

A guide to the administration of ethyl chloride / by G.A.H. Barton.

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A GUIDE TO
THE ADMINISTRATION
OF
ETHYL CHLORIDE

BARTON

PRICE TWO SHILLINGS



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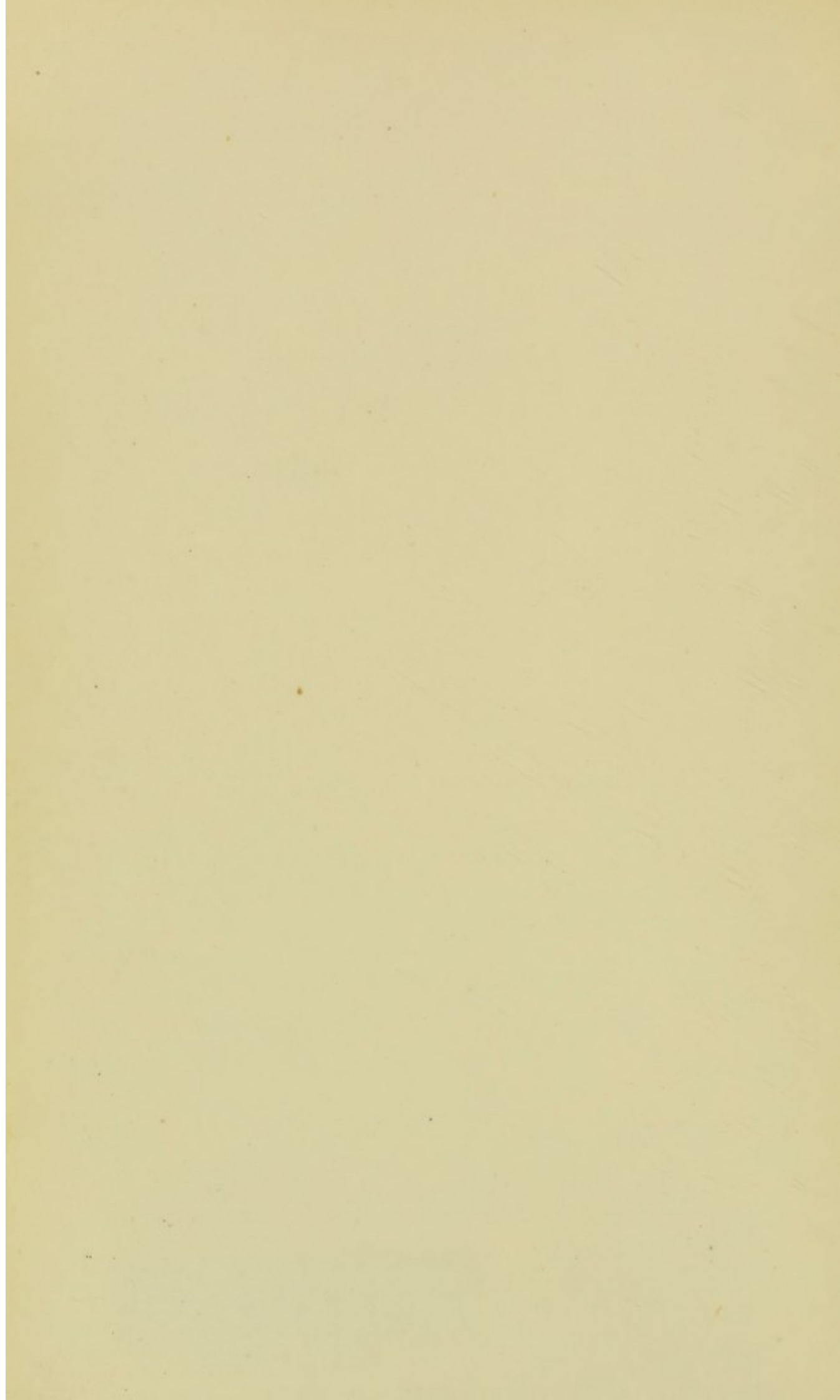
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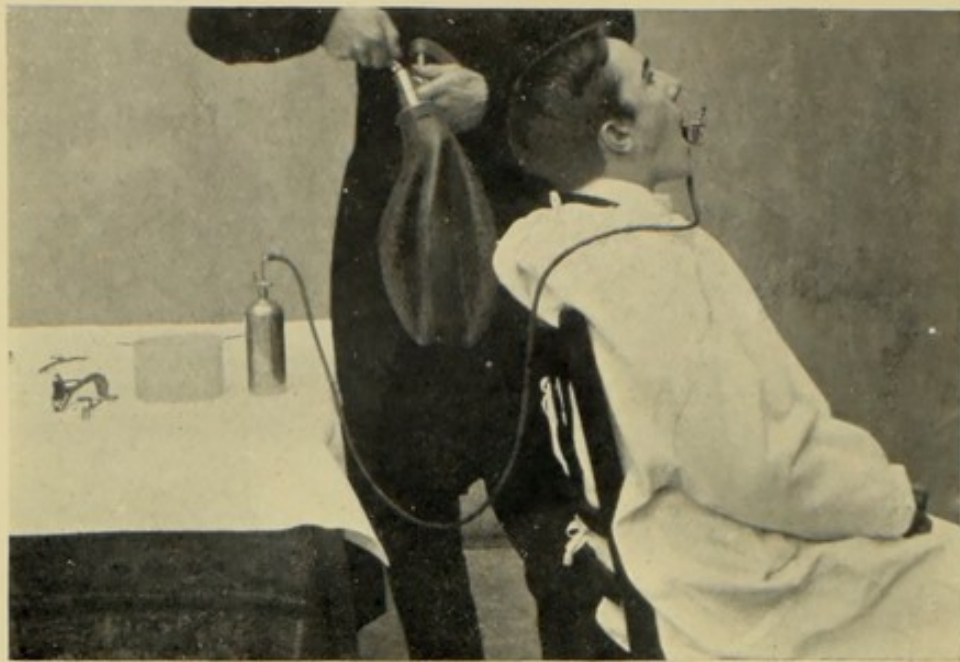
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THE INDUCTION ABOUT TO COMMENCE.

NOTE.—The ethyl chloride chamber stands on the table, and the little lever controlling the stopcock is vertical.



CONTINUING THE ADMINISTRATION THROUGH THE TUBE.

NOTE.—The ethyl chloride chamber is now in the hot water, and the lever horizontal, allowing the vapour to pass.

A GUIDE TO
THE ADMINISTRATION
OF
ETHYL CHLORIDE

BY

G. A. H. BARTON, M.D.

ANÆSTHETIST TO THE NORTH-WEST LONDON HOSPITAL, THROAT HOSPITAL (GOLDEN
SQUARE), FEMALE LOCK HOSPITAL, AND ROYAL NATIONAL
ORTHOPÆDIC HOSPITAL

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PREFACE TO THE SECOND EDITION

SINCE publishing the first edition of this little work two years ago, most of the standard works on anæsthetics have been revised, and now appear with chapters on the subject of ethyl chloride. I venture to think, however, there is still room for a short monograph dealing with this subject alone. In the present edition I have endeavoured to collate and bring up to date the work of others, and in the light of further experience have had to modify some of the views I formerly held.

My thanks are due to Messrs. Duncan and Flockhart for the loan of blocks depicting their apparatus.

G. A. H. BARTON.

TALBOT ROAD, W.

October, 1907.

PREFACE TO THE FIRST EDITION

THIS little work has no pretensions to be either an exhaustive or scientific treatise on the subject of ethyl chloride. It is the outcome of practical experience in the administration of this anæsthetic during the last three years.

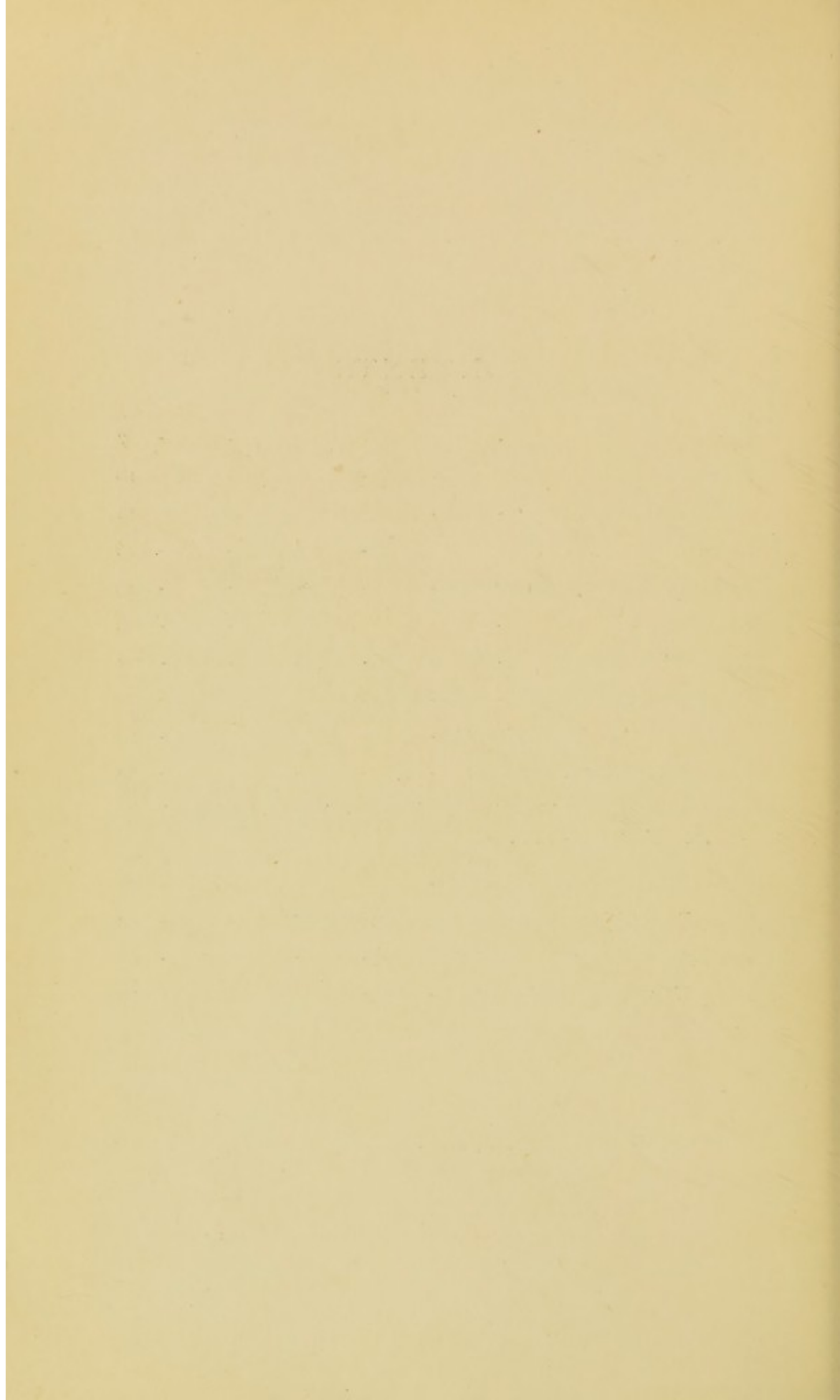
I venture to hope that the following pages may prove helpful to those whose experience of ethyl chloride has so far been limited.

G. A. H. BARTON.

WESTBOURNE PARK ROAD, W.

CONTENTS

	PAGE
PROPERTIES - - - - -	7
HISTORY - - - - -	10
COMPARATIVE SAFETY - - - - -	12
SCOPE - - - - -	16
PREPARATION OF PATIENT - - - - -	19
APPARATUS - - - - -	20
ADMINISTRATION - - - - -	22
SIGNS OF ANÆSTHESIA - - - - -	23
RECOVERY AND AFTER-EFFECTS - - - - -	26
PROLONGED ADMINISTRATION - - - - -	27
PROLONGED ADMINISTRATION IN THROAT AND NOSE CASES	29
ETHYL-CHLORIDE-ETHER SEQUENCE - - - - -	37
ETHYL-CHLORIDE-CHLOROFORM - - - - -	40
C.E.—ETHYL CHLORIDE—CHLOROFORM SEQUENCE - - - - -	42
GAS-ETHYL-CHLORIDE SEQUENCE - - - - -	49
SOME UNSATISFACTORY CASES - - - - -	50



ETHYL CHLORIDE

BEFORE entering into practical details, a short account of the properties of ethyl chloride and of its introduction to this country as a general anæsthetic may be of some interest.

Ethyl chloride, also known as chlorethyl and Kelene, the latter a proprietary preparation, is a very volatile colourless fluid, with an agreeable ethereal odour, of the chemical formula C_2H_5Cl , density 0.92 at $0^\circ C.$, density of vapour compared to air 2.3, boiling-point $12.5^\circ C.$ or $54.5^\circ F.$ This low boiling-point is of practical importance, as will appear later. It is prepared by acting on ethyl alcohol with hydrochloric acid gas, the yield being increased by the addition of zinc chloride. For anæsthetic purposes it should be obtained as pure as possible; it is wise to use only that which is guaranteed by the makers to be made from pure ethylic alcohol. For trade purposes, I am told, it may be made from methylated spirits; any such preparations should, I think, be avoided by anæsthetists, as they would not unlikely contain methyl chloride and possibly other impurities. Some specimens, I note, cause the appearance of a good deal of verdigris on the metal springs or taps connected with the apparatus, due, I should say, to the presence of some free HCl in the preparation. An analysis of several brands was made in

the *Lancet* laboratory in 1905, and the following were found free from impurities: Kelene, Duncan and Flockhart's, Hedley's, and Kuhn's. Pure ethyl chloride is a stable preparation, and should keep indefinitely without undergoing decomposition. It has a somewhat solvent action on rubber, more especially vulcanized rubber; the purer rubbers resist its action: this is a point of some practical importance, to which I shall refer again later. It burns with a green flame, and a slight explosion can be produced by bringing a naked light in contact with the vapour mixed with air. The tests of purity usually given are—(1) It should not redden litmus-paper after ten minutes' contact; (2) no turbidity should be produced by the addition of nitrate of silver to its alcoholic solution; (3) there should be no appreciable diminution of volume or darkening on shaking with concentrated sulphuric acid; (4) there should be no odour of garlic.

Its physiological action has been investigated by Dr. W. Webster, of Manitoba, and by Dr. E. H. Embley, of Melbourne. Dr. Webster published his results in the *Biochemical Journal*. He states that small doses augment the frequency and depth of respiration; large doses diminish them. Small doses raise and large depress the blood-pressure. Respiration may cease before the heart stops. Some animals were restored by means of artificial respiration after breathing had ceased for from thirty to ninety seconds, and with blood-pressure almost zero. Dr. Embley reported the results of his investigation to the Royal Society, and I cannot do better than quote the summary given by the *British Medical Journal*:

“Dogs were selected for the experiments, but many initial difficulties were encountered. Ethyl chloride is soluble in water to the extent of 253·36 per cent. by volume,

and although it is freely absorbed by blood, the exact amount taken up is not easy to estimate, as the blood becomes of tarry consistence and 'lakes' in the earlier part of the absorption process. It seems clear that, like chloroform, ethyl chloride enters into chemical union with the blood. Upon the isolated heart ethyl chloride caused paralysis, an effect common to it and chloroform, although nineteen times more ethyl chloride is needed. Similarly, it causes relaxation of the arterioles when these are isolated from the central nervous system. Upon the central vasomotor mechanism ethyl chloride acts as a stimulant—at least, for a time—and the net result upon the vasomotor system in the intact animal is dilatation, although the degree of paralysis is strikingly less than that caused by chloroform. Experiments with regard to vagus inhibition showed that, although the heart was readily stopped under ethyl chloride as it is under chloroform, yet under the former anæsthetic the inhibition was never fatal, whereas under the latter it is frequently so. The cardiac inhibition appears to be due to central stimulation ; it is not reflex. In concentrations of 10 per cent. and over, ethyl chloride, according to Dr. Embley, produces paralysis of the myocardium quite comparable to that caused by chloroform in one-nineteenth of the above concentration.

“ With regard to respiration, these experiments indicate that with ethyl chloride, as with chloroform, the respiratory function is maintained so long as blood-pressure does not fall. The fall of blood-pressure, when it takes place, is due to vagus inhibition, and so in this respect ethyl chloride differs from chloroform, since under the latter the fall in blood-pressure is due in part to cardiac paralysis and in part to vagus inhibition. High

concentrations (20 per cent.) of ethyl chloride can, however, produce respiratory failure apart from any vasomotor effects. For dogs, the limit of safety is placed at from 5 to 7 per cent. in air inspired, and Dr. Embley is led to believe from his clinical observations that a like dosage should be accepted in the case of man."

The following brief history I have culled from the writings of others to the various journals to which I have had access, being specially indebted to Dr. McCardie, of Birmingham, to whom belongs the honour of having introduced this very useful and popular anæsthetic into medical practice in England. He states (*Lancet*, April 4, 1903) that it was successfully used in the human subject so long ago as 1848 by one Heyfelder, a foreign surgeon. Its anæsthetic properties were discovered the year previously by Flourens. Its use does not appear to have been followed up; doubtless in those days there were difficulties in obtaining it pure, also in storing so volatile a drug.

Dr. (afterwards Sir) B. W. Richardson referred to it in his lectures on the action of narcotizing vapours and gases, published in the *Medical Times and Gazette* in 1867. His experiments were on animals, and he states that when the drug was pushed death resulted, with the post-mortem signs of asphyxia. I find a report (*British Medical Journal*, September 18, 1880) of a committee of the British Medical Association appointed to study the effects of various anæsthetic agents. They give the results of their experiments on animals, and sum up against ethyl chloride, finding it produce convulsions and stoppage of respiration.

For many years ethyl chloride has been used for the production of local anæsthesia by freezing, and it was

whilst using it in this way in 1895 and 1896 that Carlson and Thiesing, two foreign dentists, independently observed general anæsthetic effects. Thiesing tried it on himself, and other dentists advocated its use. Lothiesen appears to have been the first surgeon to give it a trial in 1896; his paper on it was translated by Dr. McCardie, and published in the *Birmingham Medical Review* of January, 1900. Lothiesen administered it in a Breuer's mask with inspiratory and expiratory valves, thereby allowing free admixture of air, and the anæsthesia was usually short and light, the corneal reflex not being lost nor the muscular system relaxed. He reported 170 cases in all, with no untoward result. Ages ranged from one and a half to seventy-two years. There was after-vomiting in eighteen cases; in two cases the administration was continued twenty and twenty-five minutes respectively. McCardie (*Lancet*, March 9, 1901) gives notes of his first ten cases, with an account of work already done by others. He mentions 2,500 cases collected by Lothiesen up to that date, with one death in an extremely bad subject. McCardie evidently proceeded with caution, using the Breuer's mask, and of the ten cases two were failures, and in the rest only a light anæsthesia, available from twenty to thirty seconds, was obtained.

He reports later notes of a further twenty-six cases, the results being fairly satisfactory, but, owing to the admission of air, not so good as we now obtain by using the closed method; this method was finally adopted by Dr. McCardie, and in 1903 he was able, in giving statistics of 250 cases, in which he used an Ormsby's inhaler, to report much better results. From this time onwards ethyl chloride may be said to have become established as a general anæsthetic in England; references to it in the

journals are frequent, various authorities describing their methods and apparatus and the results obtained. In the *Lancet* of November 19, 1904, is an account of an investigation made by Dr. Hewitt into various methods of administration. He used in some cases definite percentage mixtures of the vapour and air, rebreathing being prevented. In others rebreathing was allowed. In the former method he found the results unsatisfactory, and his investigation may be taken to definitely establish the necessity of rebreathing in administering this anæsthetic—at any rate, during the induction period. A general discussion on ethyl chloride was opened by Dr. McCardie at the Society of Anæsthetists in 1905. The reader will find a record of this and many other matters of interest on the subject in the Society's Transactions, vol. vii.

We may now consider the question of the safety of ethyl chloride as a general anæsthetic. This is a matter which it is a little difficult to estimate precisely.

Very many thousands of administrations have been made in this country during the last few years, and the number of deaths reported are certainly few, but I have no doubt deaths have occurred which have not been reported either in the journals or before societies. Personally, in over 2,500 administrations I have met with very few cases which have caused me any alarm. Seitz collected 16,000 administrations with only one death in a very unfavourable subject. As mentioned above, Lothiesen collected 2,500 cases with one death, also in an unfavourable subject.

In a paper read before the Birmingham branch of the British Medical Association in 1905, and published with some additions in the *Journal* of March 17, 1906, McCardie says : “ It occupies a position as an anæsthetic

between nitrous oxide and ether as regards safety." He somewhat modifies this statement farther on. He states that "at least thirty fatalities are known to have taken place under ethyl chloride." Finally, he puts the mortality at 1 in 3,000, from statistics of administrations in Birmingham and district. This rate appears very high, but Dr. McCardie did not count as ethyl chloride administrations those cases in which ethyl chloride was administered as a preliminary to ether or chloroform. Any death in the first stage of such a sequence would certainly, and quite fairly, be ascribed to ethyl chloride. These sequences must have been very numerous, as by 1905-6 the ethyl-chloride-ether sequence was well established and popular. I also think that there may well have been far more simple ethyl chloride administrations than he estimated for. For these reasons I am unable to agree with this estimate. Dr. Hewitt, in his work on Anæsthetics, quotes McCardie's figures. Dr. Dudley Buxton ("Anæsthetics," fourth ed., 1907) gives the mortality as 1 in 13,000.

Dr. Luke, of Edinburgh, in a correspondence in the *Lancet* (vol. ii., 1906), makes an ingenious calculation, based on estimated manufacturers' sales and known deaths. He says that Duncan and Flockhart informed him that they had sold enough ethyl chloride for 1,500,000 administrations of 5 c.c. each. He assumes that the other manufacturers together had sold an equal amount at least. At the time he had only been able to collect a list of twenty deaths, which in 3,000,000 administrations would give a mortality of 1 in 150,000. This is, of course, only a rough calculation, and, as pointed out by other correspondents, open to the following fallacies: It takes no account of unused stocks in the hands of retailers and doctors, of breakage, wastage, and of con-

tinuous administrations, in which far more than 5 c.c. would be used ; and, on the other hand, many deaths had doubtless occurred which had never been reported. However, if we allow for all these fallacies liberally, halve the number of administrations, and double the number of deaths, we still get a mortality of only 1 in 37,500. Dr. Luke, however, is more cautious, and in the last edition of his " Guide to the Administration of Anæsthetics " gives the death-rate as 1 in 12,000, placing it between nitrous oxide and ether in this respect. In Appendix B he gives a list of twenty-five deaths, which he had been able to collect up to date from all quarters of the world. A fuller account of twenty-two of these cases will be found in the *Lancet* of May 5, 1906, and this, with Dr. Luke's remarks thereon, should be read by every one who is interested in the matter. It is impossible here to do more than give a brief analysis. Of the twenty-two deaths, five occurred abroad, leaving seventeen in the British Isles. One was a case of somnoform administration. Several were cases which, in the light of greater experience, would, I think, now be regarded as unsuitable for ethyl chloride administration. Thus, Case II. was a tracheotomy for stenosis of the air-passages due to diphtheria. Case V. had an abscess under the right jaw, and had been unable to swallow for three days ; at the necropsy œdema of the glottis was found. Case VI. had brawny swelling of the whole of the lower jaw from malignant glands in the neck ; the necropsy showed œdema and narrowing of the air-way. Case XVI. is stated to have had chronic inflammation of the lungs and throat. The following cases had various affections of the heart (not, however, obvious during life in all) : Cases VII. (a very bad subject, with ascites), XI. (had been warned not

to take an anæsthetic), XIV. (alcoholic, struggled a good deal, and only had 3 c.c.), and XV. There were also seven dental cases, for which ethyl chloride would not now be regarded as the anæsthetic of choice.

Case III. was a strangulated hernia. Narcosis was induced by ethyl chloride, and was just being followed by ether when vomiting of a large quantity of fluid occurred, followed by cyanosis and arrest of respiration. No autopsy was performed, but I think it quite permissible to suppose that the patient was drowned in his own vomit—an accident which might have occurred under any anæsthetic. Cases IV., VIII., X., XII., XIII., and XVII. all apparently died with syncopal symptoms with appalling suddenness, there being no very obvious reason for their death, either in the state of the patient, nature of the operation, or method of administration.

The ages of the patients ranged from one year to sixty-seven, and it may be noted that, with the exception of two, they were all adults or adolescents. In a few of the cases ethyl chloride was being given as a preliminary to ether or chloroform. In very many of these deaths the administration had ceased, and in some the patient was stated to be regaining, or even to have regained, consciousness.

Writing to me on the subject, Dr. Silk states: "We have been using ethyl chloride at King's for the last four or five years, but almost entirely as part of a sequence, and rarely by itself. As far as *I* know, we have had no deaths."

Dr. Beresford Kingsford stated lately at the Society of Anæsthetists that at the Central London Throat Hospital there had been 10,000 administrations of ethyl chloride or somnoform without a single death, and

that in only two cases had artificial respiration been necessary.

To sum up : There are no accurate statistics available. Ethyl chloride has been administered an enormous number of times during the last few years ; probably, owing to its use as part of a sequence, many more times than any other anæsthetic ; hence it is not surprising that a fair number of fatalities have fallen to its share. It is not now regarded as the absolutely safe anæsthetic that it was, and, being treated with more respect, the fatalities are likely to diminish. If ever reliable statistics are available covering a sufficiently large number of cases, I should not expect the mortality to be higher than 1 in 30,000. The administration of ethyl chloride is not, however, a matter to be lightly undertaken. In my humble opinion, it should not be given by any but qualified medical men, and these should have some training in the matter first ; skilled assistance should, if possible, always be at hand ; the patient should always be prepared as if chloroform or ether were going to be administered, also examined beforehand as to his suitability for this anæsthetic. Compared with other anæsthetics, I think there is no doubt that ethyl chloride comes some way after nitrous oxide gas in point of safety, but it is a good long way ahead of the rest. Where nitrous oxide is suitable, and it will give a sufficiently long anæsthesia, it should certainly be given the preference.

In considering whether we shall give ethyl chloride in any case, we have to ask ourselves : Is it suitable for the special operation or manipulation in view, and is the patient a suitable subject ? Most short operations can be done under ethyl chloride ; an ordinary dose administered as I shall describe can be reckoned on to give two

minutes' anæsthesia, and this may be maintained by various methods for practically any length of time. I do not think, however, ethyl chloride alone should be relied on for operations lasting much longer than ten minutes. My reasons are that it is expensive and requires a good deal of watching; the strain on the anæsthetist to keep the patient just right is very considerable; also I find symptoms of collapse are more likely to arise in prolonged administrations. Hence, for operations expected to last over a few minutes it is advisable to use ethyl chloride only as part of a sequence for the induction, and continue with ether or chloroform as may seem desirable. I shall refer to these sequences later on.

Ethyl chloride is unreliable in all surgical procedures where complete muscular relaxation is required, as, so far from producing this with certainty, it is, on the contrary, frequently accompanied by spasm and rigidity. I have found it undesirable for this reason in examinations of abdomen, vagina, and rectum, and in slight operations on the last two; it may be unsatisfactory in cases where wrenching has to be done or adhesions broken down. As regards the patient, he should always be most carefully examined before administration. In particular, the neck should always be bared, so that no abnormality there may be overlooked. The heart and pulse will, of course, be carefully examined. The anæsthetist is not often called in in advanced cases of heart, lung, or kidney disease, as the surgeon recognizes that these are unsuitable for operations. I have frequently given ethyl chloride where the following conditions have been present, the patient's general condition not being unsatisfactory: Valvular disease of heart, slight hypertrophy or dilation, atheroma, small patches of tubercle in lungs. Of course, one ap-

proaches these cases with caution, and each one has to be carefully considered from all points of view. In all heart cases attended by a weak or irregular pulse, or in which there are the slightest general symptoms of failure of compensation, this anæsthetic had better be avoided. Where pleural effusion is present one must be careful; a slight amount, not causing much embarrassment to breathing, would not bar ethyl chloride, but I should not advise its use for opening a large empyema; the presence of thoracic aneurism I should consider a contraindication. The following cases are also unsafe for this anæsthetic: Partial obstruction of the windpipe from pressure from without or swelling or growths within, acute inflammation and abscess of tonsils, and angina Ludovici—in fact, any cases in which a little spasm or extra congestion might lead to blocking of the air-way. Under this category I would even include enlarged thyroid or other tumours in the neighbourhood, although not obviously pressing on the trachea. As regards the type of patient, neurotics and alcoholics generally give a deal of trouble, but this is so whatever anæsthetic is given. Strong, muscular men with powerful teeth and jaws are also very difficult subjects. On the other hand, the weedy individual, with small receding lower jaw and irregular teeth, is a type for the beginner to avoid. Dr. Flora Murray (*Lancet*, November 25, 1905) points out that children take ethyl chloride very well. This is corroborated by McCardie, Luke, and my own experience.

Some authorities consider ethyl chloride unsafe in elderly people. This has not been my experience. It has frequently happened that I have been asked to give a patient a little gas only, as he was old and feeble; I have found him take gas badly, with much cyanosis, and have

been glad to change to ethyl chloride, which has yielded a much better type of anæsthesia. I think, on the whole, with the aged and infirm this is the best plan—gas first, and if unsatisfactory, change to ethyl chloride. The change is easily effected without any recovery on the part of the patient. Wherever possible, old people should only take this anæsthetic in the recumbent position.

In dental work ethyl chloride should hardly ever be used. Gas is safer, and the after-effects less, and a prolonged anæsthesia can always be obtained by giving it through the nose. The exceptions are cases in which a somewhat prolonged anæsthesia is required in a person whose nasal passages are obstructed; young children—they take ethyl chloride well, and a semi-open method suffices; and, finally, certain cases that are known to take gas badly.

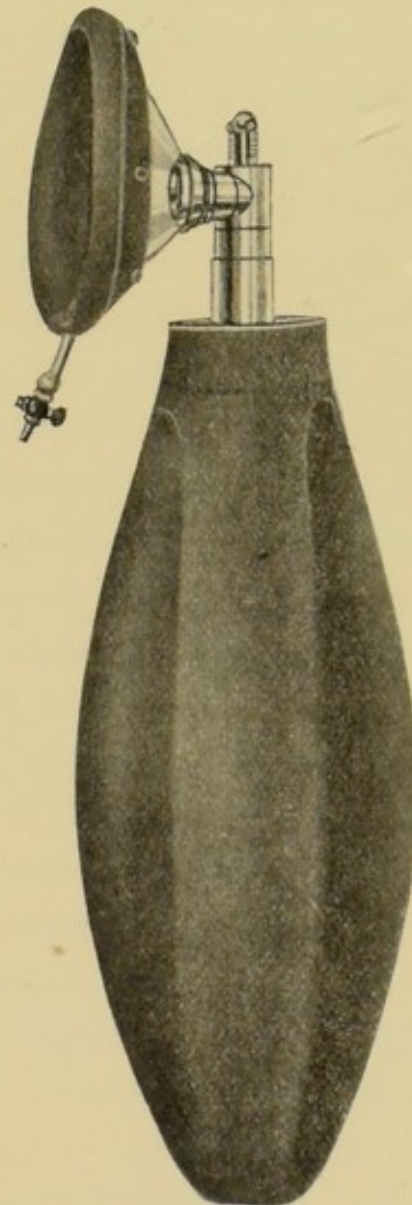
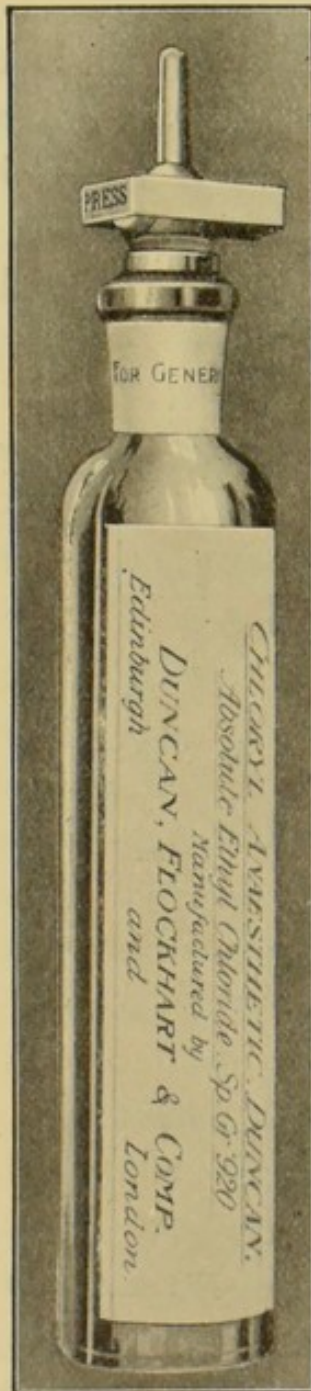
Some care should be devoted to the preparation of the patient. In my opinion, ethyl chloride should always be given fasting; the bladder should be emptied and the rectum also, otherwise there may be involuntary evacuations during anæsthesia. All constrictions about the neck or waist should be removed; the teeth should be examined and any loose ones noted, so that they may be avoided if the gag has to be used. It is recommended by many authorities that a prop should always be inserted before commencement, as sometimes there is great jaw spasm, with retraction of the tongue. I agree with this advice, especially for beginners; but, personally, in nervous, timid patients I generally spare them the discomfort of having a prop inserted, taking good care to have everything at hand to force open the jaw if required.

We may now consider the apparatus necessary for the administration of ethyl chloride. This anæsthetic is supplied either in glass capsules containing 3 or 5 c.c. each,

or in graduated glass tubes containing 50 or 60 c.c. each. If the former are used, some special form of apparatus is necessary, and much ingenuity has been expended in devising suitable inhalers. That made by Messrs. Barth to the design of Mr. Charles Heath has been used now for some time at the Throat Hospital (Golden Square), and appears in every way satisfactory. It is somewhat expensive, and so is the method of administration, as the capsules cost five shillings a dozen, but it is certainly extremely handy, and by using the capsules there can be no waste of vapour, and accuracy of dosage is ensured.

If the graduated glass tubes are used, it is important to select a convenient form. The nozzle should be in a line with the tube, and not set at an angle to it, so that when held upside down for the purpose of spraying into the bag the amount sprayed out can be easily read off at the time. The tubes supplied by Messrs. Duncan and Flockhart answer this requirement, and in addition their press-down stopper allows of the liquid coming out in a straight stream without impinging and scattering itself on any intervening obstacles. As for inhalers, their name is legion. Anyone, however, who has a Clover's ether apparatus has an ethyl chloride apparatus; all that is necessary is to fix the bag by means of the angle mount directly into the face-piece, and spray the anæsthetic into the bag. In order to obviate any possibility of liquid ethyl chloride running down on to the patient's face when the inhaler is in position, I generally take a double fold of lint of suitable length and width, and line the inner surface of the face-piece with it; this easily keeps in place by itself, does not block the air-way, and soaks any fluid that might otherwise possibly run down. As I have already mentioned, some rubbers are adversely affected by ethyl

chloride, so in buying a new bag it is as well to get one of the purer rubbers that is calculated to resist it ; also have a bag that can be turned inside out and washed after



SIMPLEX INHALER.

each administration. Those contemplating the purchase of a new apparatus cannot do better than select the simplex inhaler devised by Dr. Luke, and sold by Messrs.

Duncan and Flockhart. It answers all the requirements given above, and its parts are made to fit the ordinary ether chamber.

We now come to the administration. The anæsthetic may be as safely administered in the upright as in the recumbent position, provided the patient is of a fairly healthy type. Where there is feebleness or a suspicion of heart affection the recumbent position should be adopted. The usual dose is from 3 to 5 c.c., according to the patient's age. In hot weather and in strong, muscular individuals 7 c.c. may often be required. The measurement of the dose, on which some men lay so much stress, is, however, open to a good many fallacies. Volatilization in hot weather is so rapid that 7 c.c. sprayed from the tube would probably only mean 5 c.c. in the bag by the time it was adjusted; fluid ethyl chloride expands very readily with heat, and the warmth of the hand, together with the diminished pressure in the bottle on the evacuation of some of its contents, probably causes an uncertain amount of expansion in the fluid remaining, thereby introducing another inaccuracy. Where the glass capsules are in use this does not hold good, as they are not broken until the patient is already breathing into the bag; but even here it does not follow that he gets the full dose. In very cold weather the tube of ethyl chloride should be put in the trousers-pocket to warm during the preparations, otherwise it may only spray very slowly. The bag should not be charged till all is in readiness. If any delay occur, press the face-piece against the chest with the bag hanging down: this will minimize waste of vapour; with a simplex inhaler, the bag need not be charged till the face-piece is applied. The patient is then told to take a good breath and blow into the bag,

and, the face-piece being loosely applied, he will then breathe backwards and forwards into the apparatus, at the same time getting a little air from outside, which serves to dilute the vapour and helps to fill the bag. After two or three such breaths the face-piece should be closely applied at the end of an inspiration, and air excluded. Later, just as he is beginning to become unconscious, a breath of air may be allowed, especially in patients who take long in going under, or who require an extra dose to be sprayed into the bag to complete the induction. What happens at first depends a good deal on the patient's temperament; he may at first hold his breath, or breathe very violently, or naturally, but the following phenomena are soon observed: The patient's breathing becomes regular and deep—this passes on to stertor if the anæsthetic is continued; the face flushes; the eyes roll from side to side, and then become fixed and staring; the corneal reflex is now lost; the pupils are variable—as a rule, they dilate if the anæsthesia is deep, but in many cases they are dilated throughout, and in some they contract. As regards the muscular system, some patients go off quite quietly, becoming relaxed without any previous stage of rigidity[†]; there is, however, nearly always some spasm of the orbicular muscles of the eye, and there may be involuntary movements; and one meets with every gradation between this and complete opisthotonos, which, however, is rarely seen. On one occasion I have met with complete rigidity of the muscular system, including the muscles of respiration—a most alarming condition. As I have mentioned, there is nearly always some clenching of the jaw, amounting frequently to spasm. Spasm and rigidity, as a rule, give way to relaxation if the anæsthetic is pushed. But in short opera-

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tions it is not necessary generally to produce complete relaxation, and the rule is to cease the administration with the loss of the corneal reflex or the onset of stertor. Relaxation after marked spasm is frequently accompanied by pallor, faintness, and sweating.

The above method of induction is one that I have found quite satisfactory for some time past. Its features are a good full dose of anæsthetic (from 3 to 7 c.c., according to age, physique, etc.) put into the bag at the commencement, a fairly free allowance of air with the first few inspirations, and, according to circumstances, another breath of air later on, with or without the addition of a little more anæsthetic.

There are two points on which some authorities lay stress : the admission of air, and the very gradual increase in the strength of the vapour. The advocates of the former say that at least two full breaths of air should be allowed during the induction—one soon after the commencement, about the fifth breath, and one just before unconsciousness. The advocates of the latter have devised various means by which the patient is first presented with a very weak vapour, the strength of which is gradually increased. One method is to spray in the ethyl chloride 1 or 2 c.c. at a time at intervals. Kirkby Thomas advises that the nozzle of the ethyl chloride bottle should be connected by a short tube to the bag, and the bottle being held upright in the hand, with the thumb pressing on the stopcock, the vapour is allowed to escape through the tube into the bag, slowly mixing with the air contained therein, the patient meanwhile respiring the mixture. The warmth of the hand is sufficient to cause the evaporation of the few c.c. necessary. By this method the induction takes a little longer, but it is stated

to be economical. I think, however, the method I adopt meets all necessary requirements, both as to admixture of air and dilution of vapour during the early stages, at the cost, perhaps, of a little more ethyl chloride, but with the saving of some time.

Children are easily anæsthetized by spraying a few c.c. on a Skinner's mask and covering with a folded towel, and I am not at all sure this is not the best way with them ; it certainly is less alarming for them than a bag and mask.

From the above description of the phenomena induced by ethyl chloride, I think even the beginner should be able to tell when anæsthesia is present. It is as well to bear in mind that it is quite unnecessary to produce the deepest anæsthesia for short operations ; the deeper the anæsthesia, the longer will be the recovery, and the greater the likelihood of unpleasant after-effects. As a rough guide, subject, of course, to many limitations which practice alone will define, I would lay down the following rules : If an anæsthesia of only thirty seconds is required, do not abolish the corneal reflex, but stop as soon as the eyeballs are fixed or the breathing regular and deep. If one minute is required, cease the induction immediately the corneal reflex is abolished. If two minutes, go on a little longer until the breathing becomes snoring or the pupils dilate.

Have off
symptom

It is through want of attention to these details and the preparation of the patient that ethyl chloride is held in disfavour in the out-patient department of some hospitals, where several small operations have to be got through in a limited time. The length of time required to induce anæsthesia depends on several factors, of which the following are the principal : The depth of anæsthesia wanted, the freedom with which the patient inhales before losing

consciousness (some will hold their breath entirely for a full minute), the age and strength of the patient, and idiosyncrasy, which may be quite independent of the last factor. Out of seventy cases in which I timed the induction up to the abolishment of the corneal reflex, it took just about a minute in twenty-three, over a minute in ten, and less than a minute in thirty-seven. One case took between two and three minutes, and another between three and four, the inhaler having to be recharged in each. In any case in which anæsthesia was not present after two minutes I should spray in some more ethyl chloride after allowing a breath of air; the second dose very quickly sends the patient under, and the resulting anæsthesia is profound and more lasting than usual.

We may now consider the recovery of our patient. If the operation lasts, say, two minutes, he will very likely kick, struggle, and scream towards the end, but he will tell you afterwards that he felt no pain and remembers no struggles. The recovery is sometimes abrupt, the patient suddenly looking round him and wondering for a moment where he is, and then, quickly pulling himself together, is able to get up and walk away. At other times it is more slow, and then sponging the face with cold water hastens matters. Sometimes it is accompanied by a good deal of excitement, especially in hysterical women and alcoholics. It is interesting to observe that as patients go under, so they will come to: a nervous, excitable woman will struggle as she goes under and commence struggling again as soon as anæsthesia begins to pass off; a child goes under crying, and after a minute or so of quiet sleep commences to cry again as the effects pass off. The after-effects of ethyl chloride are not severe—a little giddiness and headache, and occasionally some vomiting

or retching may follow. An empty stomach and a nicely adjusted anæsthesia will go a long way to prevent the latter. It is also as well, whenever possible, to keep the patient quite still on the chair or couch for five or ten minutes after the operation ; and if he has to go home, he should be detained at least another half-hour, resting quietly, before he is allowed to do so.

Here are the notes of a fairly typical case :

No. 100.—M., aged twenty. Operation for adenoids. Dorsal position with Doyen's gag inserted before commencement. He voluntarily took very deep breaths from the start, afterwards settling down to the usual type. In half a minute the face was flushed, pupil moderately dilated, and corneal reflex lost. There was no rigidity. The gag was easily opened and the operation completed in one minute ; during the next minute there occurred a little rigidity and opisthotonos, and then he recovered consciousness ; was a little giddy, but not sick, and walked back to bed.

Many short operations, lasting from five to ten, or perhaps even fifteen, minutes, can be completed under ethyl chloride with comfort and safety to the patient. Longer than this I have not cared to use it, on account of the expense and the strain involved in keeping the patient just right—free from involuntary movements or rigidity, and yet not too deeply under. These cases come under two heads—those in which the ethyl chloride can be administered from the usual apparatus throughout, and those, operations on the upper air-passages, in which a mask is inadmissible during the operation. We will consider the former class first. A few years ago I used this anæsthetic largely for such short anæsthesias, but further experience has convinced me that for such short operations the ethyl-chloride-ether sequence is to be preferred. It is less likely to be accompanied by sweating and weak pulse, symp-

toms which do now and then arise when ethyl chloride is given continuously for some minutes. It is also more manageable. Very little ether is required, and in these cases the rapidity of recovery and after-effects are much the same as with ethyl chloride alone. But there may be occasions on which it is inconvenient or undesirable to adopt the sequence, and the anæsthetist may then have to continue with ethyl chloride alone. To illustrate the method of continuing the anæsthesia, I give below notes of a case, which I have selected because it also illustrates some of the minor difficulties that may arise. The patient was one of my early cases, and a bad subject.

No. 95.—Ten minutes' administration. M., aged seven. A puny imbecile with some hydrocephalus, loud hæmic murmurs, and rapid heart action. A history of having nearly died under chloroform. About 5 c.c. was sprayed into a Duncan and Flockhart's simplex inhaler and administered. He was very frightened, screamed and struggled. Under in about half a minute. Breathing exaggerated, face flushed, and corneal reflex lost. Pupil normal or moderately dilated throughout. No rigidity or movements, but not thoroughly relaxed as under chloroform. Operation (wrenching for talipes) now commenced. Anæsthetic continued at intervals, the breathing being taken as a guide; when it was deep and rapid the face-piece was removed and pressed firmly into the pillow to prevent waste from evaporation; after a few breaths of air the respirations would approach the normal, and then the face-piece was reapplied for a few breaths. A little more anæsthetic was sprayed into the bag on two occasions, an extra 5 c.c. being used in all. He required careful watching, but corneal reflex did not return. At the end of ten minutes he began to cry and move, having been left a trifle too long in one of the intervals. The face-piece was promptly reapplied; then followed holding of breath, jaw spasm, and retraction of tongue—in fact, complete respiratory spasm set in, lasting about a minute and causing cyanosis. The administration was discontinued, the operation being, fortunately, just completed. The

jaw was at length pushed forward, considerable force being required, and breathing restarted, quickly followed by violent retching, straining, and passage of flatus. There was no actual vomiting. A condition of semi-consciousness followed, lasting five minutes.

These troublesome symptoms, I am glad to say, are exceptional, and were in this case probably due to an irritable condition of the nerve centres.

In some cases the alteration in the character of the respiration is not sufficiently marked to form a satisfactory guide to the anæsthetist. One may then fall back on the corneal reflex, allowing it to just return in the intervals of administration and then just abolishing it again. By watching one or other, or both, of these symptoms a fairly satisfactory anæsthesia may be obtained; but although the patient will sometimes be perfectly quiet and relaxed, this cannot always be relied upon, and before attempting this anæsthesia I always ask the surgeon whether he requires complete muscular relaxation.

The other class of cases in which a continuous anæsthesia may be maintained by means of ethyl chloride—viz., short operations on the upper air-passages—has been of considerable interest to me, and it is about three years now since I began my first experiments in this direction. There are numerous operations about the throat, nose, and mouth that, whilst being comparatively short, take a little over the two minutes generally available after a full dose of ethyl chloride. Even in operations that may be in the ordinary course performed under two minutes little hitches may occur which unexpectedly prolong them, and it is very useful to have at hand a means whereby, with the utmost simplicity and safety, the anæsthesia may be maintained at a moment's notice, and without that loss

of time which so frequently follows a change in the anæsthetic. It is evident that in this class of operations, if the operator is to have free play, the anæsthetic must be administered through a tube conveying it to the patient's nose or mouth, according to the convenience of the operator. This has generally been done in the following ways : (1) Gas administered through the nose by means of Patterson's apparatus. I have used this frequently for extractions of teeth, and find it answer fairly well, the great advantages of this method being the safety and slight after-effects. The disadvantages are that the apparatus is cumbersome ; that it practically takes both the anæsthetist's hands to attend to it ; that its application is somewhat uncomfortable to the patient ; and the amount of gas used is large, and therefore an expense. Finally, in my experience, at any rate, it has been less certain in its effects than the method to be described. At the same time, for reasons given earlier, I am satisfied that it should be the routine method in nearly all prolonged dental cases, but it is, of course, inapplicable to intranasal operations. (2) Chloroform administered by means of a Junker's apparatus. This has been the sheet-anchor of the anæsthetist in throat and nasal cases up to now. The anæsthesia maintained in this way is nearly always reliable and smooth, and its depth easily regulated by a little practice. It is cheap, and the apparatus simple enough. On the other hand, it is less safe than ethyl chloride, especially in the upright position so frequently desired by throat surgeons. The after-effects are greater, the time of induction and of recovery much longer, and, finally, one of the anæsthetist's hands is occupied working the bellows. In spite of its drawbacks, however, I still use this method in cases where the patient is recumbent and the operation

likely to last more than three or four minutes. (3) Gas administered by means of an apparatus devised by Mr. Harvey Hilliard. I have no personal acquaintance with this method, but it appears to me to offer much the same advantages and disadvantages as the Patterson method.

Having considered the disadvantages of the methods in vogue, I determined to try what might be done with ethyl chloride. It does not require to be confined in heavy metallic cylinders, and its low boiling-point renders it quite easy to vaporize it rapidly. My observations as to the amount of air that could be allowed with ethyl chloride, once the patient was well under, had convinced me that the continuous administration of the vapour through a tube, with a certain amount of air obtaining entrance at the same time, would suffice to maintain anæsthesia. I put the making of suitable cylinders to contain the ethyl chloride in the hands of Mr. W. S. Paxton, of 4, Adam Street, Adelphi, at that time manager to Messrs. Hedley, and have to thank him for much useful advice as to practical details in their construction. At first I had cylinders of different sizes and patterns made of glass, with an index, by which the amount evaporated could be read off. But these readings are apt to be fallacious, because ethyl chloride expands considerably with heat, and, unless a very expensive and elaborate apparatus were made, the readings could only be approximate. However, they were sufficiently near to allow of a practical estimate being made of the cost of this method. The latest cylinder which I now use is made of metal, and being practically vapour-tight, the amount used in any case, or series of cases, can be estimated at one's leisure by weighing, if so desired. The weight of the cylinder when empty is 9 ounces, when charged 18 ounces. It therefore holds

9 ounces, or a little over 250 grammes, of ethyl chloride. Near the circumference of the upper surface is an orifice closed by a screw for refilling, and from the centre of this surface projects vertically a tube, which Messrs. Duncan and Flockhart have fitted with their patent stopcock as used in the ethyl chloride phials supplied by them. To obviate the necessity of constantly pressing on the stopcock with the thumb whilst the vapour is passing, a small lever has been attached, which, on being depressed, keeps the stopcock open. By this means vapour can be turned on or off in a second, and I find this arrangement works much better than ordinary taps, which I formerly used, and which generally either jammed or leaked. The metallic tube is bent to a right angle at the top, and terminates in a bulbous extremity, to which is connected one end of the india-rubber tubing, the other end of which is connected with a suitable gag or passed into one nostril as the case may require. This tubing should be about 4 feet long, to allow of free movements of the patient's head without upsetting the apparatus, and I always cut off the last few inches connected with the gag, and unite again with a piece of glass tube. These few inches can then, if soiled with blood or discharge, be thrown away, and a fresh piece supplied for the next patient.

This is all the special apparatus required, and the cost is only fifteen shillings ; but for the benefit of the uninitiated I must add a word as to the gag and the face-piece of the inhaler. The former has to be inserted before the induction of anæsthesia, which is brought about in the usual way by the ordinary closed inhaler ; it is therefore necessary that it do not allow of the admission of air by the side of its blades, and it must also be fitted with a short metallic tube for connecting up with the cylinder. I use

either Probyn Williams's modification of Doyen's gag or (especially if the teeth are loose) Wingrave's gag, having a short metal tube fixed just below the upper blade and at right angles to it, so that when turned on one side of the mouth one end of this tube projects just into the mouth close to the angle, the other end receiving the rubber tubing. A face-piece that is long and deep, and fitted with a good-sized pneumatic pad, is suitable for use with either of these gags. There only remains now to provide some means of keeping the ethyl chloride at boiling-point, as it rapidly cools by evaporation. The simplest and safest method, and one which is ever handy, is a porringer of hot water placed on the anæsthetist's table, and into this the cylinder may be put as required.

The induction is carried out in the usual way, the patient being got thoroughly well under. I generally allow a minute or two for this, and like to get complete absence of corneal reflex, with commencing dilation of pupil and deep-snoring breathing. The face-piece is then removed, and the operation commenced. The anæsthetist meanwhile turns down the lever controlling the stop-cock, and plunges the cylinder into the hot water if vapour does not at once generate freely. It can be heard and felt rushing through the tubing. During expiration this latter is pinched between the finger and thumb of the hand that steadies the gag, thereby economizing vapour and roughly estimating its tension. If the latter is getting high, the cylinder can be removed from the hot water for a time. If the patient appears to be getting too deeply under, the supply can be immediately cut off by pinching the tube for a few breaths, and in the more prolonged operations I have frequently turned off the vapour altogether for a minute or more at a time. When this is done the

cylinder should, of course, be removed from the hot water at once. With this anæsthesia, I find during the first minute or two there is a tendency to recovery, as indicated by return of corneal reflex, contraction of pupil, and disappearance of snoring. After another minute or two, if vapour is freely supplied, the anæsthesia will begin to deepen again ; but as this is not required I usually diminish the supply, and endeavour to regulate it, so as to retain the corneal reflex, and at the same time have deep, regular, but not snoring, breathing. With practice it is astonishing how easy it is to maintain an anæsthesia of just the right depth. The patient is generally relaxed and quiet, and the face flushed. If cyanosis develops, it is due to one of three causes—firstly, and most commonly, a too widely opened gag depressing the chin ; secondly, obstruction of the air-way by blood, instruments, etc. ; and, thirdly, to respiratory spasm set up by the ethyl chloride. This last is a rare condition, and an account of a case in which it occurred will be found further on.

I have now adopted this method of maintaining anæsthesia in something like 200 cases, lasting from three up to twenty minutes each, and including turbinectomies, removal of polypi, tonsils, and adenoids, operations on maxillary antra, and dental cases. The number of cases would have been many more but that of late I have restricted the use of this method somewhat. I no longer use it in dental work unless the patient is a mouth-breather. I seldom employ it in the recumbent position. But for operations in the upright position, particularly nasal operations, where a quiet anæsthesia is desirable, I find it ideal. The anæsthesia has generally been of a good type and easily regulated ; but if you get a bad subject for ethyl chloride—and this is generally obvious

during the induction—the best plan is to abandon this method, and nothing is easier than to slip the tubing off the cylinder and on to the Junker's bottle, and go on with chloroform.

As regards the cost of the method, this is a consideration, but by no means prohibitive. My first twenty cases were conducted with somewhat leaky apparatus, and before I had obtained dexterity in turning off taps and pinching the tube during expiration, but they show the following results : The available anæsthesia of all the cases added together totalled 113 minutes, and the amount of ethyl chloride (approximately) 531 c.c., being less than 5 c.c. per minute, or about 1s. 6d. for an anæsthesia lasting five minutes, including the cost of ethyl chloride used in the induction. With my latest cylinder and increasing experience I am confident that this ratio has been considerably reduced.

Here follow notes of a case illustrating this method. For this case I used a thick glass cylinder of a capacity of 500 c.c. This material, of course, conducts heat less readily than metal, and is liable to crack if the water be too hot ; hence it requires extra care and attention, especially in cold weather.

No. 16.—M., fifty-one years old. Weighs about 16 stone. Very obese, and an alcoholic ; heart-sounds weak and heart evidently flabby ; some arterio-sclerosis. Has been prepared for the operation. Removal of nasal polypi on November 9, 1904, the patient sitting upright in a chair. A Probyn Williams gag having been inserted, and the ethyl chloride cylinder placed in warm water, 8 c.c. were sprayed into a modified Ormsby's inhaler and administration commenced. The induction was very quiet and smooth. At the end of two minutes the corneal reflex was lost, the pupil being about normal, and respiration of the usual exaggerated type. The

operation now commenced, and the tap being turned on, vapour was administered through the tube ; a good and perfectly quiet anæsthesia was maintained for the eight minutes necessary to complete the operation, and the patient was relaxed, requiring one of my hands to steady his head. At the completion of the operation the tap was turned off, between 30 and 40 c.c. having evaporated from the cylinder. He was now dazed for a minute or two, but had no excitement or retching, and soon walked back to bed. He perspired very freely, but the pulse was full and steady throughout, though it got somewhat softer.

I think this was a very satisfactory case considering the subject we had to deal with. The sitting position was particularly desired by the operator, and in this position I should have had grave hesitation in administering chloroform to such a subject. I hear the critic say, "And should have had grave hesitation about ethyl chloride also." I think, perhaps, he is right in the light of our later knowledge ; but this was one of my earlier administrations, when ethyl chloride was regarded as perfectly safe.

I have already spent more time on this particular method of administration than perhaps its importance deserves. I will only add a word as to another use that has occurred to me for my cylinder. Owing to its extreme volatility, there would probably be in tropical climates considerable difficulty and waste in the storage and administration of ethyl chloride in the usual way. In this cylinder it can be stored with perfect safety, and by connecting it with a gas-bag I have no doubt that anæsthesia could easily be induced with the use of a minimum amount of ethyl chloride, as none could escape into the air.

We may now consider the use of ethyl chloride in conjunction with other anæsthetics. Here it has a great field of usefulness, and, indeed, if its use were restricted to

this field, it would still form one of the most valuable additions to the anæsthetist's pharmacopœia. Dr. Silk writes me : " I am inclined to deprecate the use of ethyl chloride for dental work as a substitute for N_2O . . . but I value it highly as a substitute for N_2O in sequence work." It is particularly useful in helping us to induce an ether anæsthesia—in my opinion more so than gas ; in fact, I hardly ever use the gas-ether sequence now. If properly administered, the patient is quickly unconscious, and the passage to a deep ether narcosis is smooth and uninterrupted, and there is generally an entire absence of cough, retching, and holding of breath. When I first began using this sequence I was at the time interested in watching the effects of ethyl chloride and timing its induction, and in order to do this I used to get the patient completely under it before turning on the ether. I am quite convinced that this is a faulty method. In many cases, directly the ether was turned on tremendous jaw spasm, with sometimes retraction of the tongue and cyanosis, would set in ; this was often accompanied by frothy and blood-stained mucus on the lips and a considerably dilated pupil. The jaw would have to be forced open—no easy matter—and the tongue drawn forward, and during these manipulations the patient would very likely partially recover. I find a much better plan is, after the first few breaths, to gradually turn on the ether, feeling my way with it, as it were, diminishing or increasing the proportion of ether vapour according to the way the patient takes it, and allowing an occasional breath of air. The patient generally goes off under the combined vapours as quickly as under ethyl chloride ; the struggling stage is cut short or nil ; there is no cyanosis and no spasm, beyond, perhaps, a little rigidity and clenching of the jaw.

The saving of time is great : in a dozen cases which I timed carefully, the operator commenced in from one-half to six minutes from commencing the administration ; half the cases were under in two minutes or less. And here let me say that this saving of time is not only an advantage to the surgeon and those helping him, but in my opinion it must be a great comfort to patients, especially nervous ones, to be spared a prolonged period of induction, where every minute drags like an hour. Another point I have noted is that in short operations, if one is careful to give only just enough ether to keep the patient under, the recoveries are remarkably rapid, and in every respect resemble those after an administration of ethyl chloride alone ; for these I generally turn the index to full in the course of the first few minutes, so as to ensure the patient's air-passages being tolerant of a strong ether vapour, and then, after a few breaths, push it gradually back to the point at which I find a light anæsthesia can be easily maintained.

Here are the notes of a case which, I think, is fairly typical, and at the same time interesting, as the patient required a free administration of ether to keep him under, although anæsthesia was induced with the help of ethyl chloride without the slightest trouble :

No. 103.—Ethyl-chloride-ether sequence. M., aged thirty-one ; a large and powerful policeman, inclined to be fat. Perfectly healthy, but a little nervous. Operation, radical cure of hernia, followed by internal urethrotomy.

Looking at the man's physique, I expected some trouble. The ordinary Clover's inhaler was put together in the usual way, and being inverted, about 7 c.c. of ethyl chloride was sprayed through the face-piece and chamber into the bag. As he *would* talk before allowing the administration to commence, a little of this probably evaporated into the air. He took it

very well, breathing freely, but not forcibly. In half a minute some twitching of the orbicular muscles and slight rigidity were noted. The index was now turned to 1, then 2, and fairly rapidly to 3 and 4; ether was not resented. In one minute the corneal reflex was lost and the pupil dilated. From this time he passed on quite easily into an ether narcosis without recovering his corneal reflex, but it was very light, and very little air could be allowed; hence slight blueness and a little clenching of the jaw. It was as much as I could do to keep him under ether; in recharging the chamber, and also at a later stage in changing to chloroform, he partially came to. No vomiting, but a good deal of excitement on recovery.

In the induction of chloroform narcosis, I think that ethyl chloride is distinctly useful for those who have a thorough experience of both anæsthetics. But let me say at once, and plainly, that I do not advise the method I am about to describe for the use of "babes and sucklings." The non-expert must stick to the well-beaten paths and not try any short-cuts, lest he be lost in the wood of perplexity. The method, however, which I shall describe, and which I call the C.E.—ethyl chloride—chloroform sequence (see p. 42), may be easily learnt in a few lessons, and, once the principles are thoroughly mastered, I think it offers one of the safest means of inducing chloroform narcosis. The man who only occasionally gives an anæsthetic is not likely to possess an expensive and cumbersome regulating inhaler, and if he did, it would be probably out of order just when wanted. This man is generally rather nervous, and it is during the early stages of induction that symptoms arise which may be attributable to too light or too deep a narcosis, landing the tyro on the horns of a dilemma. By the addition of ethyl chloride, these difficulties can be avoided, as will be seen. It early occurred to me that, as ethyl chloride has a somewhat stimulating effect, it might render the induction of

chloroform anæsthesia somewhat safer, and at the same time shorter, which would be an advantage over giving ether first. As in the ethyl-chloride-ether sequence, I first tried rendering the patient anæsthetic with ethyl chloride, and then going on with chloroform, and later discarded this for a combined method.

We must remember that, in giving ethyl chloride in the usual way, we limit the air-supply, and we get a deep, but fleeting, anæsthesia, from which the patient may recover quite suddenly and without warning any time beyond a minute from the removal of the face-piece. His breathing is exaggerated, his pupil possibly dilated. Unless you begin with chloroform immediately you cease the ethyl chloride, he will probably come round before it can produce its effects. With his deep breathing you have to be cautious with the chloroform, for fear of an overdose. Now, what *may* happen is this : his breathing gets less and less frequent and shallower, and his face, which was flushed, becomes paler as the effects of ethyl chloride pass off. His pupil may or may not remain dilated, and the problem you have to face is whether he is coming to or getting too much chloroform. In most cases he will be coming to, but you don't care to take the risks and withhold the chloroform for a few seconds ; the patient struggles, vomits, and the whole business of induction must begin again. Now, amidst all the contradictory signs of this sequence there is one which can nearly always be depended on as a guide. Under ethyl chloride there is almost invariably a clenching of the jaw. Even if this has been abolished by getting our patient too deeply under, it will return as the anæsthesia becomes lighter. Therefore, put your thumb on the chin, and try and depress it. If you cannot do so at all, or at any rate

without great force, you may safely go on with chloroform, and by the time it begins to relax you will know he is under the influence of that drug. In spite, however, of this useful sign, I do not care for this method, as I cannot but think that danger might arise in administering chloroform to a patient whose lungs are already filled with ethyl chloride vapour and rebreathed air. There is, however, one class of operations in which I sometimes use this sequence. It is the class to which I have before referred, and for which I have devised the special cylinder for maintaining ethyl chloride anæsthesia through a tube. In a case of this kind, where for any reason—the wish of the operator or the intractability of the patient—it appears desirable to go on with chloroform, I do so, using a Junker's apparatus. Before having my cylinders made, I frequently adopted this sequence, and found it satisfactory, especially in children and delicate subjects, a light chloroform anæsthesia only being maintained. It certainly presents many advantages over the gas-ether-chloroform sequence, which was the usual one with me before the advent of ethyl chloride.

There is, however, I think, a place for ethyl chloride in the induction of chloroform narcosis. Amongst children and nervous women voluntary struggling and screaming at the very commencement of induction, and due entirely to fear, is very common. This is certainly a period of intense discomfort to the patient, and may be disconcerting to the anæsthetist. On the other hand, there is the stage of excitement due to the effect of chloroform, which in many types is unduly prolonged and very violent, and it certainly has its dangers. It was in dealing with these cases, and trying to find a safe and satisfactory method of cutting short this period of the induction, that

I hit upon a method which I have found so satisfactory that I adopt it now as my routine procedure. This I call the C.E.—ethyl chloride—chloroform sequence, and, as its name indicates, it consists of three stages. I commence by sprinkling C.E. mixture on the Skinner's mask, and let the patient inhale this for a short time. This is the first stage. At the "psychological moment" I spray on the mask 5 c.c. of ethyl chloride, and cover all in with a folded towel. This does not exclude air, of course, but does prevent the ethyl chloride evaporating too freely into the open air, and does permit of a certain amount of the expired air and vapours being rebreathed. In fact, its action is somewhat similar to that of a closely fitting Rendle's mask, only perhaps a little more so. Of course, I take care that at the time of adding the ethyl chloride there is only a little C.E. mixture on the mask, so that there shall be no risk of an overdose. As a matter of fact, I find that I generally use about 1 to 3 drachms of the mixture, and spray on the ethyl chloride in from half to one minute from commencing. The precise time varies with the patient and a number of conditions, and is soon ascertained with a little practice. During this, the second stage, the patient very quickly goes under the combined vapours, showing an anæsthesia of the ethyl chloride type. The corneal reflex is tested, and *immediately* it is lost the towel is removed, we enter on the third stage, and chloroform or C.E. mixture is added to the mask, the condition of the jaw muscles being taken as a guide for pushing or withholding the drug, as explained above. The patient is almost always ready for the surgeon in two minutes from the commencement, and, being already partially chloroformed, has no tendency to recover if the anæsthetic is properly administered; and though not, of

course, always thoroughly relaxed from the first, he speedily becomes so.

One word I may say about the mask, hardly necessary, perhaps, to anæsthetists. The mask should be of such dimensions that there is no risk of its coming into contact with the patient's nose during the second stage of this procedure, when the towel may be pressed closely around it. There is not much danger of any other part of the face becoming scorched, as the amount of C.E. used is too small to run down the sides ; but this risk can be obviated by using one of the modifications of Schimmelbusch's mask, if thought desirable. I frequently, but not invariably, insert a prop before commencing. In strong muscular men, in whom there is likely to be much jaw spasm, and in all operations on the upper air-passages, I think it advisable.

Some little time ago I took notes on 200 consecutive cases in which this sequence was administered, and the results were embodied in a paper which I read at the Society of Anæsthetists in December, 1906. I append here a short account of the symptoms evoked, and an analysis of the cases.

Struggling in children and timid people may come on at the first application of the mask. This is, of course, simply due to terror, and, if there appears any chance of calming the patient, I always try to do so at the risk of prolonging the first stage. However, as a rule, it is very little use trying to reason with children of this type, and the quickest and kindest way is, I am sure, to proceed rapidly to the second stage. There is very occasionally, in young people, a little struggling due to the anæsthetic towards the end of the first stage. With the second stage struggling is sometimes marked, more especially in big

strong men and alcoholics. In many cases, however, there is practically no struggling or movement at all, and, anyway, though very severe sometimes, it is, I am sure, of much shorter duration in this method of induction than in the ordinary one. A frequent event, with muscular individuals, at the commencement of the second stage, is a stiffening of the trunk and limbs, with a tendency to raise the head and shoulders from the couch ; this is often accompanied by holding of the breath, and usually subsides in from thirty to sixty seconds, the patient becoming more or less relaxed.

The Respirations.—There is nothing special to be noted about the breathing during the first stage ; sometimes, as stated above, it is held for a few seconds at the commencement of the second stage, but the ethyl chloride soon produces its usual effect, respirations being increased in depth and rapidity, and with this one generally gets the characteristic flushing of the face. On removing the towel, the tendency is, of course, for the respirations to become less exaggerated, but, with a little care, they never drop to normal, but gradually pass into the type associated with chloroform or C.E. anæsthesia. Should they become shallow during the third stage, it means that either too much anæsthetic is being given or too little ; by watching the symptoms to be considered next, I find it, as a rule, quite easy to decide.

The Corneal Reflex.—This is present during the first stage. During the second stage there is occasionally so much spasm of the orbicular muscles as to make it difficult to know precisely when it is lost ; but, as a rule, there is no difficulty, and its disappearance is the signal for the removal of the towel. In a few cases, it does not disappear readily, and I then, after allowing two minutes for the

second stage, pass on to chloroform. These cases generally take a little longer than the average over the induction, and are always found to be people who require a large amount of anæsthetic to keep them under. The corneal reflex frequently returns during the third stage, and here, taken in conjunction with the condition of respiration and the next symptom, is a guide to the depth of anæsthesia.

Jaw Spasm.—This symptom is one to which I attach great importance in the induction of anæsthesia by this sequence.

It comes on during the second stage, and I always test it immediately at the close of this ; it may be slight, the jaws being closed, but not firmly ; as a rule, the teeth are firmly clenched, and the jaws only separated with the employment of a considerable degree of force. In some cases it is marked, and the jaws cannot be separated except by the employment of a wedge or gag. In a few cases it is absent. By watching the jaw during the third stage, one has a valuable guide to the depth of anæsthesia ; the spasm gradually passes off under the influence of chloroform. So long as it remains, no matter what other symptoms are present, one may feel sure that the patient is not getting too much chloroform. On more than one occasion, in giving this sequence, I have been confronted during the third stage with the following condition :

The breathing has become shallow ; the flush has passed off the face, leaving it pale ; the corneal reflex could not be evoked.

Chloroform had been exhibited pretty freely, owing possibly to marked struggles, a prolonged second stage, or marked jaw spasm at the end of it. All this tended to make one think of the possibility that sufficient chloro-

form had been given. But a persistent jaw spasm has been the key to the situation. The shallow breathing and pallor were only symptoms of too light an anaesthesia.

The few cases in which jaw spasm is absent are apt to give one a little difficulty; in these, of course, the breathing and corneal reflex must be looked to for help, and such symptoms as phonation, movements, or swallowing will guide. I may say here that I always like the operation to commence with the loss of the corneal reflex; the surgical stimulus rouses up all reflexes which might otherwise be merely dormant.

Loss of Consciousness.—Towards the end of the first stage the patient's perceptive faculties are becoming dulled; there is, therefore, very seldom any conscious resistance to the close application of the towel. The patient does not realize what is happening, otherwise he might easily be alarmed. Patients who have had chloroform before have told me afterwards that this induction was the quickest and pleasantest they have experienced.

Consciousness is, of course, completely abolished early in the second stage with very few exceptions, and if the sequence is properly carried out does not return during the third stage, although, as pointed out above, there may sometimes be a little phonation and movements in response to the surgical stimulus.

I have so far said nothing about the pulse, because, having only two hands, I have been unable to make a series of accurate observations. Speaking in a general way, I have found the state of the circulation good, the heart's action being, I believe, stimulated by ethyl chloride.

An analysis of the 200 cases shows the following: There were 43 male adults, 66 female adults, and 91

young persons under sixteen years of age—sex not noted. The youngest patient was four months and the oldest seventy-three years, the average age being twenty years.

The smallest quantity of C.E. administered during the first stage was ʒss., the largest ʒiv. ; the average amounted to ʒi·9. The smallest dose of ethyl chloride was 3 c.c., the largest 8 c.c., and the average 5·17 c.c.

The duration of the first stage was, in the shortest instance, $\frac{1}{4}$ minute, in the longest 3 minutes; the average was 1·1 minutes.

The second stage lasted from $\frac{1}{4}$ minute, the shortest period, to 4 minutes, the longest, the average duration being 1 minute. Hence it will be seen that the average time taken in the induction of anæsthesia was about 2 minutes, though to this there are some few exceptions, there being 20 cases out of the 200 in which the corneal reflex was not lost at the end of the second stage.

Of these 20, some were quite sufficiently anæsthetized for the operations to proceed; a few, however, required a very free administration of chloroform, and took some minutes longer before they were ready. As I have stated before, the corneal reflex frequently returns during the third stage, but without return of consciousness. Of the 180 cases in which it was lost at the end of the second stage, I have definitely noted that it returned in 92, and did not return in 81, these latter cases being mostly children. In the remaining seven cases I have no record.

The conditions as regards jaw spasm, I find, I have omitted to record in 8 cases. In 108 there was the normal tight clenching. In 17 it was absent, in 26 slight, and in 39 marked. In one case the jaw was fixed with the mouth widely open, and in one jaw spasm did

not appear till well on in the third stage, and was then well marked.

Of course, amongst these cases there have been several deviations from what I may call the normal induction. I do not propose to give the notes of all these abnormal cases, but will briefly refer to a few.

There was only one case in which any alarming symptoms set in during the induction. This was a man, aged forty-four, with mitral stenosis, who had also a very receding chin and prominent pomum Adami.

At the commencement of the second stage he had some struggling, followed by muscular spasm, and as this threatened to involve the respiratory muscles, and a slight blueness was becoming apparent, I immediately abandoned the method, gave him a few breaths of air, and afterwards continued slowly with C.E. I should not feel disposed to give ethyl chloride to this type of patient in the future.

There have been a few cases in which, although the corneal reflex has been lost satisfactorily at the end of the second stage, it has returned very quickly, and with it some struggling, perhaps a little retching, and a state of semi-consciousness. These have generally been hysterical women or alcoholics. In some of them the preliminary doses were too small, or there had been a little difficulty in the close application of the towel during the second stage.

In one or two cases I have noted that the breath was held for an abnormally long time at the commencement of the second stage. In a few jaw spasm has been very prolonged, lasting throughout the operation. In some few there has been free perspiration.

Some of my friends have considered that this sudden

induction of anæsthesia in connexion with chloroform is alarming, and have thought it not altogether a safe procedure. All I can say is that I fail to see anything objectionable in it theoretically, and that practically I have found it not only convenient, but perfectly safe, in some hundreds of cases. Having adopted this method, it was interesting to me to learn shortly afterwards at a meeting of the Society of Anæsthetists that chloroform, as ordinarily prepared from alcohol, contains a certain amount of ethyl chloride, and that with an extremely pure chloroform deficient in this, prepared from acetone, there is undue trouble and delay in inducing anæsthesia. A paper on this subject was read to the Society by Dr. Wade, and a chloroform is now actually prepared and sold containing a small definite proportion of ethyl chloride.

There is one other sequence which I may mention—viz., the gas-ethyl-chloride sequence. It has been advocated by some authorities as an agreeable method of inducing ethyl chloride anæsthesia. This has always appeared to me a somewhat unnecessary refinement, and I have not so far found occasion to deliberately resort to it, though I have frequently continued anæsthesia by ethyl chloride where it has been commenced with gas, either on account of the operation lasting longer than was anticipated, or because nitrous oxide failed to produce a satisfactory anæsthesia. Were I to meet a patient who particularly preferred gas as the inducing agent, I would, of course, adopt the sequence, and for this purpose I do not see that any special apparatus is necessary. The ethyl chloride can easily be introduced, either by opening the air-slot a little way and spraying into the aperture, or, if the gas-tube have been disconnected from the bag,

by spraying through the stopcock into its distal end, the apparatus, of course, in either case being so arranged as to permit of rebreathing. A paper was read on this combination by Dr. Moritz at the Society of Anæsthetists in 1903, and a discussion followed. It did not appear that there was any increase in the length of available anæsthesia, or diminution in after-effects, as compared with ethyl chloride used alone. A full account will be found in Vol. VII. of the Transactions. Dr. Bampfylde Daniell also has a contribution on the subject in the *Lancet* of October 21, 1905.

For many reasons ethyl chloride has become a popular anæsthetic. It is cheap; it is portable; the apparatus required to administer it is neither cumbersome nor involved; nor is any very special outlay necessary upon it, as I have shown; and, lastly, the method of administration is easily learnt after a few lessons. If one may say so, it presents almost too many facilities. Lest I appear too enthusiastic an advocate of its use, I would remind the reader that I have already stated that it is not devoid of danger, and I will conclude this little work by giving the notes of a few cases in my practice in which it has not proved a satisfactory agent. These cases were all quoted in the first edition of this work published in 1905. Since then in over 1,000 administrations I am glad to say I have only encountered one case that has caused me the least anxiety, and that I have recorded above when describing the C.E.—ethyl chloride—chloroform sequence (see p. 42).

No. 78.—M., aged about forty; muscular. A short anæsthesia was desired for the purpose of removing a small piece of bone which had lodged just within the anus. At his special request I gave him gas, which he took well to start with, but became

cyanosed in spite of the admission of some air, and so rigid that it was impossible to do anything with him. I decided, therefore, to change to ethyl chloride. In the meantime he rapidly regained consciousness. About 7 c.c. were sprayed into the bag, but a quantity must have evaporated, as he was very excited and refused to take it at once. Eventually he inhaled quietly, then got flushed, struggled, and rose up in bed, no anæsthesia being produced, and he refused to go on with it. I finally got him under gas and ether after a good deal of trouble, and the little operation was completed. He told me afterwards that he had taken brandy before coming in for the operation.

No. 121A.—Adult male; good physique, slightly nervous. Spur on septum. Sitting position with prop inserted. Five c.c. of ethyl chloride administered from a Heath's inhaler. He breathed it freely and got a good deal of rigidity, clenching of hands, tendency to opisthotonos, and turning of head to right. Pupils unaltered, corneal reflex brisk, but beginning to disappear after two minutes' inhalation. The operation was attempted, but the patient was not under, and resisted, so the inhaler was reapplied, and from 7 to 10 c.c. were sprayed into the bag, the capsule and its case having been removed. He now became relaxed and went under almost immediately, and developed an anæsthesia which lasted nearly five minutes and was followed by a little giddiness, but no excitement or vomiting.

No. 127.—Young female. Small, pale, and delicate. Has had a temperature of about 100° F. for several weeks; has pyorrhœa alveolaris, for which several extractions were to be done. The administration was commenced, as usual, with 5 c.c. of ethyl chloride; the patient appeared to take it well, but her colour did not heighten, nor respiration become exaggerated as usual. The corneal reflex almost disappeared at times. After waiting two minutes a further dose was sprayed into the inhaler, the patient struggling a little on reapplication. Some rigidity of arms and movements. At the end of five minutes a further dose was given. Then the prop slipped and had to be readjusted, and the patient struggled a good deal. At the end of eight minutes the patient was no doubt slightly under, and was a little dusky; the corneal reflex was absent and

the breathing exaggerated. The inhaler was removed and an attempt made to operate, but the patient came to almost at once, and it had to be abandoned. In all 10 c.c. were given in three doses. I may say that on subsequent occasions I twice gave her gas through Patterson's apparatus, inducing anæsthesia with the greatest difficulty, intense cyanosis being developed on each occasion, and an enormous quantity of gas being used.

No. 128.—Young, healthy female. Two minutes' anæsthesia required for extraction of stumps. As she was a mouth-breather and took gas badly, Patterson's method was not available. It was a very hot day, so, having inserted a prop, I commenced with 7 or 8 c.c. of ethyl chloride. Beyond a little voluntary struggling there were no results during the first two minutes. Ten c.c. were now sprayed in and the inhaler reapplied. She told me afterwards that she remembered nothing after this, but as no signs of deep anæsthesia developed after waiting another two minutes, a further 10 c.c. were sprayed in, which finally developed a good quiet anæsthesia, lasting quite two minutes, and allowing the operation to be entirely completed. On coming to she screamed lustily, and managed to wriggle on to the floor, then remained quiet and dazed for a few minutes. There was no retching, vomiting, or headache, but she complained of feeling a little giddy. She was, however, able to walk downstairs with only nominal assistance, and drove home soon after, feeling none the worse.

These four cases illustrate difficulties that sometimes arise in inducing anæsthesia. It is evident that, as with other anæsthetics, some patients require a much larger dose than others. The following cases illustrate dangers that may arise during anæsthesia, and are both taken from a special series of cases in which anæsthesia was being maintained through a tube by my method :

No. 21.—M., aged about twenty. A spare, neurotic Jew. The induction lasted two minutes, and he went under quickly and quietly, and was relaxed, and remained so throughout the operation, which lasted fifteen and a half minutes, and required the

evaporation of 50 c.c. from the cylinder. The corneal reflex was abolished except during the last three or four minutes. It was a fairly mild day in January, but in spite of plenty of warm water and occasional shaking of the cylinder, the ethyl chloride only vaporized slowly, not boiling at all. This led me, I fear, to misinterpret the symptoms which subsequently arose, and to think that he was coming to, when, as a fact, the small amount of vapour he had had was an overdose for him. After he had been under eight minutes he became pale, somewhat dusky and sweated freely; respiration almost stopped, and his pupil dilated. I then, of course, stopped the administration; the operation was, however, continued, a careful watch being kept upon him. At the end of five minutes corneal reflex and other signs of recovery developed, so the vapour was turned on again, and he was easily kept under for a further two and a half minutes, during which the operation was completed. He remained unconscious for two or three minutes longer, then retched and brought up a little blood which he had swallowed. The operation was on the maxillary antrum, and the patient recumbent throughout.

No. 22.—M., aged twenty-eight. A thin, narrow-chested, weedy-looking individual, with a very receding chin. Suspected of tubercle, but no obvious disease of lungs. His apex-beat was in the nipple line, slapping, with a slight thrill; there was reduplication of the first sound, probably mitral stenosis.

Operation on both maxillary antra. The induction lasted two minutes, and was quite satisfactory; the corneal reflex was abolished, and there was no cyanosis. The operation now commenced, and the administration was continued through the tube for about two minutes, when the breathing, which had been unsatisfactory, stopped, and he became cyanosed. His whole body was in a condition of tonic spasm, including the muscles of respiration; the chest walls were absolutely immobile; the corneal reflex, curiously, had returned and was brisk. Both operation and administration now ceased, and after rhythmical traction on the tongue and pressure on the chest walls for two or three minutes the spasm passed off and respiration recommenced. Junker's apparatus was now used, and the operation completed under a light chloroform anæsthesia. The appearance of this patient was extremely alarm-

ing; not a breath of air entered his chest for nearly three minutes, during which he was perfectly rigid and nearly black in the face. At the same time the anæsthesia can only have been light, as the corneal reflex had returned. Precisely how much ethyl chloride he had I cannot say; immediately the alarming symptoms developed I removed the tube from his nose and turned off the tap, but, as I found afterwards, not quite fully, so that some had wasted in the air whilst I was attending to the patient.



