or fixity as the case may be.

Contra-Indications for Ether.

However safe ether may be as an anæsthetic, the list of cases in which it is unsuitable is a formidable one. Dr. Dudley Buxton, who is a strong advocate for ether, enumerates the following cases in which it should *not* be used :—

(*a.*) In protracted operations about the mouth, jaws (other than the extraction of teeth), 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.

(*b.*) All operations needing the employment of the actual cautery, or lighted candles, lamps, &c., in the vicinity of the mouth, ether being highly inflammable, and when mixed with air detonating, so that the incautious approximation of a light may lead to grave consequences.

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

(*d.*) 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.

(*e.*) The vascular excitement to which ether gives rise contra-indicates its use for persons whose arteries are pre-

sumably 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 may, by increasing arterial tension, induce a repetition of so dangerous a complication.

(*f.*) As ether always 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. However, with the exception of the conditions considered under (*e*), *no hard and fast rule negatives the use of ether.* Further, other anæsthetics may be contra-indicated, and then ether may be advisable, even in cases grouped under (*a*), (*c*), and (*d*).

* On the other hand, however, Dr. Armstrong, of Kirkintilloch, recently told me he has known apoplexy to occur on two occasions after chloroform administration.

CHAPTER V.

CHLOROFORM ($CHCl_3$).

CHLOROFORM is undoubtedly the anæsthetic we could least do without. Discovered in 1831 by Soubeiran, its chemical formula was ascertained by Dumas in 1835, and Simpson first used it for pain-killing purposes in 1847. It is a colourless, transparent, mobile, volatile liquid, with a sweetish not unpleasant odour and fiery taste. Only that made by a thoroughly reliable firm should be used. There are three well-known Edinburgh makers, whose names it is needless to mention, and in these the fullest confidence can be placed. It is an interesting fact that most of the chloroform used all over the world is made in the city where it was first employed.

Chloroform will keep well if stored in a cool, dark cupboard in small bottles. Some chloroform made during the Russian War, with two per cent. added alcohol, by MacFarlan, has kept in good condition since 1857. If, owing to circumstances, chloroform has been laid aside for some time, it should be carefully examined before using.

(1.) It should have a S.G. of 1·495 at 62° F.

(2.) It should be transparent and colourless.

(3.) It should be neutral to test paper.

(4.) It should have an agreeable non-irritating odour.

The Apparatus for Administering.—The vehicles most commonly employed are the following :—

A Handkerchief.
A Napkin.
A Piece of Lint.
Schimmelbusch's Mask.
A Towel.

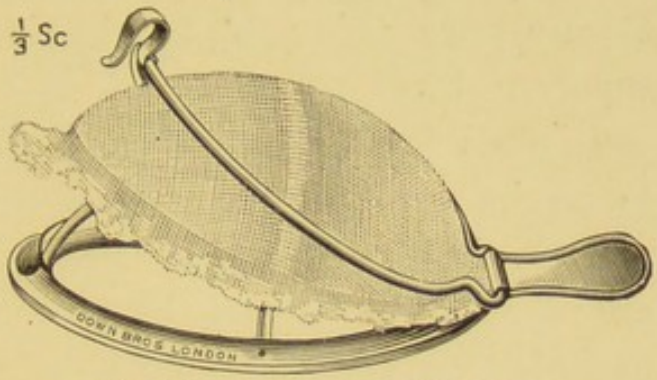


FIG. 19.—SCHIMMELBUSCH'S MASK.

These must be supplemented by some form of drop bottle, of which there are various patterns — Skinner's and Mill's being the best.*

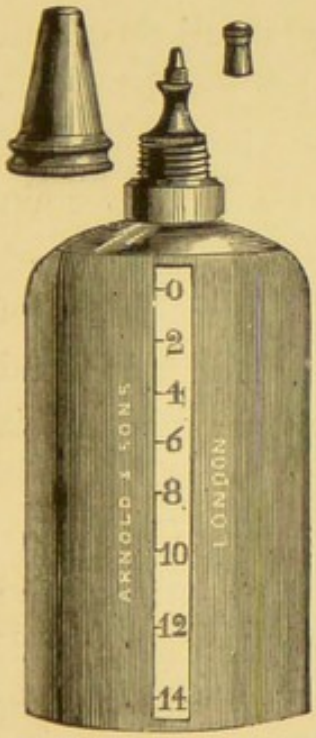


FIG. 20.—SKINNER'S BOTTLE.

Technique of the Administration.—The patient, having been as carefully prepared as circumstances permit, is laid in the supine position,† and, whenever possible, on the table on which he is to be during the operation. Nervous patients may object to this, and then the anæsthetist must accommodate himself to circumstances. It is very objectionable to have to give chloroform to a patient lying in bed, but if it has to be done, the patient should be asked to lie, so far, diagonally across the bed.

* A quite efficient, but inexpensive drop bottle can be readily improvised with a flat 2-oz. medicine bottle and a perfume stopper.

† Chloroform, more than any other known agent, rapidly abolishes the vascular mechanism which compensates for the hydrostatic effect of gravity (L. Hill).

The physiological experiment of glass tube and rubber tube and stop-cock, connected with a water-cistern, very well illustrates the difference between the blood-vessels under the influence of chloroform and normally. In a patient fully under chloroform the arteries have almost as little capacity to compensate for gravity as a gas-pipe.

If two or more pillows are desired, the anæsthetist may concede the point to humour the patient, as many as necessary being rémoved when unconsciousness has supervened.

It gives no offence in these days, even with the fair sex, to inquire as to the presence of artificial teeth ; if they are present, they should, of course, be removed. A few words are necessary to reassure the patient, and gain his confidence, as he is almost certain to be dreading the anæsthetic more than anything else. "They are told they will know nothing of the surgeon's work, but they do know that they will be unpleasantly conscious of those palpitating sensations which precede the anæsthetic sleep. To lie on a table and breathe a subtle vapour which will soon cloud the anxious brain and plunge the throbbing personality into an outer and uncertain darkness, is no slight ordeal" (Treves).

The attitude of the anæsthetist must therefore be one of kindly sympathy, blended with sobriety, and he should endeavour to inspire the patient with confidence in his carefulness and experience.

Turning the patient's head slightly to one side, a few drops of chloroform are sprinkled on to the centre of the mask or lint, which is gradually brought to within about half an inch of the patient's face. No coughing or choking should be produced, but as soon as the patient has become accustomed to the vapour, the mask should be removed, and about half a drachm of chloroform sprinkled on the inside layer of lint, and the mask again approximated to the face. This should be repeated about every thirty seconds until the patient loses consciousness, in a normal case. On no account must any air restriction be permitted, but an interval of about half an inch should be allowed to remain throughout the administration between the patient's face

and the margin of the mask. If struggling occur, the chloroform should at once be withdrawn, and the struggling be passively resisted, any violent movements being restrained. When the patient quiets down again, as he invariably will if rationally treated, the administration may be resumed.

Care is necessary to see that the lint on the mask does not become so saturated with chloroform as to allow of

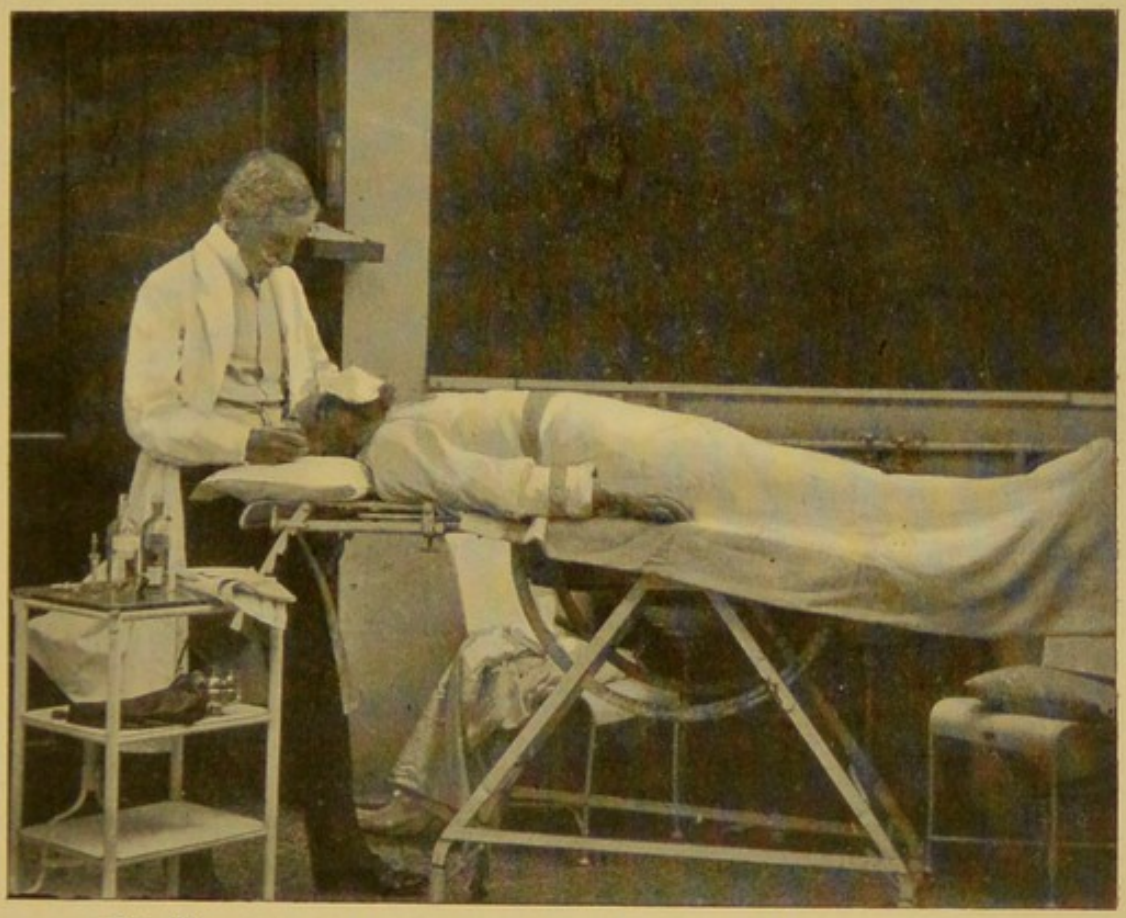


FIG. 21.—ADMINISTERING CHLOROFORM ON A SCHIMMELBUSCH MASK.
(The head should be a little more on one side.)

dripping on to the patient's face. If this be seen to, and the patient's face kept on the side throughout the administration, the use of vaseline, to prevent blistering, will be superfluous.

From the time of the introduction of chloroform until quite recently, the Edinburgh method has been to use a towel, in one form or another. Syme's method was to fold

it into a sort of cone, open at both ends, and fastened with a safety-pin. Simpson gave chloroform on a single layer of towel spread over his fingers, while Lister used the corner of a towel drawn through a safety-pin. Others have recommended the folding of the towel flat in several layers—about 6 ins. by 10 ins.—and then bending the oblong thus produced to the shape of a ridge tile.

Chloroform has generally been poured on freely from the original ½-lb. or 1-lb. bottle, and no particular regard paid to the quantity used. While this has—or should have—the advantage of making the administrator watch his patient and not count the drops of chloroform, it undoubtedly puts the patient in a position of unnecessary jeopardy. Too large a quantity is put within his reach at one time, and if the administrator's attention is distracted for a moment or two —no uncommon occurrence with the beginner—an overdose may be inhaled. While a fatal issue need not always result, yet "scares," and need for restorative measures are more common than if the anæsthetic be added in a somewhat more homœopathic manner.

The essential principle in chloroform anæsthesia is merely to give sufficient to get the patient completely anæsthetised, and then by repeated small doses—the call for which is seen by the closest observation of the patient—to keep up a degree of anæsthesia suitable for the operation being performed. This is what may be termed the "continuous" method. To merely get a patient anæsthetised, and then wait until obvious and active signs of returning consciousness, such as vomiting and struggling, show themselves, is an elementary performance in no way adapted to the successful carrying out of modern surgical operations.

Chloroform cannot be used "to charge up a patient" in the manner in which ether is employed occasionally, for it is

far too powerful a poison. Ringer has shown that it is ten times as powerful an anæsthetic and toxic agent as ether, and Waller has confirmed this observation.

Stages of Anæsthesia.

Somewhat arbitrarily chloroform anæsthesia and its induction have been divided into four stages or degrees.

It is always difficult to draw a hard and fast line between one stage and another in any particular case, but for purposes of convenience, &c., there are generally considered to be four stages. It is undesirable that the administrator should be practically acquainted with the fourth and last stage, but his recognition of the first three will be necessary, for, as will be seen later, different depths or degrees of anæsthesia will be required for different operations and stages of operations.

First Stage.—The patient swallows and coughs slightly, is often restless, and turns his face if possible away from the anæsthetic—if it is too closely applied he will hold his breath, and inevitably a long sighing inspiration or gasp will follow. Flashes of light, buzzing or hammering,* rhythmical and developing into a mere ringing in the ears, are experienced. A curious and indescribable thrilling sensation is felt throughout the body, the general effect being somewhat exhilarating. Thoughts and ideas occur in rapid succession and in the most vivid manner.

The patient in the latter part of this stage is usually analgesic, without being in a really anæsthetic condition; he is conscious of his surroundings but unconscious of pain.

* Recently I was giving a woman chloroform, and she said several times, "Oh, stop that hammering!"

Second Stage.—The patient now becomes rapidly unconscious. He will mutter, laugh, and talk nonsense, and respond to any questions, but not in a rational way. His conversation is usually in regard to something in connection with his occupation. Thus a soldier will quote something from the drill-book; a housewife will discuss some domestic matter in a garbled way, or make some nonsensical inquiry of her "doctor." Struggling will now commonly occur, particularly in the male sex, and all alcoholics, especially if the chloroform is pushed. The face will flush, the pulse increase in rapidity, the pupils are dilated and mobile, and a marked conjunctival reflex is still present. There is a tendency to sickness in this stage, particularly if it is dwelt over, and any pallor or depression of the circulation should be taken as an indication for more chloroform. If the patient flushes and struggling occurs, the chloroform should be withdrawn, and the patient's efforts passively resisted until the anæsthesia deepens, as it will, and the struggling subsides.

Any mechanical restraint, such as strapping, &c., is better avoided if possible.

Third Stage.—The patient now becomes completely anæsthetised. The breathing becomes regular and automatic, like that of a sleeping person, often with a soft, quiet snore. The pupils contract usually to a diameter of 2–3 mm., but this is by no means invariable, and they should react sluggishly to light. The lid reflex has disappeared. The muscles throughout the body are relaxed. The pulse is somewhat slower than normal and more compressible. The eyeballs are usually fixed in a horizontal plane, or rotating very slowly from side to side. The administrator should beware of being misled by the condition of "false anæsthesia." This is particularly common in children, and is probably due

to the patient simply going to sleep. There is a tightly contracted pupil, usually smaller than the typical chloroform pupil, the breathing is quiet, regular and automatic, and conjunctival reflex absent. A sharp pinch, a prick, or the primary incision will wake the patient completely up, and reveal to the chloroformist the painful fact that he is still practically in the first stage. When the pupil, therefore, is very contracted, the administrator must be on his guard, and have recourse to a sharp pinch before telling the surgeon that he may proceed. To recapitulate briefly, the four signs of the establishment of full chloroform anæsthesia are :—

(1.) Automatic respiration.

(2.) Loss of conjunctival reflex.

(3.) A fixed and more or less contracted pupil.

(4.) Muscular relaxation.

Unless these are present, in the very large majority of cases no operative procedure should be undertaken.

A few words are specially needed as to *the treatment of young children.* The breathing here is all important ; little reliance can be placed on the pupil, and less on the conjunctival reflex. A useful sign, however, is the rotation of the eyeballs, which commonly occurs on the advent of anæsthesia, downwards upon a horizontal axis. In very young children, also, in the early stages, the fingers will clasp tightly on any object, such as the nurse's finger, placed on the palm. This is due to a sort of hereditary prehensile instinct. As the anæsthesia deepens, the fingers relax. "False anæsthesia" is particularly common in children. The ruling principle, however, in dealing with them must be "err on the safe side," and give too little rather than too much chloroform, for reflex troubles do not commonly arise, and the real danger is absolute chloroform poisoning ; that is the production of the

Fourth Stage.—Impairment or complete cessation of respiration ; an abnormally slow, feeble, or running pulse, tending to become irregular or imperceptible ; moderately to widely dilated *fixed* pupils ; complete absence of lid reflex ; dusky pallor of complexion and separation of eyelids : such are the indications of *overdose* of chloroform.

If the administration is conducted rapidly and recklessly, and without the absolutely essential precaution of giving plenty of air, the patient may die so suddenly that the order in which the fatal symptoms arose cannot possibly be recognised. This occurs sometimes quite at the beginning of an operation. Perhaps the case is one of tooth extraction. The patient does not go under easily ; he is well dosed with chloroform, and just at the first tooth he turns pale or ashy gray and stops breathing. He is often said to have died from cardiac failure or shock, when it is simply undetected asphyxia *plus* excess of chloroform. How death occurs also in such cases from shock during imperfect anæsthesia will be shown later on.

Chloroform anæsthesia affords an excellent opportunity of studying the action of the drug on the various centres of the nervous system, from the highest downwards. The first parts to be stimulated are the cerebral centres with mental functions, the control of special senses, and consciousness ; and these also are the first to be depressed and annulled. The lower cerebral and spinal centres are affected less and somewhat later, so that a certain degree of excitement of these accompanies the first cerebral depression, and the spinal centres being no longer controlled by the cerebral, irregular, excessive movements of the limbs ensue. As the depression deepens in the spinal centres, the muscles are paralysed. Lastly, the lowest centres of all, those connected with organic life—connected with the heart, vessels,

respiratory organs and sphincters—situated in the medulla and cord, yield to the action of chloroform. Although affected from the first, it is not until higher parts have been completely overpowered that the functions of these vital centres are seriously impaired and death threatens. It is on account of the safe order of invasion of the different centres by chloroform that it has been selected as the proper agent for temporarily arresting consciousness. There are many other powerful drugs which equally depress the nervous system, but in a reverse order.

The peripheral nerves are affected last, and the loss of sensibility is due to a central and not a peripheral effect. The muscles are finally affected directly as well as through the nervous system.

The essential characteristic of chloroform anæsthesia is *depression*. Paralysis of the respiratory centre is the most usual cause of death in fatal cases, but is often accompanied or immediately followed by paralysis of the cardiac centre, while primary cardiac failure is not unknown.

Syme's one rule in chloroforming was "Watch the breathing;" and too much importance cannot be attached to it. Professor Macewen well says: "Let the sound of each respiration be registered on the tympanum of the administrator."

The colour of the ears and lips is of great assistance in estimating the vaso-motor tone. Too great a readiness to feel the pulse when giving chloroform is to be avoided. It varies a great deal during the conduct of an anæsthesia, and constantly feeling it may cause a great deal of unnecessary anxiety and mislead one. A bad pulse may be caused from too little chloroform and also from too much.

The experienced anæsthetist judges of the condition of the patient from no single sign, but from the breathing,

condition of pupil, colour of lips, amount of chloroform given, the type of the patient and nature of operation.

The Pupil during Anæsthesia.—The pupil is a most valuable aid to the administrator, as enabling him to determine with some exactitude, taken along with other signs, the stage of anæsthesia in which the patient is.

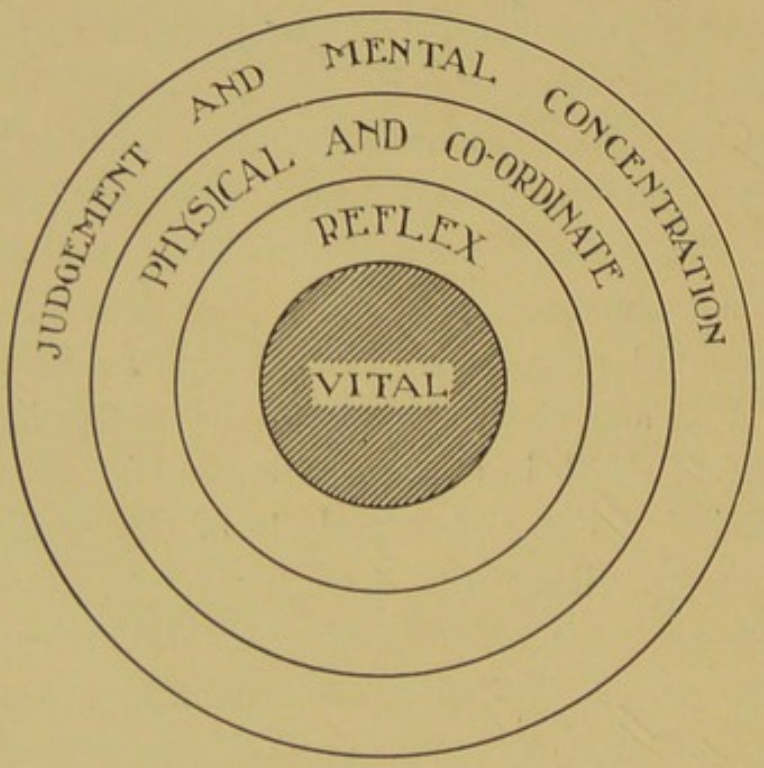


FIG. 22.—DIAGRAMMATIC REPRESENTATION OF INVASION OF NERVE CENTRES BY CHLOROFORM.

(In true $CHCl_3$ anæsthesia all the centres but the vital—centres of circulatory and respiratory organs—are paralysed.)

On the application of chloroform to a patient for inhalation, the pupil rapidly dilates from stimulation of the sympathetic. As soon as the patient loses consciousness and begins to breathe more regularly and deeply, the pupil as a rule gradually decreases in size, due to stimulation of the oculo-motor nerve by the drug, and in a normal case of chloroform anæsthesia usually contracts until it is about 2·5 mm. in diameter.

Push the anæsthetic further, and it will dilate again, being fixed and not responding to the stimulus of light. Here the dilatation is due to paralysis of the third or oculo-motor nerve, and thus of the sphincter pupillæ, and the patient is in a dangerous condition.

Much the same may be said of the pupil in ether anæsthesia—but here the pupil does not contract so markedly as with chloroform, being usually about 3·5 mm. in diameter in good anæsthesia. The ether may be pushed beyond this stage, however, and the pupil become somewhat dilated and fixed without any degree of danger. When the pupil becomes *small—i.e.*, less than 3·5 mm.—and mobile, with

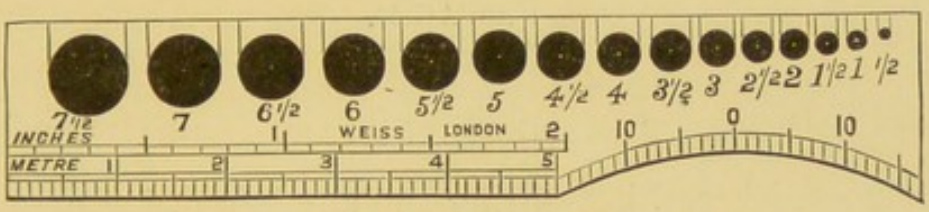


FIG. 23.—BROWNE'S PUPILLOMETER.

ether anæsthesia, the patient is lightly under and will rapidly come out or vomit if the anæsthetic is not rapidly re-applied.

Less reliance can be placed on the pupil when using ether than with chloroform, and with neither can it be of much use until the anæsthesia is fairly established.

Under chloroform the pupil dilates from four causes—

(1.) Vomiting.
(2.) Vaso-motor depression.
(3.) Too much chloroform.
(4.) Commencing asphyxia or CO_2 poisoning.

In the two first named the pupil is usually mobile and responds to light.

In the two later (which often co-exist) the pupil is immobile and does not respond to light.

Recapitulating—During chloroform anæsthesia a dilating and mobile pupil indicates need for more chloroform.

A dilated and fixed pupil means "Stop the chloroform, remove any possible obstruction to the air-way, such as a tongue fallen back, and be on your guard generally."

What are the troubles that are apt to arise during chloroform anæsthesia apart from chloroform poisoning?

(1.) Cessation of Respiration.

(2.) Cardiac Failure.

(3.) Vomiting.

(4.) Passage of Food, Mucus, &c., into Air-Passages.

I.—Cessation of Respiration Apart from Overdose.

Obstructed breathing during the administration of chloroform is especially prone to occur in highly nervous, in muscular, and in alcoholic subjects. During the second stage of chloroformisation it demands special care. The abdomen may be hard, the chest fixed, jaws clenched, and tongue pressed against the palate and pharynx, and respiration may become completely arrested for a while. The arrest is the result of muscular spasm, and the air-way actually becomes temporarily closed. It is directly after this condition that overdose is apt to occur. By holding his breath the patient raises the intra-thoracic tension. Through this the venous system is congested and less blood pumped into the arteries; the arterial tension is lowered, and less blood is supplied to the coronary arteries. Also owing to no breathing going on, less oxygen is supplied to the lungs, and so the supply to the cardiac muscle is of poor quality and the heart is *pro tem.* asthenic. On the relief of the obstruction, or

when the patient starts breathing again, two or three deep inspirations are taken, and if chloroform has been freely poured on to the inhaler, a large dose is inspired. Some of it at once passes into the coronary arteries to an already enfeebled heart, which by this poisonous overdose is thrown into a state of paralytic dilatation from which it rarely recovers. This is one of the most common ways in which death occurs in early stages of chloroformisation.

A slight movement of the patient's arms and hands during chloroform anæsthesia is not by any means always to be taken as a sign of the patient coming out. It is not uncommon for the arm or arms to be more or less rhythmically jerked, by a sort of clonic spasm, towards the middle line, while the fingers are alternately flexed and extended.* This may be due to spasm of the pectoral and other muscles, and indicate a pressing necessity for more air and less chloroform. The automatic and perhaps stertorous breathing of the patient, combined with a dilating and fixed pupil, enable one to differentiate between this condition and the mere gesticulations of a patient who is only semi-anæsthetised.

There is one form of respiratory obstruction which the student will meet with in all probability in his first case of chloroform—simple falling back of the tongue. Relaxation of muscles is one of the normal and necessary accompaniments of true anæsthesia, and, along with the other muscles, the elevators of the tongue relax, and allow it to slip down and back and partially occlude the opening of the larynx. The slight stertor caused by this is not to be regarded as an indication for immediate tongue traction. It is a characteristic sign of the tyro to commence fishing away in the

* These are known as "Athetotic movements."

mouth for the tip of the tongue directly this phenomenon occurs. The proper treatment is to get the fingers well behind the angle of the jaw and drag it forward; the muscles of the base of the tongue are attached chiefly near the symphysis of the Inf. maxilla, and so, by dragging it forward, these are put on the stretch and the tongue raised. If the jaw is "underhung," some difficulty may be experienced in getting it well forward, and the aid of a mouth wedge or Mason's gag may be needed.

Spasm of the glottis due to approximation of the aryteno-epiglottidean folds is seen in adults, but more commonly in children. It gives rise to loud crowing breathing and to increasing cyanosis. The condition is usually relieved at once by rhythmical tongue traction.

II.—Failure of Circulation Independent of Overdose:—

(1.) From fright or shock before true anæsthesia in highly-strung nervous subjects.

(2.) During light anæsthesia from actual or threatened vomiting.

(3.) From partial asphyxia—that is, secondary to respiratory obstruction.

(4.) Due to strain of the operative procedure, excessive hæmorrhage, or withdrawal of fluid from abdomen or chest.

(1.) Fainting and collapse during early stages of inhalation are by no means uncommon, and death from syncope may occur. The anæsthetic is not altogether to blame, for, prior to the introduction of anæsthetics, death from fright, either before or at the commencement of an operation, was by no means unknown. The primary cause of death

is excessive emotion and fear. We see cases of death occurring in this manner recorded in the public press, and very often emphasis is laid on the small amount of anæsthetic given, but in this really lies the danger. The more rapidly such patients are got under the better, and hence the advantage of the rapidity of gas and ether in producing anæsthesia.

(2.) During light anæsthesia from threatened vomiting, &c. All troubles during anæsthesia are more prone to occur during light narcosis. The reflexes are not subdued completely, and the activity of the vomiting centre may give trouble. Why chloroform causes early vomiting in some patients and not in others is difficult to explain, but the fact remains. Sickly, pale, unhealthy girls are specially apt to give trouble in this way. The onset of vomiting is signalised by swallowing movements, sudden pallor, and dilatation of the pupil ; the pulse may become very shabby, and breathing shallow. The patient's face must be turned to one side and the chloroform *pushed*. As in the large majority of cases the patient has been fasting prior to operation, there is nothing much to come up—at least nothing solid. It is surprising, however, how much fluid matter, composed of swallowed saliva, mucus, and bile regurgitated from the duodenum, some patients can produce. If the case be an emergency one, and there is a possibility of a recent meal, it is best to let the patient be thoroughly sick while he is about it. ' Raise the right shoulder and turn him well over on his left side. After he has vomited, see that there is no solid matter hanging about mouth or pharynx, and proceed to get him well under. In patients suffering from heart disease, especially aortic disease, or even cardiac asthenia, there is considerable risk of syncope during vomiting.

(3.) The danger of cardiac failure, secondary to obstructed respiration and partial asphyxia, has already been referred to, and the treatment is simply prevention of the antecedent condition.

(4.) Failure of circulation, from the strain of the operation and continued use of chloroform, is by no means uncommon in prolonged operations. As has already been stated, the keynote to the physiological action of chloroform is *depression*.

How long the human organism can sustain this depressant action on the circulatory mechanism will entirely depend on the personal factor—on the presence or absence of a good condition in the patient operated on.

Death occurs :—

I. From overdose—either

(1.) Overdose acting on an anæmic and asthenic heart during struggling stage—*i.e.*, syncope ; *or*,

(2.) Overdose, pure and simple, during course of a long anæsthesia.

II. From syncope, caused by upright position of patient during chloroform anæsthesia.

III. From reflex cardiac inhibition ; * syncope or shock during light anæsthesia—*e.g.*, in dental cases, operations on the rectum, or castration.

IV. From partial or undetected asphyxia, with an amount of chloroform normal or non-toxic under ordinary circumstances.

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* Dr. Embley, Anæsthetist to Melbourne Hospital, has fully demonstrated that cardiac inhibition from the vagus does occur. *British Medical Journal*, 8th, 15th, 22nd April, 1902.

The Advantages of Chloroform.—Chloroform is indispensable, in spite of its drawbacks. Notwithstanding all that has been truly advanced against it, chloroform always has been, and probably it or mixtures of it will largely remain, the drug for producing anæsthesia which the general practitioner most commonly uses. The following advantages may be fairly claimed for it :—

(1.) It is pleasant in smell, and *seems* easy to administer. It produces little or no choking, so that even children often inhale it without demur or resistance.

(2.) Smallness of quantity required. In most cases anæsthesia is produced by a small quantity, and thus the bulk of the amount to be carried in the practitioner's bag is small. The odour does not cling to him for any time after using it. Sir James Simpson particularly urged its advantage in this respect over ether.

(3.) Quiet anæsthesia. Once the anæsthesia is produced, the patient lies completely relaxed and breathing quietly, and the absence of abdominal respiration and excessive movement is a distinct advantage in abdominal operations.

(4.) Chloroform is non-inflammable and less volatile than ether. In tropical countries ether evaporates so rapidly that it is extremely difficult, if not impossible, to anæsthetise a patient with it except with a closed inhaler ; also it is difficult to store, for a bottle of it, if not hermetically sealed, rapidly empties itself by evaporation.

The Disadvantages of Chloroform.—A great deal can be said against chloroform.

(1.) The high rate of mortality among patients put under its influence. We find that out of every thousand persons anæsthetised with chloroform one succumbs, and that the conclusion drawn from laboratory experiment as to this drug

being ten times as toxic as ether is confirmed in every-day practice.

(2.) It appears to possess what may be almost termed a selective action on the circulatory apparatus. Both man and animal show signs of progressive lowering of blood pressure and weakened heart action under its influence.

Sudden and unexpected diminution of blood pressure may occur at any time during chloroform anæsthesia :—

(*a*) At the commencement of the administration just after the repetition of a dose ; (*b*) while the patient is fully anæsthetised and the drug is evenly given ; (*c*) late on, in a prolonged surgical operation, or even after the administration has ceased for some time and the influence of the drug is passing off. At no moment can we be sure of the heart during the administration of chloroform.

(3.) Chloroform is essentially depressant to animal vitality, and is a protoplasmic poison. In some cases it causes fatty degeneration of the ganglionic cells of the heart, and of the cardiac muscle fibres ; also of the muscle cells throughout the body ; of the cells of the viscera and glands ; and of the coats of blood-vessels ; and these changes may produce fatal results long after the administration (Stiles). These facts constitute a strong argument against the routine use of chloroform for anæsthetic purposes, the truth and force of which cannot be denied, although, where its use is indicated, care and proper management can greatly lessen all its dangers.

The After-Effects of Ether and Chloroform.

(1.) Vomiting, retching, and nausea are the most frequent and worthy of note. The vomiting may vary from a severe and prolonged kind, lasting three or four days, to transient nausea and slight retching with a

little mucus. Much depends on the digestive history of the patient, and the care and precaution exercised in preparing him for the operation; the amount of the anæsthetic and the manner of its administration can also have some influence. A patient will more commonly suffer from severe sickness after two hours' chloroform for a severe abdominal section than after four or five minutes' anæsthesia for opening an abscess or evulsion of a toe nail. When administering ether, a great deal depends on the amount of air which the patient is allowed during the anæsthesia, and the maintenance of good colour at least after the initiatory stages. Accordingly, as far as possible, the bag of Clover's inhaler should be removed as often and for as long as possible when once the patient is completely anæsthetised. By so doing, constant cyanosis and slight carbonic acid poisoning are avoided. I am satisfied that the worst forms of vomiting seen after ether are due to want of this precaution, and the headache so commonly seen is similar to that which occurs after sitting for a long time in a small ill-ventilated apartment or at a smoking concert. There seems no more reason why a patient should be sick after ether when he has emerged from its anæsthetic effect and got rid of the ether-impregnated mucus which he has swallowed, than after a fairly large dose of alcohol. Chloroform, on the other hand, has a very strong tendency to produce nausea and sometimes severe sickness, not from any local irritating action on the digestive apparatus, but, I believe, from an irritant action on the vomiting centres

in the medulla and interference with the functions of the liver. Administered by the mouth, chloroform frequently stops obstinate vomiting, and, in the form of spirit of chloroform diluted, acts as a very comforting carminative.

(2.) Albuminuria, nephritis, and uræmia have been known as sequelæ to etherisation. There is little doubt, however, that there was in most cases pre-existent renal disease, and that neither chloroform nor ether has the power of producing anything more than a transient albuminuria, where the kidneys are previously in a really healthy condition. As, however, ether raises the blood pressure, and stimulates the kidney, often causing some polyuria, it is undesirable to administer it in some conditions of renal incompetency, and chloroform (or the CE mixture) is here preferable.

On the other hand, glycosuria may be produced by chloroform, and in some cases jaundice has been induced. Ether is more apt than chloroform to produce temporary mental and even maniacal excitement, and accordingly, when dealing with the insane or those having any tendency to insanity, chloroform is best where local anæsthesia is not sufficient.

(3.) "Ether Bronchitis" is the pet bugbear of those who advocate the exclusive use of chloroform, and the frequency of its occurrence has been greatly exaggerated, chiefly by persons having very little, and sometimes no practical experience of ether anæsthesia.

Personally, I have never had a patient die from this cause, nor have I seen more than a very few

cases altogether out of several thousand anæsthesias. In twenty years of private practice Mr. Pridgin Teale of Leeds only noted one case.

There is no doubt that bronchitis and broncho-pneumonia do occur occasionally after ether administration, but they are more common in hospital than private practice, which is probably due to the following causes :—

I. The operating theatre may be at too low a temperature ; or,

II. While the theatre itself is sufficiently warm, the patient, while still under the influence of the anæsthetic, is taken through a cold corridor back to the ward, and placed in his bed (possibly near an open window). This I actually know to be the case in an hospital where "ether-bronchitis" is of unduly frequent occurrence.

III. Septic pneumonia or bronchitis from dirty inhalers, or from some septic discharge from the nose, pharynx or mouth—*e.g.*, after tooth extraction, has often been attributed to ether.

An error in investigating these cases also arises from the fact that a certain number of cases admitted to hospital for operation will develop respiratory trouble, either in the shape of bronchitis or pneumonia, even if no anæsthetic be given. Further, in patients who previously suffered from bronchitis it sometimes recurs.

The proportion of patients suffering from true ether bronchitis is a very small one, provided the anæsthetic is properly administered, and the operating room, &c., kept at a proper temperature.

CHAPTER VI.

THE NITROUS OXIDE AND ETHER AND ETHYL CHLORIDE AND ETHER SEQUENCES. ANÆSTHETIC MIXTURES.

ETHER may be advantageously preceded by one of the minor anæsthetics, the advantage being that the patient is more rapidly rendered unconscious, without being subjected to the unpleasantly pungent smell and taste of the ether during the period of induction. Further, much time is saved, and practically all struggling avoided.

There are two distinct ways of using nitrous oxide and ether :—

(1.) Simply getting the patient partially anæsthetised with nitrous oxide, and then, before jactitation appears, passing the gas over the ether in the reservoir, keeping the indicator at F. for a period of from a half to one minute according to the length of anæsthesia required. The anæsthesia so obtained is a true "gas and ether" type. This must not be confused with—

(2.) Ether anæsthesia preceded by nitrous oxide (Dr. Hewitt's method), where a three-gallon bag attached to a Clover is filled with nitrous oxide, and simply used to render a patient unconscious for, perhaps, a prolonged operation under true ether anæsthesia.

Neither of these methods is well suited for children under

ten years of age, as the somewhat extensive apparatus is rather apt to frighten them. For such patients the

Ethyl Chloride and Ether Sequence is much better adapted, and it is rapidly growing in favour at the present time for all classes of cases for which ether is suitable. It can be used in both the ways just described in regard to nitrous oxide, and we get a true ethyl chloride ether anæsthesia in the one case, and an ether anæsthesia preceded by ethyl chloride in the other. As regards the dose of ethyl chloride, about 3 c.c. to 5 c.c. will be sufficient, according to the age of the patient. The best method is to charge a Clover's Inhaler with ether, and then, carefully keeping the indicator at O, introduce 3 c.c. to 5 c.c. ethyl chloride into the bag (by means of a special aperture); apply the inhaler to the patient's face, and after allowing six good inspirations of ethyl chloride, which will occupy about 20 seconds, begin to turn on the ether, at first slowly, and then more rapidly, so that in the majority of cases a good anæsthesia is obtained in

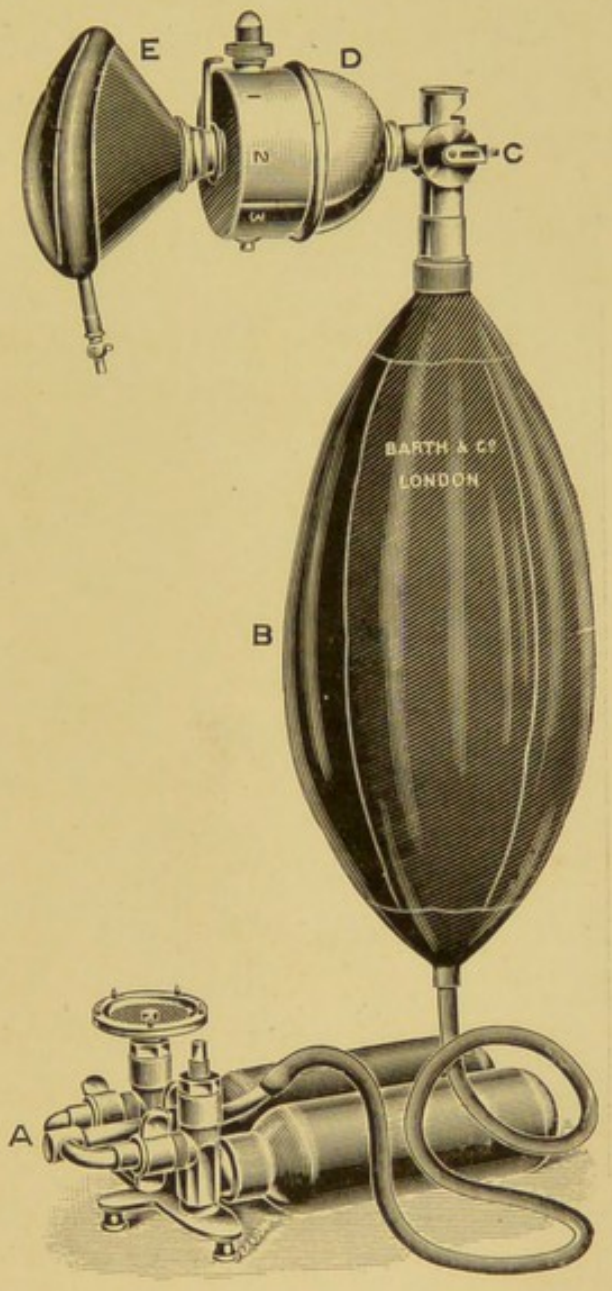

FIG. 24.—GAS AND ETHER APPARATUS.

$2\frac{1}{2}$ to 3 minutes. In this method the patient usually loses consciousness before the ether is perceptible, and coughing and delay from respiratory hesitancy are avoided.

Care must be taken to use neither too little nor too much ethyl chloride, the first mistake will cause delay in inducing anæsthesia and discomfort to the patient, and the second an

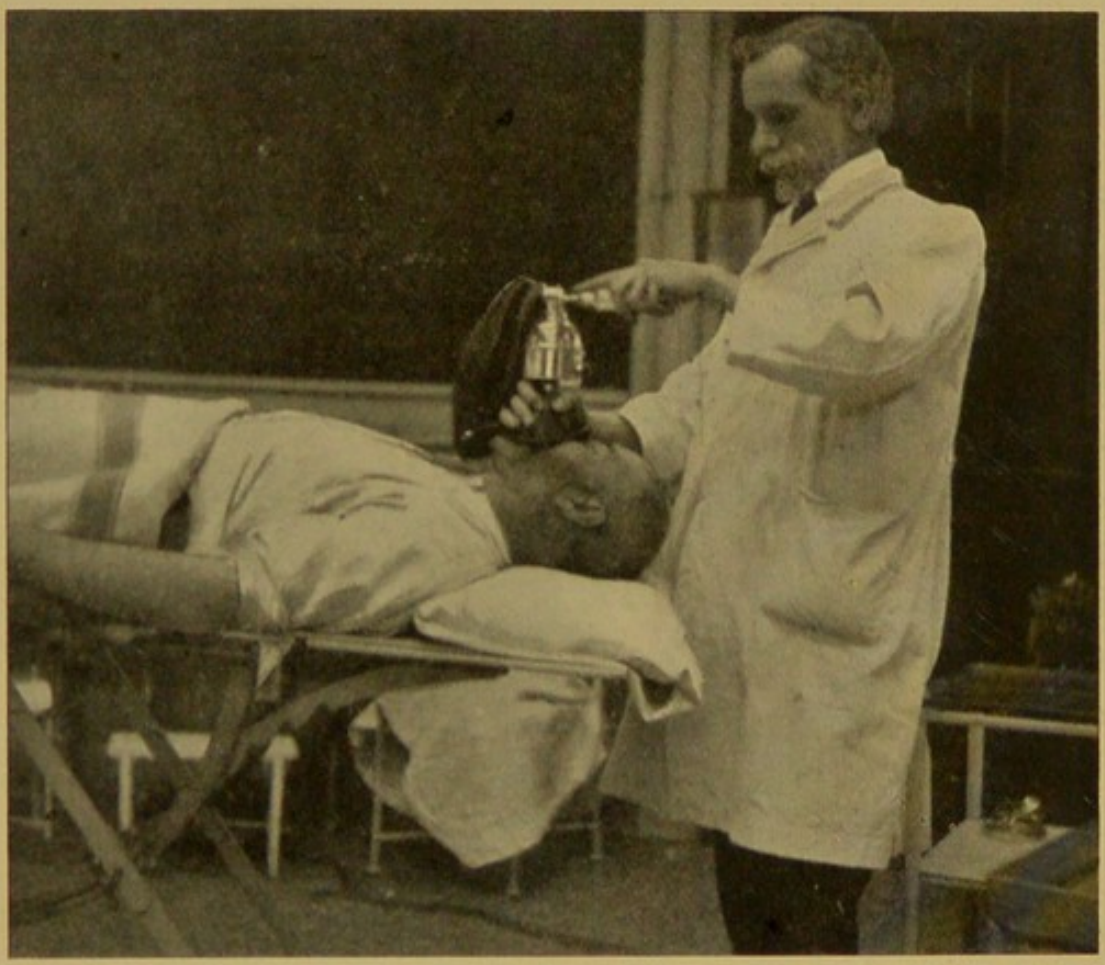

FIG. 25.—METHOD OF USING ETHYL CHLORIDE AND ETHER SEQUENCE BY MEANS OF CLOVER'S INHALER.

undue amount of stertor, with rigidity and possibly marked respiratory spasm. Very seldom will more than 5 c.c. be needed.

ANÆSTHETIC MIXTURES.

With the tendency to undue circulatory depression, on the one hand, under chloroform, and the tendency to too

profuse secretion of saliva, and to spasm, under ether, it is often found advantageous to use a mixture of these anæsthetics in certain cases, as it is found that a suitable combination so far presents the advantages of both anæsthetics, while the disadvantages are largely neutralised.

The ACE mixture suggested by the late Dr. George Harley has found much favour. It consists, as might be supposed, of

Alcohol, ...	1 part,
Chloroform, . . .	2 parts,
Ether, ...	3 parts.

Objection has been taken, however, and we think rightly, to the presence of the alcohol in such a proportion, as it is obvious, even *theoretically*, that it cannot evaporate at the same rate as the other constituents of the mixture, and, practically, we find this confirmed, as, after using such a mixture for some time, the fabric used as the inhaler becomes completely saturated with unevaporated alcohol.

The most generally serviceable mixture is one of chloroform 1 part and ether 2 parts, or simply the ACE mixture with the alcohol omitted, according to the type of our patients, as for the more robust and the alcoholic it is advantageous to employ a rather larger proportion of chloroform in the mixture.

Throughout these pages, where the term CE is used, a mixture of 1 part of chloroform to 2 of ether is meant.

The Anæsthesia is of the chloroform type. The breathing is more easily heard than when chloroform is employed, but not of so robust a character as when the patient is under

ether. The pulse is fuller than under pure chloroform, but has not the bounding character of an ether pulse. The pupils are midway between ether and chloroform pupils in size. Salivation and secretion of mucus are slight in amount compared with what is sometimes seen with ether, but rather more common than under chloroform, especially in children.

The Inhaler.—Except when dealing with young children, it will, as a rule, be found advantageous and economical as regards the anæsthetic to use some form of open inhaler for the CE mixture.

For young patients and the feebler types of patients a Schimmelbusch mask (with *two* layers of lint) will answer quite well, but with the more robust types and alcoholics the case is different, and one of the open cone inhalers is desirable, and even necessary.

Rendle's mask and the Hyderabad cone have both been much used, but are open to objection, as they cannot be readily sterilised, and so may convey infection from one patient to another. The former has now been made of celluloid, and this form is to be recommended. To avoid dripping of the anæsthetic, it is necessary to put it in small quantities at a time on the sponge, and not on the flannel lining. We have for some time, however, been experimenting with various of the inhalers for mixtures on the market, and have come to the conclusion, after a prolonged trial, that the most generally useful, and the one with fewest

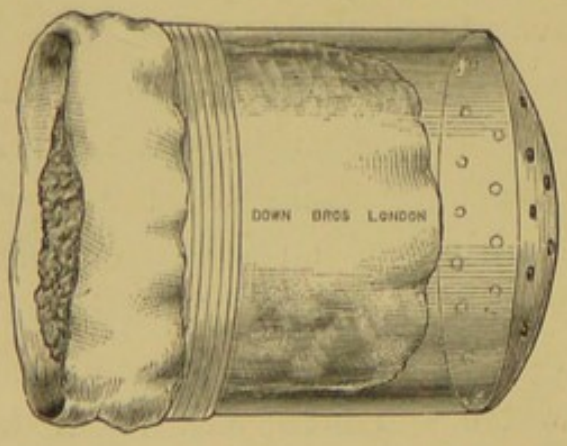

FIG. 26.—RENDLE'S MASK (CELLULOID).

drawbacks, is Blake's inhaler, first introduced by Mr. Clarence Blake of Boston, which we have modified to some extent.

It is described elsewhere in this volume under "Ether," but when using it for the open administration of ether, it is advantageous to use a rubber face-pad, which is inadmissible when giving a mixture containing chloroform.

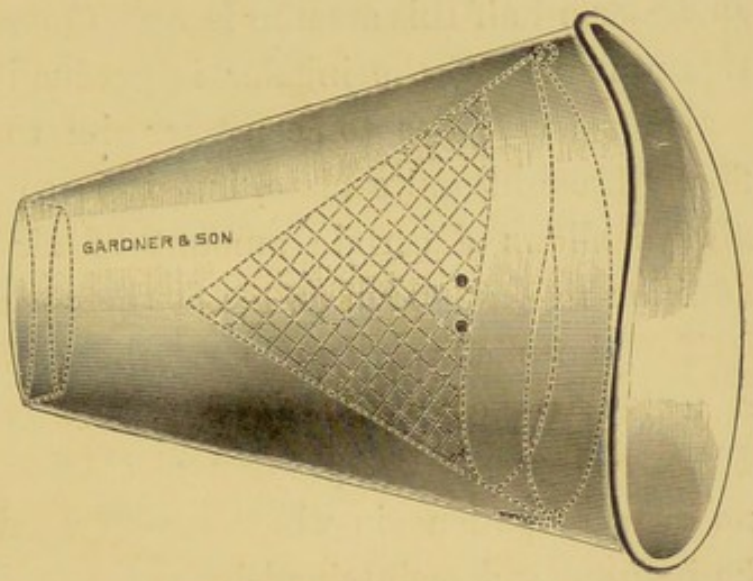

FIG. 27.—INHALER FOR CE MIXTURE.
(Blake's modified by Author.)

The Administration. — Mixtures containing chloroform are given in very much the same way as chloroform itself, but as they are, to all intents and purposes, diluted chloroform, it is necessary to give them more freely. Care must be taken, however, not to put on too much at one time, as the absorbent fabric in the inhaler will then become supersaturated, and the anæsthetic drip down over the patient's face and cause blistering. Moreover, if the mixture be too freely applied, the patient will at one time be inhaling almost pure ether, and then a fairly strong chloroform vapour, as the ether evaporates more rapidly than the chloroform. When using Blake's cone, it is useful, as a precaution against blistering, to have a corner of a towel tucked up between the edge of the inhaler and the patient's face, so that, if the anæsthetic is inadvertently allowed to drip, it is absorbed by the towel and causes no blistering.

It requires considerable practice to use one of these cones skilfully, so as to maintain an even vapour of CE, and to prevent any of the anæsthetic from dripping.

As regards the quantity put on, a drachm is about the average to aim at (it will be remembered that with chloroform half this amount is recommended). After putting this amount on, the inhaler is gradually brought near the patient's face, so as to accustom him to the vapour, and is finally brought quite close, but it is so constructed that it always allows a certain amount of air to be admitted in addition to that which enters at the open top of the cone.

To the medical man not thoroughly accustomed to anæsthetics the CE mixture presents many real advantages. If we exclude the very worst alcoholics, there is practically no type of patient in whom a very good anæsthesia cannot be induced and maintained by means of it. There is always less risk of trouble arising with the circulation than when pure chloroform is used, and in any case the onset of any difficulty is less sudden, and treatment more commonly efficacious.

As regards the after-effects, *vomiting* is rather more common than after chloroform or ether.

CHAPTER VII.

ANÆSTHETIC APPARATUS IN GENERAL PRACTICE.

THE apparatus of which a doctor in general practice should be possessed for anæsthetic work will largely depend on the character of his practice, and the frequency of the calls on his anæsthetic skill. This being so, however, there is an irreducible minimum without which the administration of an anæsthetic should on no account be undertaken.

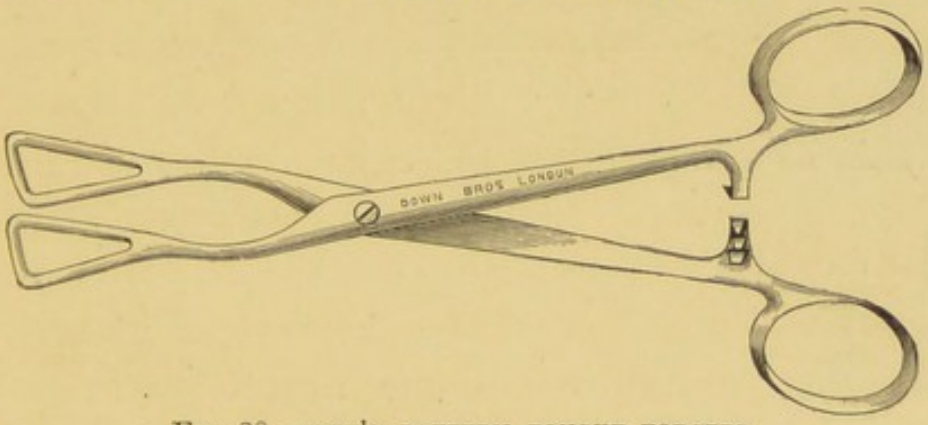

FIG. 28.—GUY'S PATTERN TONGUE FORCEPS.

A medical man about to give an anæsthetic should be possessed of the following articles, and have them immediately at hand :—

(1.) The anæsthetic agent—chloroform or ether, *both* if possible ; if one only, then chloroform.

(2.) Some means of exhibiting the drug—a towel or napkin—*à pis aller*—or better, one of Schimmelbusch's masks.

(3.) A tongue forceps of some kind. Guy's pattern is the best, but, failing this, a dressing forceps or Kocher

artery forceps does very well. If obtainable, one *without* a take-off joint is to be preferred.

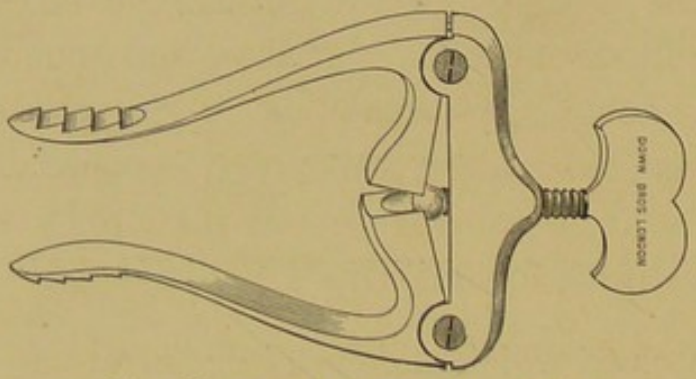

FIG. 29.—MOUTH-OPENER (HEISTER'S).

(4.) Some means of opening the patient's mouth in case of masseteric spasm. An ordinary wooden wedge, supplemented by a Mason or Ferguson's gag, is best.

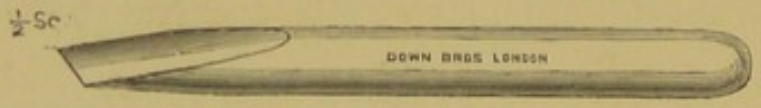

FIG. 30.—WOODEN WEDGE.

(5.) A drop bottle for the chloroform. Symond's and Mill's are the best patterns, but one can be easily and economically improvised with a four-ounce round-shouldered bottle and the stopper of a perfume bottle.

FIG. 31.—SKINNER'S BOTTLE.

(6.) A hypodermic syringe with two needles which are known to be in working order.

(7.) Some brandy or other alcoholic stimulant.

(8.) A set of instruments for performing tracheotomy, or at the very least a sharp scalpel and trachea tube.

(9.) A towel in addition to the one which may be used as a vehicle for the anæsthetic. This may be of the greatest service during the anæsthesia. It will serve to remove saliva and mucus from the patient's lips, and as a receptacle for any vomited matter, while it is occasionally of great use in improving the circulation by rubbing the patient's lips briskly.

These articles are absolutely essential, and no reasonable or reasoning man will give an anæsthetic, under ordinary

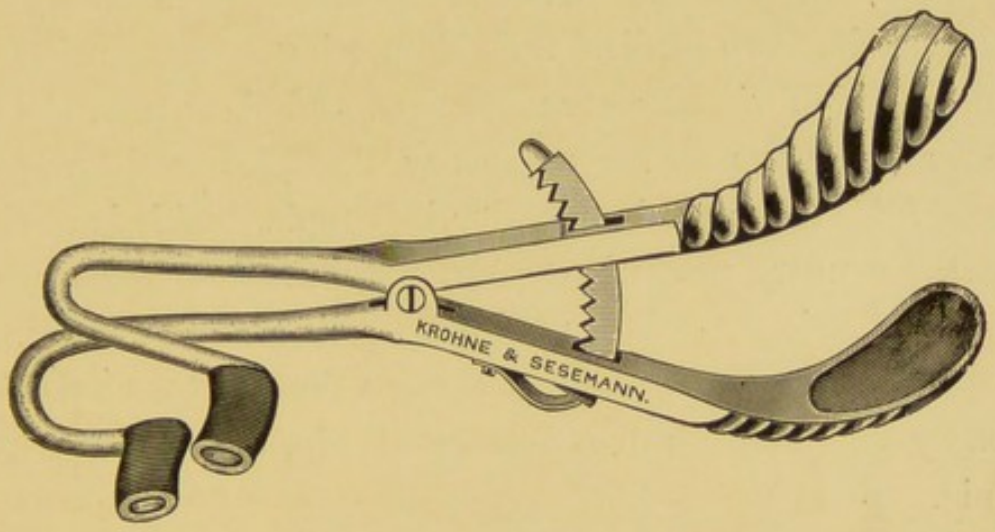

FIG. 32.—DUDLEY BUXTON'S RATCHET PATTERN GAG.

conditions, without them; for to do so is to jeopardise the patient's life unjustifiably, and to render oneself unworthy of confidence. But, further, it is most desirable, and almost essential, for the practitioner to have in his possession a means of giving ether or CE—such as Blake's Inhaler, while any man who has a large amount of surgery in his practice should have a Hewitt's Ether Inhaler in his possession and be able to use it.

Lastly, the possession of a cool head and a power of observation is all important; these cannot be purchased at the instrument makers, but the possessor of the former in anæs-

thetic emergencies, as in others which occur from time to time in medical practice, will rise above his fellows, and, when the patient's life is trembling in the balance, bring down the scale on the right side.

Mechanical Anæsthesia;

or, How the Practitioner can best work Single-Handed.

Some years ago, when the Glasgow Medico-Chirurgical Society took up the question of anæsthetics for discussion, it was urged by some members that it was most necessary and desirable that two medical men should be present during the administration of chloroform or ether, and since then Colonel Lawrie has gone so far as to say that *five assistants are needed!** This may be possible in Utopia, but it is obvious that the country practitioner has not infrequently in out-of-the-way districts to face, unaided by any skilled hand, the dangers of anæsthesia, and at the same time attend to possibly a badly fractured limb, a dislocated hip, or a strangulated hernia.

It is said that more people die in Great Britain, annually, from unreduced herniæ than from anæsthetic drugs.

A practitioner so placed is in the most unenviable position. We will assume that his knowledge of surgical technique is all that can be desired. How can he best solve the problem of conducting a safe anæsthesia, and at the same time carry out the surgical procedure indicated? He should have some exact or mechanical method of maintaining anæsthesia, which a person quite unskilled can look after, the only attention required of him being to see, as far as possible, that the respiratory rhythm is uninterfered with.

* Letter to B.M.A. Anæsthetic Committee, 8th January, 1893.

Two methods may be used—

1. If he is fairly expert, he can give the patient ether by means of a Clover's Inhaler, and get him very deeply under, "charge him up" with the anæsthetic so as to produce analgesia at least for ten, fifteen, or even twenty minutes, as is quite possible with ether. He can then hand over the care of the patient's head to a groom, a mechanic, or a nurse, whose only duty will be to wipe the patient's mouth with a towel, keep his face on one side, draw the chin forward, and warn the doctor if the breathing is failing, if the patient is getting "blue," or coming out.

Such a measure is particularly well adapted to reducing a dislocation, setting a fracture, or operative midwifery.

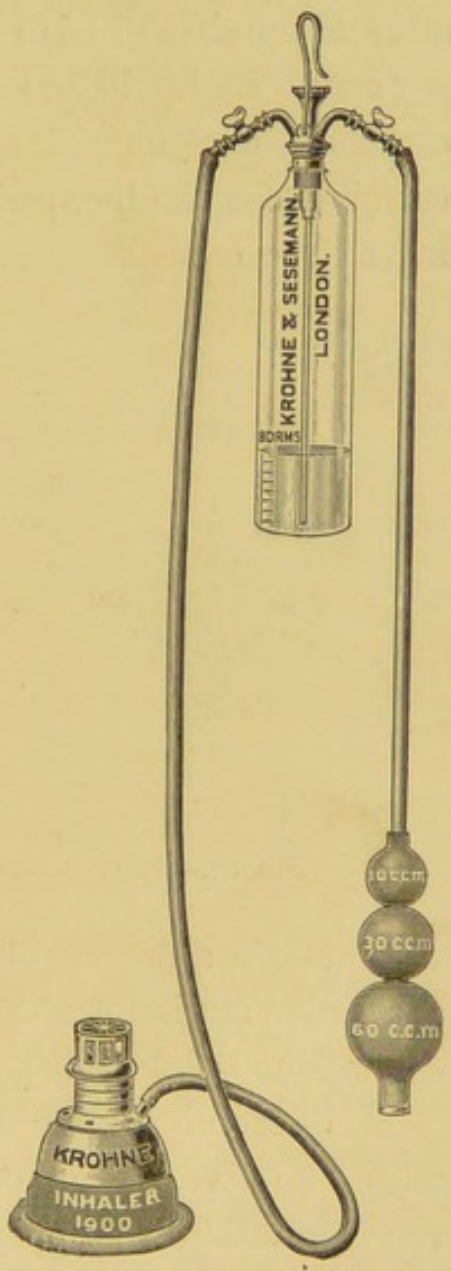

FIG. 33.—KROHNE AND SESEMANN'S NEW PATTERN REGULATING INHALER.

2. KROHNE'S REGULATING INHALER.

This is a modification of a spraying apparatus, introduced a number of years ago by Dr. Junker for the administration of bichloride of methylene. It has been altered in various ways, and the apparatus figured here is one of the best kind made by Messrs. Krohne & Sesemann.

The *modus operandi* is very simple, just like that of a Bay Rum spray for the hair. By means of the double

ball pump a continuous supply of dilute vapour of chloroform is kept up.

Lord Lister, many years ago, carried out a series of experiments to ascertain approximately the percentage of $CHCl_3$ in the vapour inhaled from a towel, as used then as a matter of routine at the Edinburgh Royal Infirmary. He ascertained, after a number of trials, that it was generally about 4 to 5 per cent. So it will be seen that Krohne's Regulating Inhaler attains this result with a minimum use of chloroform, and is certainly, for the inexperienced, a safer method of administering a drug of such power than the towel and bottle.*

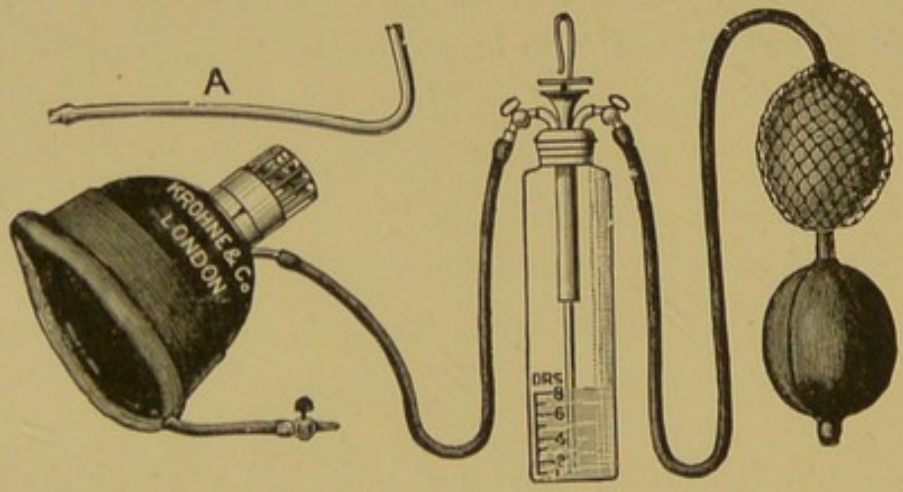

FIG. 34.—KROHNE AND SESEMANN'S INHALER (OLD PATTERN).

To attain a degree of narcotism, in which under $CHCl_3$ a surgical operation can be performed painlessly in an adult, Snow found that it was necessary for 18 m. to be absorbed.

The second degree of anæsthesia is thus attained, and with 24 m. very deep anæsthesia ; on 36 m. being absorbed the respiration is stopped.

The length of time which, according to Dr. Snow, it is most desirable to occupy in the administration of chloroform before the commencement of an operation, is about two

* *Vide* footnote on Dr. Embley's Researches, p. 64.

minutes in infants, three minutes in children, and four or five minutes in adults. Circumstances occasionally occur to lengthen these periods. The problem is, how to induce the absorption of eighteen minims of chloroform within the required time, so as to secure complete anæsthesia. To accomplish this *safely* it is necessary that the administration should be commenced, in every case, with chloroform very

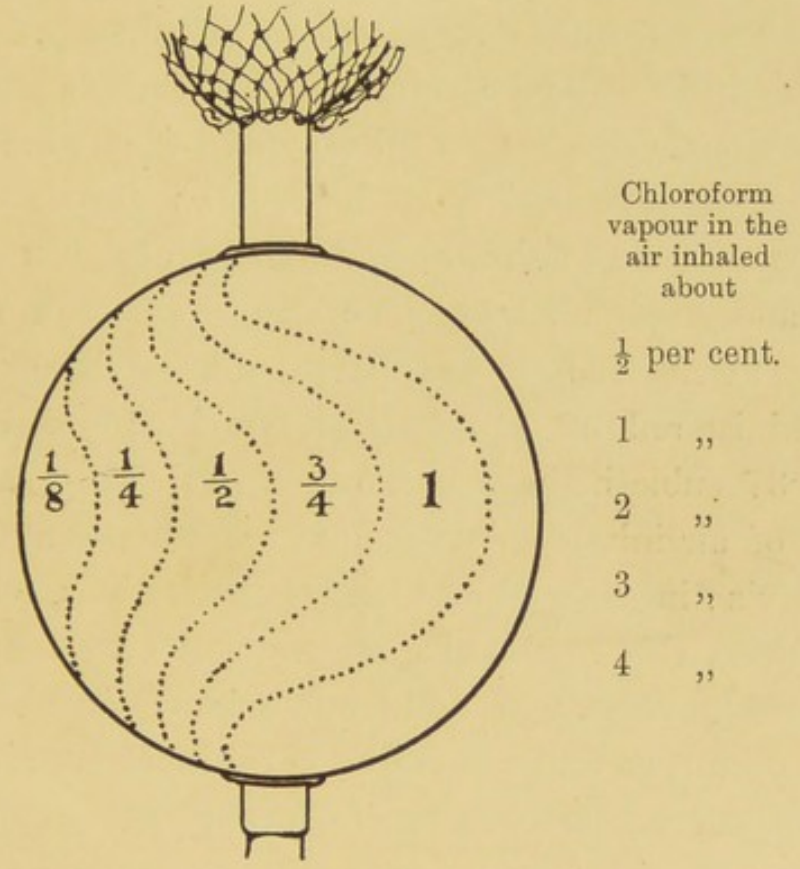

FIG. 35.—PUMP OF KROHNE'S INHALER.

(Showing amount of chloroform expressed—in fractions of minim according to strength of compression.)

much diluted; there should then be a gradual and systematic increase to the largest percentage of vapour which the patient is able to inhale comfortably, with *normal and regular respiration,* until anæsthesia of the required degree is induced. Thus, during the first minute (taking the number of inspirations at twenty) there should

be twenty $\frac{1}{8}$ compressions of the bellows, during the second minute twenty $\frac{1}{4}$ compressions, during the third minute twenty $\frac{1}{2}$ compressions, and during the fourth minute twenty $\frac{3}{4}$ compressions. The chloroform vapour is always projected into the air-way as inspiration commences.

The bellows or elastic ball by which air is pumped through the chloroform bottle is shown on previous page, together with the degrees of compression by which the amount of chloroform vapour is regulated and projected into the air-way.

Administration may be commenced with about $\frac{1}{20}$, $\frac{1}{10}$, or $\frac{1}{8}$ compressions, according to the patient's size and strength.

"Each full compression of the bellows evaporates, at a temperature of 62° Fahr., one minim of chloroform on an average, and produces 1·15 cubic inch of chloroform vapour. Therefore, at the end of the fourth minute there will have been administered 32·5 minims of liquid chloroform, which gives 37·37 cubic inches of chloroform vapour. Taking the quantity of air inhaled during four minutes at 2000 cubic inches—(viz., in each minute twenty inspirations, each of 25 cubic inches), this would give an average of 1·869 per cent. of chloroform vapour to 2000 cubic inches inhaled during the four minutes; or, to each 500 cubic inches of air inhaled during the several minutes, the following percentages :—

Minutes.	Compressions.	Chloroform. Minims.	Chloroform. Cubic Inches.	To 500 Cubic Inches of Air.
1st	Twenty $\frac{1}{8}$	2·5	2·87	0·575 per cent.
2nd	„ $\frac{1}{4}$	5	5·75	1·150 „
3rd	„ $\frac{1}{2}$	10	11·50	2·300 „
4th	„ $\frac{3}{4}$	15	17·25	3·450 „
Average over the whole four minutes,				1·869 „

"Provided the compressions of the bellows have been fairly timed to the commencement of each inspiration, and the

vapour is inhaled with the normal respiration of an adult, it will probably be found during the fourth minute that the required eighteen minims of chloroform have been absorbed into the blood. If not, a full compression of the bellows should be given with each inspiration during the fifth minute, until anæsthesia of the desired degree is induced. From this point onwards only small doses are required to maintain anæsthesia, as it is only necessary to introduce so much further chloroform as is required to replace what is lost by exhalation, &c., and thus to maintain in the blood that percentage of chloroform which at first was required to induce anæsthesia.

"When signs of returning consciousness are observed, a few fuller compressions of the bellows suffice to deepen the anæsthesia. The anæsthesia is at once eased off by intermitting or stopping the compressions, and without disturbing the mask.

"For children and weakly adults the administration should be commenced with even smaller doses, according to the age and state of health, say with $\frac{1}{16}$ compression, or even less. The dosage should then be gradually increased so long as the patient is able to breathe easily without cough, much less holding of the breath or struggling" (Krohne).

From the above it would appear that the administration of chloroform is reduced to mathematical accuracy. Unfortunately patients vary so much that such a method cannot be entirely relied on.* As regards the respiratory indicator—during chloroform anæsthesia the respirations are sometimes so feeble as not to be strong enough to raise the feather which constitutes the indicator. Further, in the

* I have never tried but several authorities state that it is practically impossible to get a vigorous alcoholic properly anæsthetised with this apparatus.

struggling stage the apparatus may be in the administrator's way and hamper him, or may get smashed up. As regards personal experience, I have very rarely used this inhaler except for operations in the region of the throat and nose, when the chloroform must be given through a tube so that the anæsthetist may not interfere with the surgeon's work.

In such cases it answers excellently well, and very seldom is it necessary to stop the operation and give the drug a little more vigorously for two or three minutes.

Apart from this, however, it would appear to me that for the absolutely inexperienced practitioner as regards anæsthetics (a person who, I trust, will soon be out of fashion), the above is a safer and more accurate method of producing and maintaining anæsthesia. Of course the country doctor cannot be expected to go his rounds with a Krohne Inhaler in his pocket, but other things being equal, if an operation, not one of emergency, is being done, he may find this apparatus of great service and comfort.

A number of medical men have written to the journals from time to time advocating its general employment, notably Dr. Jas. Edmunds of London, and Dr. Carter of Weymouth, who read a paper on its advantages before the Society of Anæsthetists in December, 1895.

It was used for a long time almost exclusively at the Samaritan Hospital, London, and Drs. Dudley Buxton, Blumfeld, and a number of other anæsthetists use it, I believe, fairly extensively in their practice.

Finally, when working single-handed, it is questionable if a medical man need give an anæsthetic such as ether or $CHCl_3$ at all in some cases—*e.g.*, in severe smashes of limbs and joints, associated with much shock and loss of blood, and also in head injuries where there is cerebral compression and insensibility.

In the first case $\frac{1}{4}$ grain of morphia followed by 3 oz. of brandy will often amply suffice to deaden or entirely annul painful sensations, and in the last a depressed fragment of the calvarium may be readily and painlessly elevated with the aid of $\frac{1}{4}$ grain of morphia alone—or without any drug whatever.

CHAPTER VIII.

SUMMARY OF THE DIFFICULTIES ARISING DURING ANÆSTHESIA AND THEIR TREATMENT.

The difficulties arising during the administration of an anæsthetic may be due either to :—

(1.) Circulatory Depression or Failure ; or,
(2.) Respiratory Difficulty.

Frequently, of course, these conditions co-exist, but it is more convenient to consider them separately.

Circulatory Failure or Depression may be directly due to—

(*A*) The toxic action of the anæsthetic ; or,
(*B*) Some extrinsic cause, and not actually to overdose.

(*A*) **Toxic Action of Anæsthetic.**—Syncope may occur in the early stages of the anæsthesia, and more especially of a chloroform anæsthesia, owing to a relative overdose, or to cardiac inhibition caused by too strong a vapour irritating the laryngeal branches of the vagus nerve.

Later in an anæsthesia syncope occurs from too free use of the anæsthetic causing the absorption of a toxic dose, which may produce paralysis of the cardiac centre in the medulla, or of the cardiac muscle and intrinsic ganglia themselves.

The Symptoms.—Sudden pallor, rapid failure of pulse and respiration, with wide dilatation of the pupils. Pulse and breathing may cease at the same moment or within a few seconds of each other. In the early type of syncope the onset is extremely rapid and recovery is very rare ; in the later type the symptoms appear more gradually and immediate treatment is occasionally successful.

(*B*) **Extrinsic Causes of Cardiac Failure and Depression :—**

(1.) Fright—at the very commencement of the anæsthetic.
(2.) Feeble condition of the patient existing prior to the operation, constitutional dyscrasia, exhaustion, &c.
(3.) Shock from the operation, or some procedure during it, such as twisting or cutting the spermatic cord or compressing the testicle or ovary during imperfect anæsthesia.
(4.) Reflex effect of threatened vomiting.
(5.) Sitting the patient up during the operation, or immediately after, before the effects of the chloroform have passed off.

Respiratory Difficulty.

(*A*) May be due to the **toxic effect of the anæsthetic**—*i.e.*, to overdose, and is then often associated with cardiac failure.

The Symptoms are :—Pallor of an ashy grey type, shallow breathing, with failing pulse and dilated pupils.

(*B*) May be due to **Respiratory Obstruction :—**

(1.) Spasm of the muscles at the base of the tongue, or falling back of the tongue.

(2.) Spasm of the muscles of the jaw and neck.

(3.) Spasm of the aryteno-epiglottidean folds in the larynx.

(4.) General spasm of the respiratory muscles, including the intercostals.

(5.) Position of the patient—*e.g.*, the absolutely prone posture in laminectomy, trephining for cerebellar tumour, kidney operations, &c.

(6.) Foreign bodies entering the air-passages—*e.g.*, vomited matter, blood, excessive mucus, or false teeth.

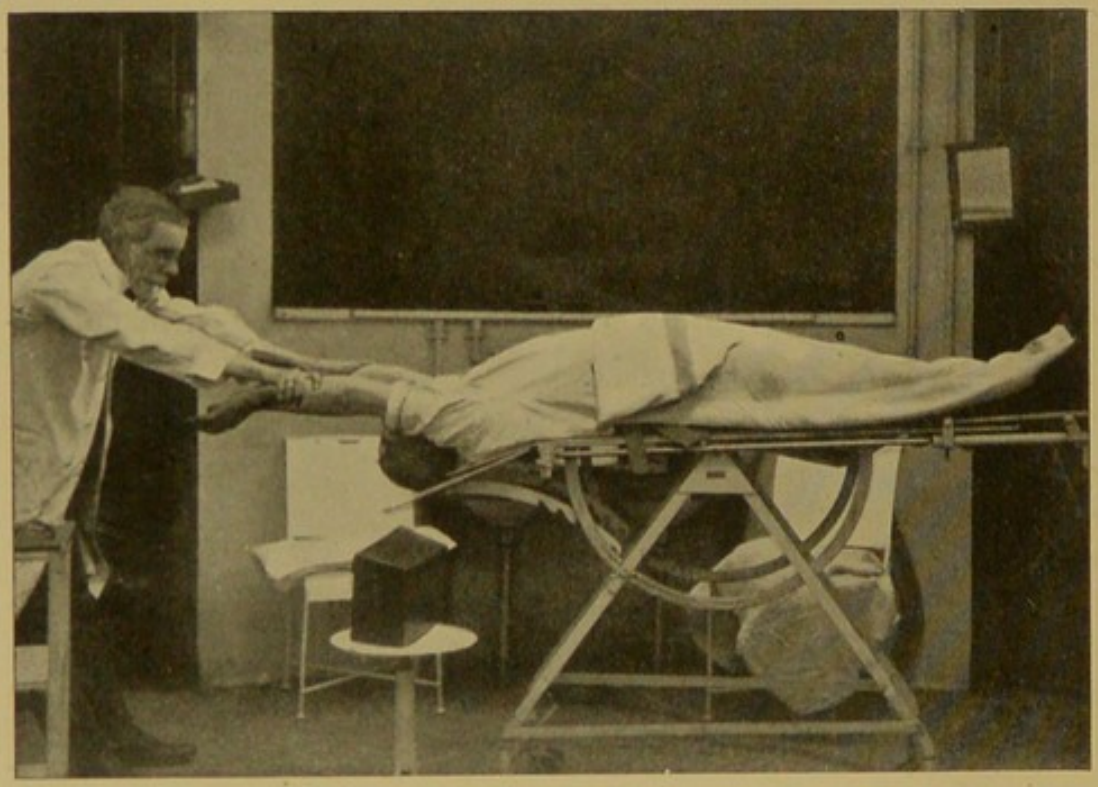

FIG. 36.—ARTIFICIAL RESPIRATION—INSPIRATION (FIRST POSITION).

The Symptoms of Respiratory Obstruction, if gradual, are :—

Increasingly stertorous breathing, duskiness of the lips, ears and face, increasing to marked cyanosis. If complete, the chest continues to heave without air entering or leaving it, and if the cause of the obstruction be not removed, the patient dies of asphyxia.

Treatment of these Conditions.—As regards treatment, it is convenient to divide patients in the conditions described, clinically, into two classes :—

X. Pale patients, who are suffering mainly from circulatory disturbance.

Y. Cyanosed patients, who are suffering mainly from respiratory obstruction.

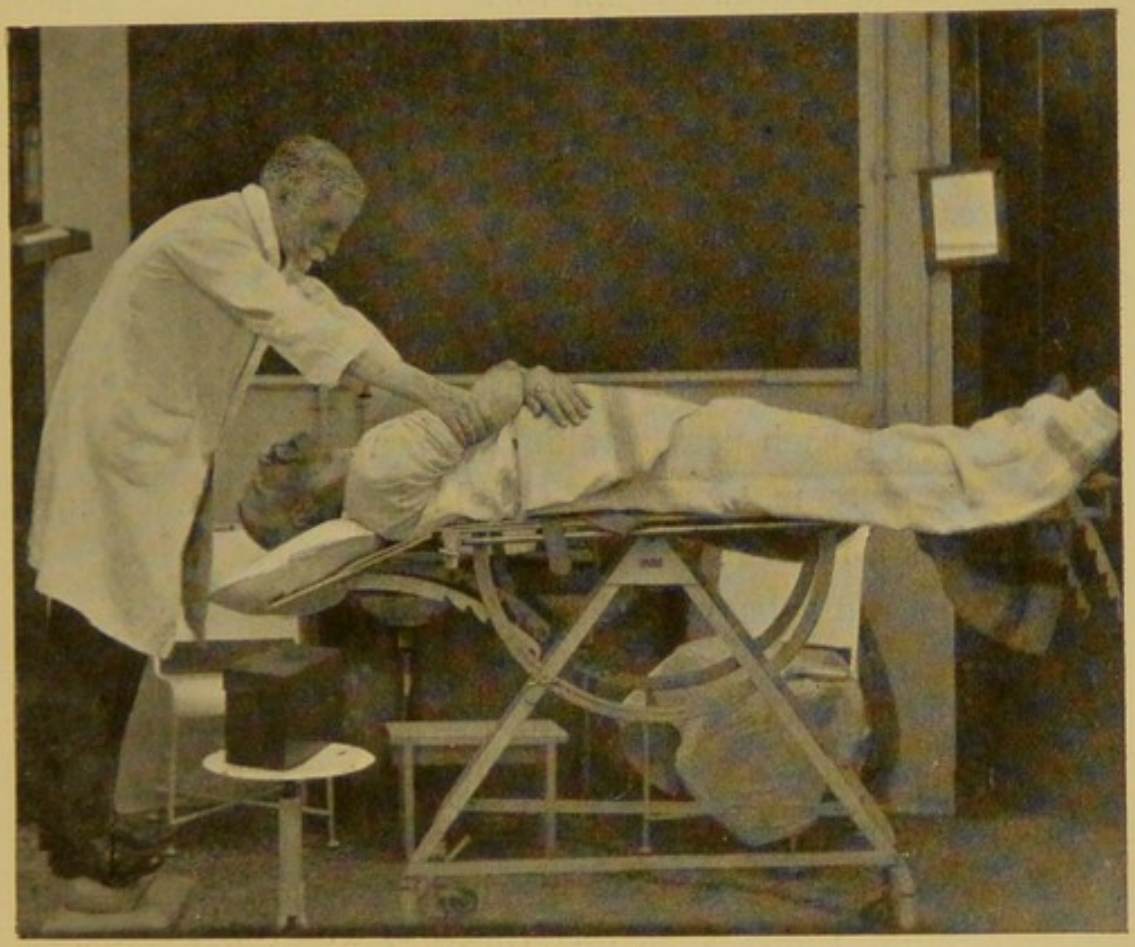

FIG. 37.—ARTIFICIAL RESPIRATION—EXPIRATION (SECOND POSITION).

X. **The Patient is suffering from Circulatory Disturbance.**—The head should be quickly lowered (children may be completely inverted), the tongue must be drawn out and given to an assistant to keep up the traction while *artificial respiration* is carried out. The movements must not be carried out too rapidly, as is often the case from over-zeal and alarm.

Sylvester's method is the best, and may be briefly described as follows :—

The patient's arms are firmly grasped just above the elbow, and pressed firmly against the thoracic parietes so as to imitate expiration, and then fully extended, and the thorax expanded (so as to imitate inspiration), the extended arms being drawn upwards and outwards; after counting three, they are brought down again to the side of the chest, the natural rhythm of the respiration being followed as closely as possible.

The recovery of the patient will depend on the care with which each movement is performed rather than their frequency. When the patient is slight, one person can carry on the movements unaided, but if the patient is heavily built, the effort will be too fatiguing, and an assistant will be needed, each person taking an arm.

The complete manipulation should be carried out about fifteen times a minute.

No time must be wasted by the anæsthetist or person responsible in applying other remedies; his unremitting attention is needed to keep up artificial respiration until a deep sigh from the patient, with improving colour, heralds returning animation. If, however, there is a second assistant available, he may be employed in administering a hypodermic of strychnine $\frac{1}{10}$ grain, or injecting a pint of hot water or saline solution per rectum. The lips of the patient may also be rubbed with a dry towel, and eight to ten drops of adrenalin solution put into the conjunctival sac. This last is one of the most powerful cardio-vascular stimulants known.

An electric battery has at times been found useful when properly applied, but one is seldom available.

If there be one at hand and in working order, a flat-plate

electrode should be placed on the nape of the neck, and a button electrode or wire-brush just between the two heads of the sterno-mastoid. Actual puncture of the heart with a needle has been suggested, but is scarcely justifiable.

If the abdomen has already been opened for the purposes of the operation, the surgeon may pass his hand in and massage the heart between the diaphragm and the thoracic wall, the direct mechanical stimulus thus applied being sometimes of service.

Y: **The Patient is cyanosed and suffering from Respiratory Obstruction.** — When the breathing stops, the first thing to be done is to open the patient's mouth as quickly as possible by means of a wooden wedge or gag, and pull out the tongue with a forceps. If this does not clear the way, as it frequently will, sweep the finger around the fauces and back of the pharynx to see if any vomited matter or foreign body is lying there. If nothing be found, and if rhythmical tongue traction, combined with chest compression or even full artificial respiration, fails to improve matters, a tracheotomy should be performed, and afterwards artificial respiration kept going for an hour or more unless the patient comes round sooner. As mentioned under the treatment of syncope, the artificial respiration may be supplemented by the injection of strychnine or ether, or a saline enema.

CHAPTER IX.

THE PREPARATION OF THE PATIENT AND AFTER-TREATMENT.

EVERY patient who is to undergo an operation under an anæsthetic requires a certain amount of preparation for it, varying from a couple of hours' abstinence from food in the case of a short nitrous oxide anæsthesia in a healthy person, to perhaps weeks or months of dieting and medicinal treatment, where a prolonged operation is indicated in those whose constitution generally is in a bad state, or where cardiac and respiratory systems are impaired and halting.

Of course there are many cases of emergency in which immediate operative interference is necessitated, such as dislocation and strangulated herniæ. Here one can only hope the patient's constitution will rise to the occasion. Generally speaking, however, in an operation of any gravity, a few days' dieting and rest in the patient's own house, or in a nursing home in some cases, together with the exhibition of some digitalis, or strophanthus and nux vomica, may have a great bearing on how the patient stands both operation and anæsthetic.

A purgative administered the night prior to the operation is a time-honoured custom. I am inclined to think, however, that the custom followed by some surgeons of giving perhaps 1 grain of calomel and 3 grains of Pil. Colocynth. et Hyoscy. *two* nights before the operation is distinctly more

desirable. It may be followed by 2 oz. of Franz Joseph water, or any saline, on the morning of the day before the operation—or by an enema of soap and water.

Two or three copious evacuations of the bowels a few hours before a prolonged operation on the abdomen, such as a hysterectomy or gastro-enterostomy, are by no means calculated to put the patient's circulation and nervous system in a condition best fitted to stand the strain of operation, or the chloroform used to produce anæsthesia. By those said evacuations the solar plexus and sympathetic nervous system generally are subjected to a marked depressant influence, and the blood pressure is greatly reduced. Most people are able to recall the sense of collapse and temporary exhaustion occasioned by the free action of a purgative, or following the injection and subsequent evacuation of a large enema. I am, therefore, strongly disposed to suggest that the purgative should be given thirty-six hours before the operation, and during the day before the operation the patient be most carefully dieted, and fed with such things as are readily digested and leave little residue. It must also be remembered that in some persons a mercurial purgative itself will cause sickness, so that the after-vomiting due to the anæsthetic will in this way be aggravated.

The actual administrations of food on the day of the operation will largely depend on the time at which it is performed. The time of election is undoubtedly 9 A.M., when the vitality of the human species is at about its highest. For this hour, if the patient is awake, a cup of tea or beef-tea might be given at 6 A.M., or 6.30—if not, the rest to body and mind afforded by sleep is more desirable.*

* In gastric cases where there is marked dilatation and food retention, lavage on the evening before or the morning of operation may be desirable. If the case is of a malignant nature, and the patient very feeble, it is best left alone (*v.* F. M. Caird, *Scott. Med. and Surg. J.*, July, 1902).

If the operation is postponed until one or two, the patient should certainly have a light breakfast at 9 A.M. It is to be borne in mind, however, that nervous fear and apprehension, especially in young people, almost entirely inhibit digestion. I have seen even Bovril, taken several hours before, reappear practically unchanged after the operation. Milk is to be regarded as solid food.

The breakfast should therefore be very light, consisting of Cocoatina (or Plasmon Cocoa) with thin bread or rusks. When chloroform is to be used, if the patient be somewhat collapsed, or have feeble heart action, an ounce of good brandy* in a similar quantity of water may be given twenty minutes before the operation, or a nutrient brandy and beef-tea enema, or suppository, may be given as an alternative.

The Treatment of a Patient after an Anæsthetic will, of course, depend on the anæsthetic used and the nature of the operation.

After nitrous oxide most patients are quite ready for food in less even than half an hour. If, however, they happen to be inclined to headache and nauseated, an hour's rest on a couch and a little stimulant will soon put them right. The nausea which one sees occasionally is, generally speaking, due rather to swallowed blood than to the gas.

After ether or chloroform, of course, some vomiting is quite common. It is best to give no food of any kind until this is much subdued, or has disappeared. A few sips of hot water are often grateful to the patient, as also is a little effervescing soda or potass-water—not necessarily for drink-

* When *ether* is the anæsthetic, in my experience, a previous dose of alcohol only increases the sickness and stupor after the operation.

ing, but to rinse out the mouth. A slice of lemon added to it assists in removing the rather lasting taste of ether. For the smell of the anæsthetic, due to traces left in the nasal passages, several patients have told me they found a fresh cake of Vinolia soap—to smell at—invaluable. This is due probably to the "Otto of Roses" contained.

If the patient has persistent hiccough and retching, a sinapism to the epigastrium will usually control it, and the completely supine position is necessary.

If the vomiting does not subside in an hour or two, 15 grs. Sodæ Bicarb. in a cup of strong coffee sometimes help matters. A fresh cup of tea is peculiarly grateful to patients after ether.

Chloretone given in 15 grs. doses has latterly been used with great success as a preventive of vomiting after anæsthesia. It should be given about fifteen minutes prior to commencement of the operation.

In regard to abdominal operations, particular care is usually taken in restricting the fluid and food taken during the twenty-four hours following the operation.

Sips of hot water, or soda water, or Valentine's beef juice only are allowed in most cases. Whether this is helpful or necessary I cannot say, but I know the patients complain most bitterly of a sense of emptiness and sinking, most trying flatulence, and often intense thirst.

Two cases recently recorded are of interest—No. 1, a girl, æt. 19, emptied a rubber hot-water bottle immediately after an ovariotomy, without any apparent discomfort or harm; and No. 2, a male patient, after a gastrotomy, drank a quart of milk with no ill effect. Such cases make one doubt the desirability of enforcing too strict an abstinence after a laparotomy.

In almost all cases stimulants are best avoided—unless a

small quantity of brandy be given almost neat—in fainting conditions, or in prostration following the operation, while the patient is unconscious, an ounce of brandy and 3 oz. good beef tea, per rectum.

For headache following ether or chloroform, antikamnia, gr. v., repeated in two hours if needed, is most efficacious.

CHAPTER X.

METHODS OF PRODUCING LOCAL ANÆSTHESIA.

THERE are two distinct methods of producing local anæsthesia (or more correctly analgesia) generally employed.

I. The local application or injection of drugs.

II. The application of intense cold, usually produced by evaporation, to the part which it is desired to render anæsthetic.

I. The Local Injection of Drugs.

COCAINE HYDROCHLORATE is most commonly used for this purpose. It is simply a salt of the alkaloid Cocaine, $C_{17}H_{21}NO_4$, which was first obtained in 1860 by Gaedeke from the leaves of Erythroxylon Coca. It was first used for surgical purposes in 1884 by Koller of Vienna, and since then has been of priceless value, particularly in ophthalmic surgery. It was until recently extremely expensive, but greater facility in its production, &c., has brought down the cost to something like ½d. per grain.

Cocaine is soluble in water to only a slight degree, 1 in 700; in alcohol 1 in 20; freely in chloroform, ether, and in many volatile and fixed oils. Cocaine Hydrochlorate is freely soluble in water, spirit, and glycerine.

Fungi are apt to grow in the solutions, and, to prevent

this, pharmacists usually add either boric acid, salicylic acid, or saccharin, when making up aqueous solutions.

Toxic Effects of Cocaine.—Symptoms pointing to the absorption of cocaine into the general systemic circulation most commonly arise when the injection has been made into a highly vascular part, or the needle has punctured a blood-vessel.

Untoward symptoms may arise alike from unnecessarily large dose, impurities in the solution, want of aseptic precautions, or from physical causes apart from the anæsthetic.

The effect produced by any given dose, however, will vary very greatly with the type of patient on whom it is employed, the age of the patient, and the part treated. A great deal depends on the absorptive capacity of the mucous membrane, as influencing the actual amount of cocaine which gets into the systemic circulation. The laryngeal mucous membrane will stand a strong solution of 10 per cent. or 15 per cent., while for the pharynx or urethra this would be quite unsuitable.

The absorption of ½ gr. of the drug, gradually, will, generally speaking, do no harm. One grain will often produce dangerous symptoms, while, on the other hand, as much as two grains are sometimes injected for a minor operation on a vigorous man without any ill effect.

The Toxic Symptoms are:—Trembling of the limbs, especially legs; headache, vertigo, pallor, a cold, moist skin, feeble, rapid pulse, which in grave cases becomes imperceptible; slow, shallow respirations, incoherence of speech, nausea, vomiting, unconsciousness, tremors and other muscular spasms, epileptiform attacks, dilated and unequal pupils, and disturbance of the circulation, ending in dyspnœa and asphyxia.

The treatment consists mainly in using every effort to stimulate and restore the circulation. The patient, if not already supine, should be instantly placed in this position, air freely admitted, and some alcoholic stimulant, brandy, whisky, or sal-volatile quickly administered, or a drachm of ether injected subcutaneously.

The patient should be warmly covered, and pulse and respiration carefully watched, artificial respiration being used if necessary. A capsule of nitrite of amyl may be of service. $\frac{1}{150}$ gr. atropin and 10 minims of tinct. of strophanthus may be used as a prophylactic measure.

Eucaine.

A-eucaine and B-eucaine have recently been introduced as substitutes for cocaine. They are prepared synthetically, and their cost is about half that of cocaine. Further, it is claimed that eucaine has only one-fourth the toxicity of cocaine; has no unpleasant after-effects; is more constant and lasting in action; does not decompose on boiling, and can in this way be rendered permanently sterile, so that the solutions keep indefinitely.

It is soluble in cold water to the extent of 1 in 20, in hot water 1 in 10—the eucaine precipitating, however, as the solution cools. A-eucaine is slightly more irritating to the mucous membranes than B-eucaine, and both are more so than cocaine. Eucaine applied to the conjunctiva causes considerable burning and smarting, but no dilatation of the pupil. Used in the urethra or bladder, eucaine may cause considerable inflammation. As much as $3\frac{1}{2}$ grains of eucaine may be used hypodermically; as much as $1\frac{1}{2}$ drs. of a 5 per cent. aqueous solution may be injected without any ill effect. The injection of eucaine into the tissues in a certain number

of cases causes persistent sloughing, particularly in fatty tissue under sheaths, also in the matrix of nails or in bursæ. This disadvantage, together with its more irritating action on mucous membranes, accounts for it not completely displacing cocaine.

When injected hypodermically, cocaine and eucaine act in about 1 minute to 1½ minutes, and the analgesia passes off in about 15 minutes.

When used along with cocaine in solution, carbolic acid distinctly enhances its anæsthetic action in addition to being antiseptic.

The application of 10 per cent. solution of carbolic over the spot where a hypodermic needle is to be inserted will go far to prevent any pain from the prick, and this is of assistance when dealing with very sensitive people.

The following formula is a valuable one for making up a cocaine solution :—

℞

Sol. ac. carbolic (10 per cent.),	½ oz.
Sol. cocain hydroch. (10 per cent.),	½ oz.
Glycerin,	2 drs.
Aq. Destillat.,	ad 2 oz.

Supposing an acutely painful whitlow requires opening, the insertion of a needle will cause the patient infinite pain. Accordingly, enough of the above solution should be put in a wine-glass or wide test-tube to completely immerse the finger, and allowed to soak for ten or twelve minutes. The whitlow may then be incised without causing the patient anything but trifling pain. An elastic band or temporary ligature of some sort around the base of the finger markedly increases the depth of the anæsthesia.

Similarly, to lay open a carbuncle, if the patient does not desire a general anæsthetic, or if the medical man is single-handed, the following may be done :—

A pad of lint large enough to cover the entire surface of the carbuncle is wetted with the above-mentioned solution, and laid over the affected surface, being left for eight or ten minutes.

It is then removed, and a small crystal of carbolic acid placed on each of the openings of the carbuncle, well within the orifice : the pad of lint is again wetted with the anæsthetic solution and replaced. In three or four minutes more it is possible to make a practically painless incision, with perfect safety to the patient.

This solution can also be used hypodermically for removal of warts, small sebaceous cysts, or epithelial growths on the lip.

For circumcision or reduction of a paraphimosis in an adult, 20 per cent. cocaine solution may be painted on the skin three or four times, but in children a general anæsthetic is preferable.

For removal of external piles, or even treatment of painful fissure, cocaine may be used, five to eight per cent. solution being strong enough, but there is rather a greater tendency for toxic symptoms to arise when it is used for recto-anal procedures than elsewhere. It may be both injected and applied as paint.

Ten per cent. solution painted two or three times over a vascular caruncle will render it sufficiently anæsthetic for cauterising.

A four per cent. solution introduced into the urethral orifice will usually render the introduction of a catheter painless, where a patient would otherwise resent it to a marked degree.

Cocaine in ophthalmic cases may be applied for the relief

of painful superficial inflammatory affections, or for removing "fires" (*i.e.*, small chips of steel dust), in the form of $\frac{1}{30}$ to $\frac{1}{20}$ grain wafers or discs, or, if a very complete anæsthesia is needed, a drop or two of four per cent. solution every minute for five minutes will produce it. To prevent toxic symptoms in nose, ear, and throat, a combination of cocaine and B-eucaine has been recommended (Gray, *Lancet*, March, 1901). The cocaine is dissolved in aniline oil and rectified spirit. A ten per cent. (No. 1) and a twenty per cent. (No. 2) solution of cocaine may be made, and a twenty per cent. (No. 3) solution of B-eucaine.

Nos. 1 or 2 may be mixed with No. 3 in equal proportions or one part to three, according to the depth of anæsthesia needed and the part to be treated. The mixture so formed can be dropped into an ear or applied on a piece of gauze held in an aural forceps.

A slightly burning sensation is produced immediately on application.

To throat or nose it can be applied on a probe dressed with cotton wool. The anæsthesia is complete in six or seven minutes, and is more profound than that obtained by much larger quantities of aqueous solutions of cocaine.

Not more than 20 mins. of the stronger mixed solutions should be used.

When injecting cocaine or eucaine *hypodermically*, a practical point of some importance to bear in mind is if more than one syringeful is needed, not to withdraw the syringe to refill it, but simply to unscrew the barrel from the needle, and thus save the patient the pain of its re-insertion.*

* In Schleich's *endermic* method, the needle must be withdrawn and reinserted at another spot.

Oberst's Regional Anæsthesia is specially adapted for operations on the fingers, toes, and extremities generally. It consists in first arresting the circulation of the part by means of a rubber band, and then injecting a solution of one per cent. cocaine or eucaine around the nerves of supply, so that the whole part is rendered completely anæsthetic and all constitutional symptoms are avoided.

The Infiltration Method of Schleich consists in injecting a dilute solution of cocaine and morphia endermically—*i.e.*, *into* the true skin and not *beneath* it. Thus used, Schleich found cocaine had a markedly stronger local anæsthetic action, due to the process of infiltration bringing the anæsthetic solution into direct contact with all the nerve filaments of a considerable area, and no constitutional effect.

He uses three solutions, all of which should be recently made, sterilised, and cooled on ice just before using.

The solutions are of graduated strengths A., B., and C. :—

	A.	B.	C.
Cocaine Hydroch., . . .	2 grs.	1 gr.	$\frac{1}{10}$ gr.
Morphia Hydroch., . . .	$\frac{1}{5}$ gr.	$\frac{1}{5}$ gr.	$\frac{1}{20}$ gr.
Sodium Chloride, . . .	2 grs.	2 grs.	2 grs.
Aq. destil. et steril.,	1000 mins.	1000 mins.	1000 mins.

Solution B. is the most generally useful. If the tissues are very inflamed and tender, solution A. is used; and if the area to be rendered analgesic is extensive, solution C. is more suitable.

Braun has stated that morphia is of no practical use—it will certainly take longer than the cocaine to act, but may be of service to the patient after the action of the cocaine has passed off.

These solutions, properly used, will render all tissues analgesic except the face.

Method of Injection.—The skin over the region to be treated is thoroughly sterilised by washing it with soap and water, 1 in 5000 Perchloride of Mercury, and Ether. A well-made hypodermic syringe—all of metal and glass—is the most suitable for injecting. The plunger should be padded with asbestos. It should hold 10 c.c.

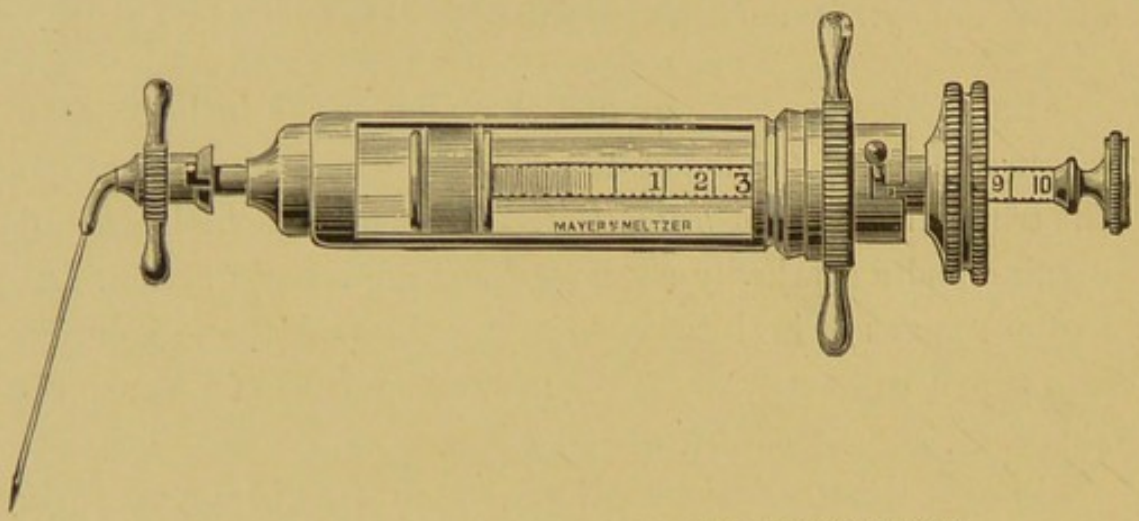

FIG. 38.—SYRINGE FOR INFILTRATING WITH CURVED NEEDLE.

It is convenient to have the needle curved near the butt.

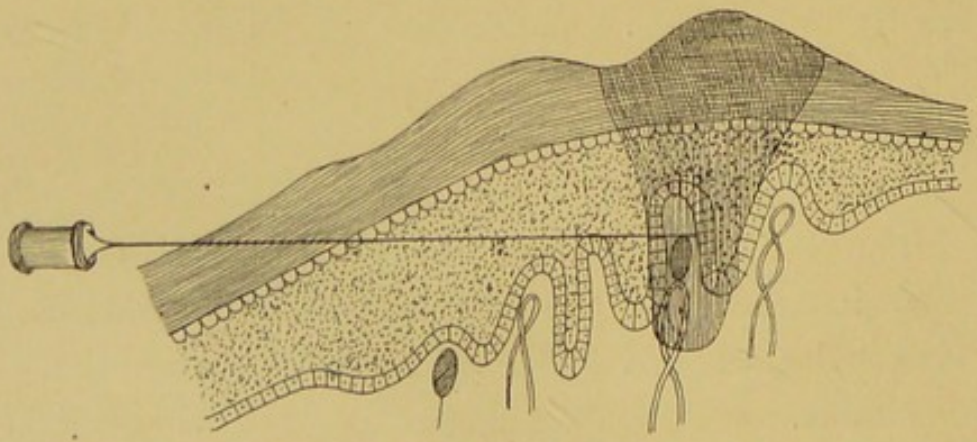

FIG. 39.—NEEDLE DOWN TO PAPILLÆ.

The skin at the point where the needle is to be entered should be frozen with ethyl chloride. The needle is entered obliquely and carried in its entire length into the Malpighian layer. A few drops of the solution are forced out, and a

white wheal like a mosquito bite is formed, about $\frac{1}{2}$ in. in diameter. The area occupied by the wheal becomes at once analgesic.

At its margin the needle is reinserted, more fluid forced out, and the process is repeated until the whole area is infiltrated.

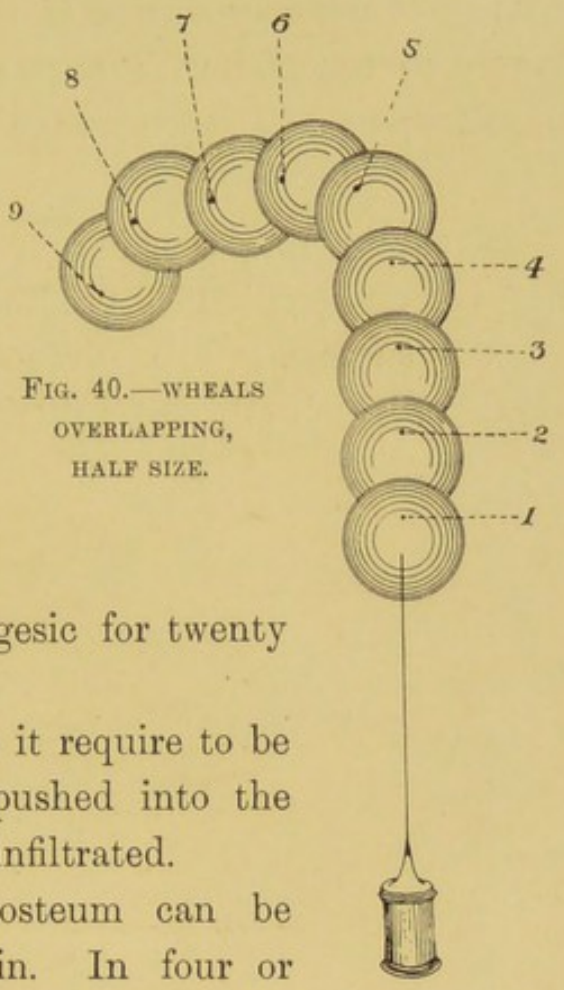

FIG. 40.—WHEALS OVERLAPPING, HALF SIZE.

To render inflamed tissues anæsthetic it is necessary to surround them with a zone of analgesic healthy skin, and from this to extend the wheals centripetally.

The skin will remain analgesic for twenty minutes.

If other structures besides it require to be anæsthetised, the needle is pushed into the deeper tissues, and they are infiltrated.

Fascia, muscles, and periosteum can be anæsthetised as well as skin. In four or five minutes, when complete analgesia will have been produced, the skin is incised and the operation proceeded with.

Injections can be made into an abscess wall but never into an abscess cavity, the sac of a cyst, or the substance of a tumour (Land).

Some experience in the technique of this method is necessary to obtain good results.

It is well to give the patient a light meal with a little alcohol before the injections are commenced.

Drawback of the Method.—The superficial parts will be found to be œdematous, which, when a delicate dissection is

necessary, is a serious drawback. The vital resistance of infiltrated tissues is also lessened, and they are thus more liable to infection than in their normal condition. The parts usually bleed very little; if a vessel requires clamping, it should be touched with pure carbolic acid before applying the forceps.

Adrenalin and Cocaine or Eucaine.—This combination has of late been largely used as a local anæsthetic, and with marked success. The success depends on the fact that anything which retards or diminishes the circulation of the

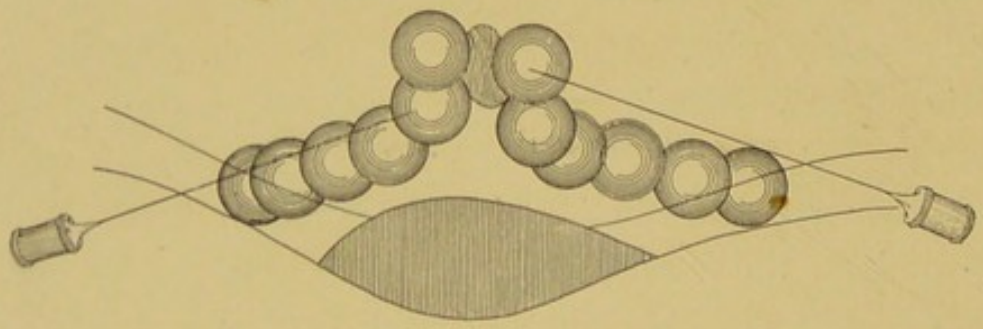

FIG. 41.—ABSCESS OR INFLAMED AREA.

blood in a part infiltrated with one of the analgesic agents enhances the potency of the latter. We see this demonstrated in Oberst's method, when a constricting band is placed about the part, and it is found that the same things happen when adrenalin is injected along with an analgesic, the adrenalin acting as a local vaso-constrictor, while possessing no analgesic properties itself.

A very serviceable solution is prepared as follows:—3 grains of Eucaine with 12 grains of Sodium Chloride are dissolved in $3\frac{1}{2}$ ounces of distilled water at boiling point, and, after the solution has cooled, 18 drops of Adrenalin Chloride (1 in 1000 solution) are added to it.

The mixture should be allowed to stand for a little time, and should then be held up to the light to see if it is quite clear. If so, it is ready for use. The solution must be injected by means of a hypodermic syringe into the skin and tissues of the area about to be operated on, and the full analgesic effect will be obtained in about twenty minutes. If the skin fails to become white and bloodless, the solution is bad. The part treated should be insensitive to pin pricks before any operation is commenced, but the sense of touch will remain. By means of this solution Barker has performed numerous major operations, including hernia, castration, varicose vein operation, psoas abscess, foreign body in the knee-joint, and tumour of the thyroid, without the patient suffering any appreciable amount of physical pain. The success attending these cases is of great interest and importance, as showing indisputably that spinal cocainisation is as unnecessary as it is unjustifiable, and further, that a surgeon who is working in the country is able, single-handed, if put to it, to perform many operations without subjecting the patients to the risk of general anæsthesia in unskilled hands, and without causing them more than a moderate degree of discomfort.

For the performance of an operation for radical cure of a hernia about 50 c.c. or 15 fluid drachms of the solution we have mentioned will be necessary.

Kocher, who, like most German surgeons uses local anæsthesia very largely, prefers a $\frac{1}{2}$ per cent. or 1 per cent. solution of cocaine in $\frac{3}{4}$ per cent. sodium chloride solution, *freshly prepared* and sterilised by boiling, and injected while warm. He apparently meets with no trouble from the cocaine decomposing when prepared in this way. With this solution he is able to induce, and by reinjection to maintain, a sufficient degree of anæsthesia for the carrying

out of extensive operative procedures, such as gastrostomies, colostomies, and extirpation of the thyroid. The last-named operation he has done over two thousand times with cocaine anæsthesia only. There is, however, something in the stolid and phlegmatic Teutonic temperament which has to be remembered in this connection, as enabling the patient to submit without demur to manipulations involving a degree of pain and disgust which the Anglo-Saxon, or his "nervous" cousin the American, would resent intensely.

Bier's Method of Sub-Arachnoid Spinal Cocainisation has found no favour in this country. It has been employed both in France and America, but the present trend of opinion seems to be towards its complete abandonment, unless, by some modification of the method, the untoward after-effects are minimised.

Were it not for the risk and common occurrence of sequelæ, it would appear to be an ideal method for the practitioner working single-handed.

The patient is blindfolded, and his ears filled with cotton wool, or a screen is erected to shut off the field of operation. He lies on one side, is told to round his back, flexing legs on thighs, and thighs on abdomen, and a cushion is placed beneath his flank. The spinous processes of the vertebræ are thus separated to a great extent. The fourth lumbar spine is located, the third or fourth lumbar interspace being the seat of election for the injection.

The injection is made very slowly, and when completed the needle is withdrawn and the puncture covered with collodion. The quantity of cocaine injected must never exceed $\frac{3}{5}$ grain. A one per cent. solution is most commonly used—20 to 30 mins. of this usually sufficing.

The duration of the analgesia varies from thirty minutes

to one and a-half hours according to dose; 20 milligrammes is considered a medium dose. The analgesia disappears in the reverse order of its invasion.

The chief exponent of this method has been M. Tuffier, surgeon of the Lariboisière Hospital in Paris. Under the anæsthesia so obtained he has performed amputation of thigh, arthrectomies, herniotomies, hysterectomies, and many other major operations.

After-effects are usually severe—often extremely so. The most common are :—

Severe headache, sometimes lasting four or five days; violent retching and nausea; pyrexia of 3 or 4 degrees; tachycardia, and even paralysis of the sphincters have been recorded. In one case paraplegia of both legs was found a month after injection. Réclus records eight deaths in 2000 cases, and concludes "that the ordinary methods of anæsthesia cannot at the present time be replaced by this method, which is dangerous, obscure in technique, and sometimes uncertain." Kocher agrees with him. Bier himself has abandoned it pending further experiments. Dumont regards it as "unjustifiable."

II. **Local Anæsthesia by Freezing.**—The necessary cold may be applied to the part by means of crushed ice and salt placed in a rubber bag. The skin blanches in about fifteen minutes, and the part is ready for operation.

This method is of use in emergencies, but is clumsy, and it is difficult, when using it, to restrict the freezing exactly to the part which it is desired to render analgesic.

A further advance was the ether spray introduced by Sir B. W. Richardson. With a double ball pump and nozzled bottle, as illustrated in Fig. 42, methylated ether is played

in a fine spray over the part. The skin is readily frozen, but the analgesia is of a very evanescent description, and the spraying may need repetition. Recovery of sensation is characterised by much smarting and tingling. In some cases sloughing of the part has resulted. The ether spray is

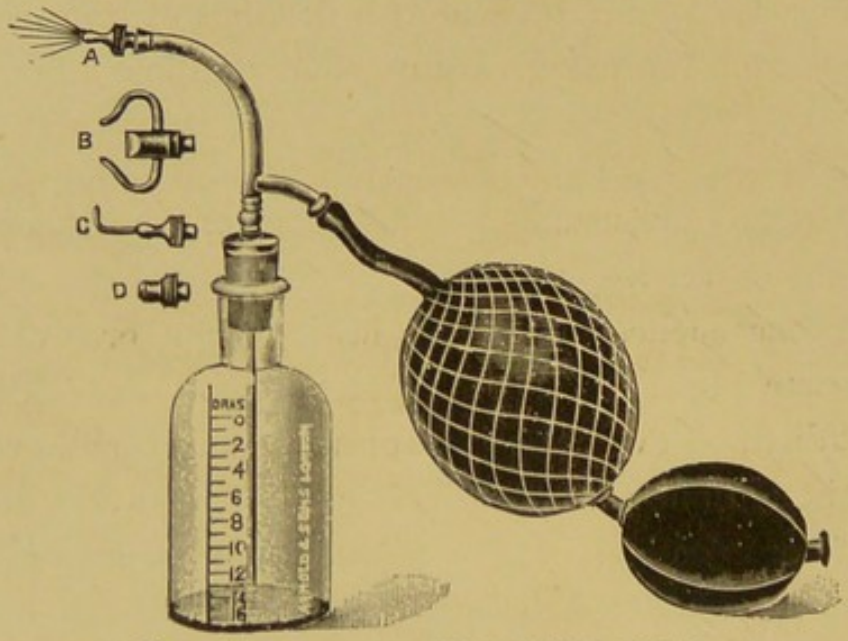

FIG. 42.—ILLUSTRATION OF ETHER SPRAY.

suitable for opening acute abscesses, removing "wens," or for paracentesis.

The method most popular at the present day is freezing by means of the ethyl chloride spray, a very rapid and convenient one.

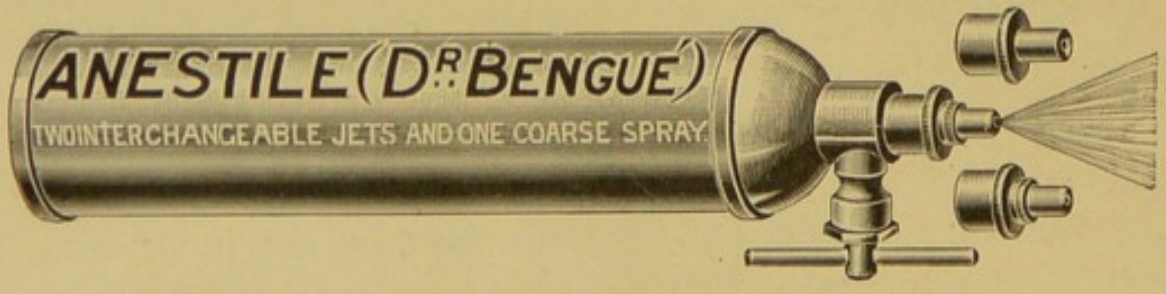

FIG. 43.—ETHYL CHLORIDE CYLINDER FOR LOCAL ANÆSTHESIA.

For local anæsthetic purposes this drug is supplied in glass tubes or cylinders with a narrow neck, kept closed by a brass screw cap or "trigger" stopper. When a part is to be

frozen, the screw cap is removed and the cylinder held in the palm of the hand so as to warm it.

A fine spray of the drug is projected through a small opening in the neck of the bulb on to the area of the incision.

The cylinder should be held at a distance of from eight to ten inches from the patient's skin, so as to allow a fine spray to form.

The skin gets hard and intensely white in round patches, which coalesce as it freezes; it will remain insensitive for

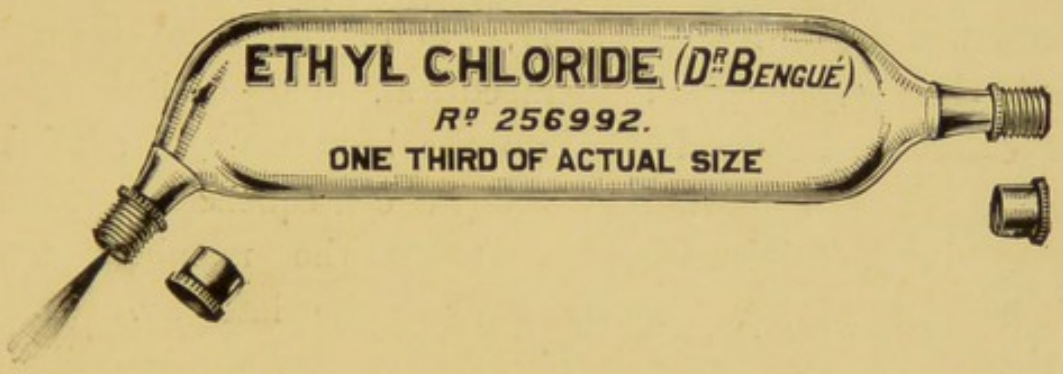

FIG. 44.—ETHYL CHLORIDE CYLINDER (LOCAL).

three or four minutes. The frozen tissues are hard and difficult to cut, and their appearance much altered.

The process of freezing in itself causes the patient some pain, and occasionally sloughing occurs, as after the ether spray.

Only an operation of very short duration can be carried out under freezing anæsthesia. It is quite unsuitable for incising a whitlow, and is almost equally useless in Dental Extractions, where, as a rule, anæsthesia, if present, is largely due to the patient *inhaling* a certain amount of the ethyl chloride vapour.

CHAPTER XI.

ANÆSTHETIC COMMISSIONS AND INVESTIGATIONS.

The Committee of the Royal Medico-Chirurgical Society (London).

This was appointed in 1864, "to inquire into the uses and the physiological, therapeutical, and toxical effect of chloroform, as well as into the best mode of administering it, and obviating any ill consequences resulting from its administration." Among the members were such men as Mr. Thomas Bryant, the late Dr. George Harley, Prescott Hewitt, Sir James Paget, Sir William Priestly, and Richard Quain. Mr. Clover administered the chloroform for the experiments, and devised much ingenious apparatus for carrying them on. The Committee collected a great many facts, and made valuable suggestions for the guidance of anæsthetists. Their Report, completed on the 14th June, 1864, occupied over one hundred pages of their transactions, and some of the rules relating to the administration of chloroform were sound and valuable, and will bear repeating at the present day.

Others were erroneous, and have been shown to be so by more extensive clinical experience and reliable physiological research.

First British Medical Association Committee.

In 1880 a Committee was appointed by the British Medical Association to discuss and generally investigate the

relative safety of anæsthetics and make a report on them. Many cases, collected by them, of death during the administration of anæsthetics, were clearly proved to be due either to carelessness or ignorance and in some cases both. The Report appeared in the *British Medical Journal* for 15th December, 1880, and its practical outcome was a strong condemnation of chloroform, a partial condemnation of ether, and a strong recommendation of dichloride of ethidene—an anæsthetic which to-day is practically unknown to the profession, and which has entirely fallen into disuse from its high price and want of any special advantage over chloroform or ether.

The Hyderabad Commissions.

In 1889, on the recommendation of Surgeon-Major Lawrie, the Nizam of Hyderabad generously put aside a sum of money to defray the expenses of a special Commission on Anæsthetics. The Commission consisted of Dr. Lawrie, Dr. Athir, Mr. Kelly, and Mr. Chamarette. They particularly directed their experiments to the solving of the question as to whether chloroform ever affected the heart directly or not. To obtain evidence on this point they killed with chloroform upwards of 120 full-grown dogs, averaging over 20 lbs. weight each. In addition to this, they performed many hundreds of experiments, and tested the value of artificial respiration in nearly every case by reviving the dogs over and over again, after the breathing had stopped, and before the heart had ceased to beat. They reported accordingly. The profession, however, hesitated to accept their conclusions, and it was accordingly proposed to hold a second Commission at Hyderabad, and to carry out further extensive physiological experiments. The Nizam again rose to the occasion with the necessary funds, and Dr. Lauder Brunton

was sent out from England by the *Lancet* to assist. The former conclusions of the Commission were corroborated in most respects, but it was soon shown by more eminent and expert physiologists, notably Drs. Shore, Gaskell, and Leonard Hill, that there were numerous fallacies in the technical work of the Commission, and that the conclusions which they based on many of their tracings were erroneous. Beyond stimulating scientific research in the Physiological Laboratory in the department of anæsthetics, the Hyderabad Commission cannot be said to have benefited humanity to any extent. The researches of the anæsthetists appointed by the *Lancet*, particularly Dr. Dudley Buxton, into the evidence afforded clinically by over six hundred authentic cases of death under chloroform, &c., were of considerable value. Dr. Dudley Buxton made the following deductions from the reports as a whole :—

1. That the death-rate under anæsthetics heretofore has been unduly high, and may, by improved methods and greater care, be lowered.

2. That ether, when properly given from an inhaler permitting graduation of the strength of the vapour, is the safest anæsthetic in temperate climes for general surgery.

3. That nitrous oxide gas should be employed for minor surgery, and should replace chloroform in dental surgery.

4. That chloroform, when given by a carefully trained person, is a comparatively safe body, but is not in any case wholly devoid of risk.

5. That no age or nation is free from danger under anæsthetics.

6. That the perils of anæsthetics, however slight, demand that the undivided attention of a duly qualified and trained medical man should be given to the administration of the anæsthetic.

THE SECOND BRITISH MEDICAL ASSOCIATION COMMITTEE

was formed at the Bournemouth meeting of the Association, 1891, to investigate the clinical evidence with regard to the effect of anæsthetics upon the human subject, and especially the relative safety of various anæsthetics; the best methods of administering them, and the best methods of restoring a patient in case of threatened death. The Chairman of the Committee was Mr. Jonathan Hutchison, and among its members were Professor Chiene, Mr. Teale of Leeds, Mr. Joseph Bell, Dr. F. W. Hewitt, and Mr. David Wallace. All anæsthetists throughout the kingdom were requested to record their cases during the year 1892 in books prepared for the purpose. Accordingly, in January, 1893, 156 books were returned with details of 26,000 cases in hospital and private practice. These were very carefully investigated and classified by a Sub-Committee, which met over three hundred times and expended an enormous amount of labour on the matter. They divided the cases into—

(*a*) Complicated, and (*b*) uncomplicated.

The complicated were divided into—

1. Cases of anxiety.
2. Cases of danger.
3. Fatal cases.

Of the latter twenty-nine were recorded. Eighteen of the fatalities occurred under chloroform; three of these were considered entirely due to the anæsthetic, and four to the anæsthetic principally and to the patient's condition secondarily. In the others there was either doubt as to the relative shares taken by the three factors — anæsthetic, patient's condition, and operation; or the death was distinctly due more to one or both of the two latter causes than to the anæsthetic.

Of the deaths during ether anæsthesia, not one was held to be due entirely to the anæsthetic. Six occurred under ether and one under gas and ether. There is a strong probability that the fatal results were reflexly produced by the operation; in other cases by entrance of vomitus into the larynx.

Chloroform was found to put the patient's life in jeopardy once in two hundred administrations, ether once in fifteen hundred; and these figures are sufficiently striking to make those who advocate the universal and exclusive employment of chloroform pause and consider their position. Severe and prolonged vomiting was found to be more common after chloroform than ether, although transient retching occurred more frequently after ether.

The most important **conclusions in regard to chloroform** were the following:—

I. No method of administration of chloroform is free from danger, but an examination of the complicated cases appears to show that the occurrence of danger depends largely upon the administrator who employs any particular method.

II. Complications and danger are more commonly met with in males than females.

III. Excluding infancy, the complications and dangers of anæsthesia increase *pari passu* with advancing age.

IV. Danger to life is especially likely to be incurred in early periods of the administration of the anæsthetic and during light anæsthesia.

V. Chloroform is about twice as dangerous in males as in females; most dangerous during early infancy and after thirty years of age.

VI. In good health chloroform is very much more dangerous than other anæsthetics. In grave conditions chloroform still remains the least safe anæsthetic, but the disparity between it and other anæsthetics is far less marked

than in health. When danger does occur under chloroform, in the large proportion of cases the symptoms are those of primary circulatory failure.

VII. Vomiting during anæsthesia which may lead to danger seems to be much more frequent under chloroform than other anæsthetics. Struggling is a great source of danger. Further, circulatory depression following anæsthesia is more commonly seen after chloroform.

Conclusions in regard to Ether. — 1. Ether, where employed throughout, or preceded by (ethyl chloride), nitrous oxide gas, or CE, is singularly free from danger in healthy patients.

2. Minor troubles in administration due to laryngeal irritation and increased secretion are more common under ether than under chloroform and its mixtures.

3. Bronchitis is more common after ether than after chloroform, especially in hospital practice, but neither chloroform nor local anæsthesia is free from some risk of bronchitis as an after-effect or sequela.*

The general and final conclusion of the Sub-Committee was that they were convinced that by far *the most important factor in the safe administration of anæsthetics was the experience acquired by the administrator.* Accordingly, no one should be allowed to qualify until he or she has obtained some experience and shown some proficiency in this important branch of medical work.

THE THIRD BRITISH MEDICAL ASSOCIATION COMMITTEE.

This consists of a small Special Committee appointed in 1901 at the instigation of Professor Waller. It consists of Sir Victor Horsley, Professor Dunstan, Dr. Dudley Buxton,

* Confirmed by v. Mikulicz, of Breslau. *Trans. Germ. Surg. Soc.*, 1901.

Dr. Barr, Dr. W. J. M'Cardie, and Professors Sherrington and A. D. Waller. The services of Mr. Vernon Harcourt were also engaged, and a yearly report has been published of the work carried out by the Committee.

The Committee critically reviewed the methods of determining chloroform quantitatively in the atmosphere. Of the two classes of method, *gravimetric* and *chemical*, they preferred the latter as being the more likely to give accurate results.

The object of the Committee was to put the quantitative determination of chloroform on a sound basis. Having attained this, they proceeded to discover, by means of it, two practical points.

(1.) The smallest possible dose by volume in the atmosphere breathed requisite to induce anæsthesia. (2.) The smallest possible dose to maintain analgesia, after the initial loss of consciousness. It was shown that although it was the common practice to begin with a considerable quantity of chloroform and then reduce the dose, it was not recognised to what a remarkable degree this could be carried out. To demonstrate this, Mr. Vernon Harcourt devised a special apparatus, and by means of it in certain cases chloroform anæsthesia was obtained with what might almost be described as mathematical precision. It was found that to obtain complete unconsciousness to the pain of the incision, &c., the dose to be adequate was from 1 to 2 per cent. of the atmosphere breathed. For the maintenance of anæsthesia the dose could be diminished to even ·2 per cent.

The Committee have as yet been unable to decide whether chloroform accumulates in the body or not, but Professor Sherrington established the fact that it does not accumulate in the heart itself at any rate.

The investigations of the Committee are not yet completed.

APPENDIX.

VERNON HARCOURT'S CHLOROFORM REGULATION APPARATUS.

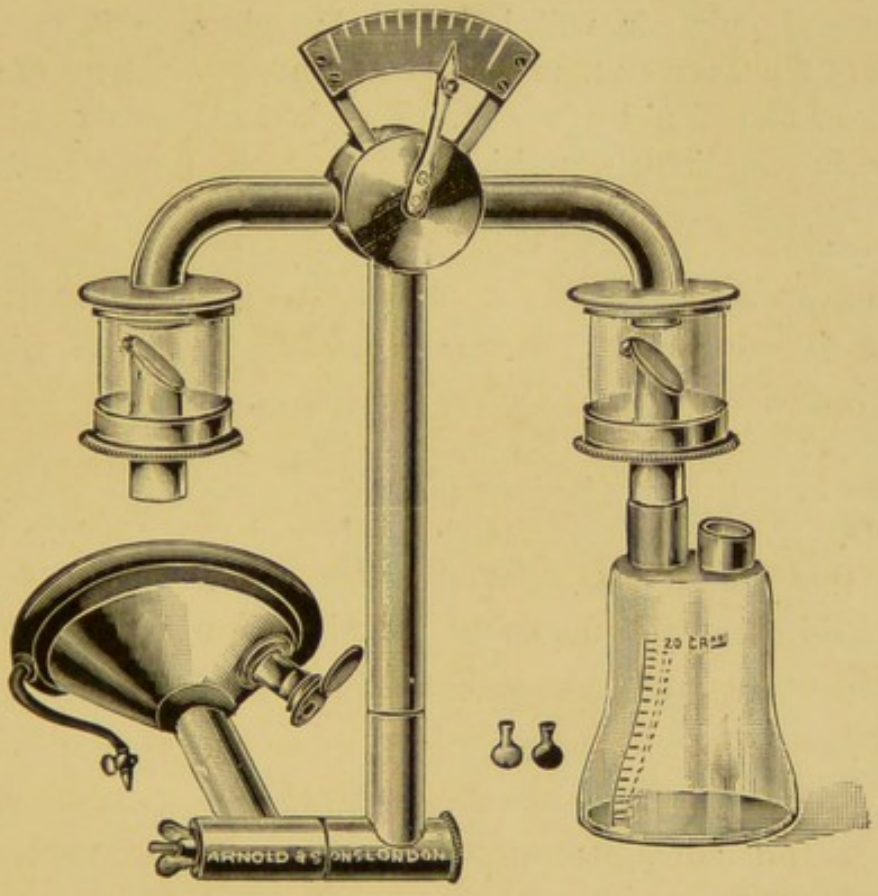

FIG. 45.—VERNON HARCOURT'S CHLOROFORM INHALER.

THIS inhaler provides, in sufficient quantity for full and free respiration, a mixture of air and chloroform which is automatically limited to a maximum strength of 2 per cent., and can be diluted at will with additional air down to any smaller proportion.

The two-necked bottle is filled with chloroform to near the top of the conical part, and two coloured glass beads are dropped into the

liquid to indicate when the temperature is within the range 13°-15° C. If the temperature of the chloroform is below 13° both the coloured beads will float; if it is above 15° both will sink; in the former case the proportion of chloroform inhaled will be less than the pointer of the stopcock indicates, in the latter case it will be greater. During inhalation the chloroform is cooled by evaporation; its temperature may be kept between 13° and 15° by now and then holding the bottle in the hand till the red bead has floated up and the blue bead is beginning to rise.

The stopcock is so made that when the pointer is at the end of the arc nearest the bottle of chloroform the maximum quantity is being administered, namely 2 per cent. When the pointer is at the opposite end only air will be inhaled; and when it is midway dilution of the 2 per cent. mixture with an equal volume of air will make the proportion 1 per cent. The shorter lines on either side indicate intermediate quantities, namely 0·8, 0·6, 0·4, 0·2, and towards the chloroform bottle 1·2, 1·4, 1·6, 1·8.

The valves on the two branches prevent the entrance into the apparatus of expired air, and also serve to show whether the stopcock is working rightly. Only one valve opens when the pointer is at either end of the scale, both equally when the pointer is midway, and for all other positions one valve opens more and the other less in the degree indicated by the position of the pointer on the scale. The movement of these valves shows also how full and regular the breathing is, and the slight click which they make conveys this information to the ears when the eyes are otherwise occupied.

It is generally found that beginning with the pointer at 0·4 and moving it on towards the chloroform bottle at the rate of about one division every half minute up to 1·6 or 1·8 produces narcosis as quickly as is desirable. In case it should happen, perhaps owing to imperfect adjustment of the face-piece, that a dose stronger than 2 per cent. appears to be required, a small tube is provided fitting into the open neck of the bottle, by the use of which the dose may be raised to either 2·5 or 3 per cent. To obtain a 2·5 per cent. mixture the larger end of the tube, marked 2·5, must be inserted in the bottle, and for 3 per cent. the smaller end, while the pointer is kept at the end of the scale nearest the chloroform.

For the maintenance of narcosis it is believed that 1 per cent. or

even less will be found sufficient. The stopcock can be moved by a touch of the finger so as at once to increase or diminish the dose.

The face-piece, which is provided with an expiratory valve, and can be fixed in any position, is either attached directly to the inhaler, which in this case is held in the hand, and should be kept as nearly vertical and as steady as possible, or can be connected by about 20 inches of half-inch rubber tubing, the inhaler in this case being supported on a stand or hung on to the back of the bed.

Similar stands are also made provided with tubes connecting at one end with the inlets for air and chloroform and for air only and at the opposite end with a blower, the object of this arrangement being to supply the regulated mixture of chloroform and air in any case in which the patient's breathing cannot be used as the motive power.

The face-piece is made of solid toughened rubber fitted with a rubber air-cushion. It can be washed or boiled, and as it becomes plastic in hot water the shape can easily be modified, if required, so as better to fit the patient's face.

No chloroform evaporates excepting that which is inhaled by the patient; and only that which is exhaled passes into the air of the room.

The DUBOIS APPARATUS, which has been strongly advocated by Professor Waller, among others, as being the most reliable and safest dosimetrical method, is so heavy and elaborate as to be utterly unsuited for anything but a museum or a laboratory. It weighs considerably over 2 stone, and costs nearly £20. However interesting these apparatus and experiments with them may be to physiologists, and however praiseworthy the end in view—viz., the lowering of the present high death-rate under chloroform—it is extremely unlikely that either will ever take a very important part in practical anæsthetics of the future.

It has been pointed out and proved with almost mathematical accuracy by Dr. Embley, himself an anæsthetist, that high percentage chloroform vapours cause vagus inhibition and death. It has been proved by means of Harcourt's and Dubois' machines that good anæsthesia can be *maintained*, if not rapidly induced, by means of vapours of only 1 to 2 per cent. This is a most valuable piece of knowledge, and shows that the use of large quantities of chloroform

with air exclusion is as unnecessary as it is extremely dangerous, and that the person so employing chloroform is culpable in the highest degree. But no piece of mechanism, however ingenious, can supply the lack of brains and skill in the medical man, and if an individual is incapable of learning to administer chloroform judiciously and properly by means of a drop bottle and a piece of lint, it is unlikely that he will wield an apparatus like either of those we mention with safety to the patient, or satisfaction to the operator.

Moreover, there are a number of valves in Harcourt's apparatus which are very prone to get out of order, especially if the inhaler be only occasionally used. Any agitation of the bottle during the administration increases the strength of the vapour and upsets all the administrator's calculations based on the index, and quite recently a death very nearly occurred with Harcourt's apparatus in the hands of a skilled and practised operator.

The *raison d'être* of such an apparatus is, that it would give results in inexperienced hands better than we get at present with bottle and mask, but if accidents occur with those accustomed to the apparatus, what can we expect with the tyro?

Accordingly, the fact remains that, while *any attempt to develop accuracy of dosage with chloroform is in the right direction*, by no means known to us at present can this valuable but lethal drug be rendered as safe as ether, ethyl chloride, &c., and especially is this the case in the early stage of any anæsthesia, when, as is well known, practically speaking, all the accidents occur.

The only means to ensure increased safety with anæsthesia is to raise the standard of education of medical men in this subject, and to encourage the use of ethyl chloride in minor surgery, and in the induction of anæsthesia for longer operations, in which the subsequent employment of ether, chloroform, or CE may be necessary.

INDEX.

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