THE ANÆSTHETIST'S *Pocket Companion*

BY ROBERT MARSTON.

ANÆSTHETICS.

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PREFACE

When I commenced writing I only contemplated a practical guide to the use of my Anæsthetisers, but it subsequently occurred to my mind that before practical men could accept my tabulated results as facts, they would expect me to say something about my methods of calculation, the data upon which those calculations are based, and my plan of making subservient, those physical forces which have thwarted the costly efforts of many who have attempted to materialize a convenient form of Dr. Snow's Ideal Anæsthetiser, **the purpose of which was the exact measurement of both the Naroctic and its diluent** and **the maintenance of those proportions, whatever the inspiratory volume might be, or however irregular the frequency, and depth, of the respiration became.**

The inadequateness and danger of the plan common to all other Anæsthetisers, viz.: that of **measuring the poison** and **not measuring its diluent** should be apparent to any practitioner who has ever prescribed a bottle of medicine.

Having proceeded thus far, I thought it might not be out of place to make some kind of reference to Dr. Snow's theory, **which supposes that all the phenomena arising from the physiological action of Narcotics when inhaled are referrable to a constant, direct ratio of cause and effect.** At this stage I realized that a sense of moral duty was impelling me to criticise the theories and practices of Anæsthetists, and to recount my personal observations, made during the Anæsthetising of patients, and my physiological experiments upon different animals, extending over a period of 25 years.

The introduction of my new Anæsthetic, namely, De-Oxygenated Air plus Normal Air, requisitioned my views concerning the physiological action of Nitrous Oxide, also a criticism of the common practice of administering mixtures of Nitrous Oxide and Oxygen, and my opinion of the physiological action of the dissociated constituents of common air.

It may be urged that my apparata for the administration of Narcotics are not so convenient as a napkin, but, it should be remembered that **life depends upon quantity,** and that **quantity depends upon accuracy.** For half a century men have been trying to elude the exactions of Nature's laws, and in consequence, their anthetisers have been embodiments of failure. Let us hope the time is near when the death of a patient may be universally regarded, not only as the greatest inconvenience, but also as an appalling calamity. I cannot recall a time when I was not oppressed with the great responsibility which each operation laid upon me, although law justified my position, and I never operated without having previously arranged the appointment, I never operated whilst the patient was in re-action from over-exertion, I never allowed a patient to tell me what to do; I either did what I felt to be my duty, or refused the case; and although I have had a large number of extensive Chloroform cases, to say nothing of Ether and Gas operations, I thank God because the terrible experience inevitably consequent on a casuality of that kind has never fallen to my lot.

I deeply regret that the time at my disposal prohibited a fuller treatment of this subject, the importance of which cannot be over-estimated, involving as it does **the issues of life and death,** and that my every-day duties compel me to issue in such a crude form, that which has been hurriedly written during snatches of time taken from my daily routine. I am conscious of the defects of this little production, considered from a literary stand-point, which, however, I have no time to remove just at present, therefore this explanation will distinguish the unfairness of criticism from any other than a technical position.

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Marston's

ANÆSTHETISTS' POCKET COMPANION.

Although a comprehensive history of Anæsthetics, would be quite outside the contemplated scope of the Anæsthetists' Pocket Companion, its range properly includes, and indeed necessitates, reference to the various theories which have been advanced from time to time, regarding the Physiological action of Anæsthetics, as well as information relating to the various Anæsthetisers, and methods of administration, which these views originated and have put into operation. It is regrettable that the daily extensive use of Anæsthetics for over fifty years, has not removed the cause of these theoretical contentions, and evolved some efficient means for removing, or diminishing, those appalling risks which beset Anæsthetists, and jeopardize their patients, but, it could not be assumed for one moment, that the dangers which were natural to inexperience, and consequently, were encountered at the time when Anæsthetics first came into general use; have since that day been removed by the later acquisition of knowledge, which has been obtained at such a dreadful cost of human life, during that protracted period: for all the experimenting and theorising of practitioners during that long period, has failed to place the practice of Anæsthetics on either a scientific, or a reasonable foundation. Proof of this assertion may be found in the Anæsthetics Controversy of to-day; it is also manifest in the rule of thumb methods now in use; and worse still, it is evidenced by the large proportion of Anæsthetic fatalities proved to have been caused by accidental over-narcotisation. It is well known that in most of those cases, the Anæsthetic was administered from a napkin, or other absorbtive material, without the slightest pretension of ascertaining either the quantity, or percentage, of the drug inhaled; and it is remarkable that whenever such an accident occurs, professional representative journals decry, not the uncertain and dangerous method which undoubtedly caused death, but the Anæsthetic selected for the operation, and in that way they tacitly censure the Anæsthetist, whose alleged error of judgment, they suppose, has caused, or faciliated the patients death. Such censure is all the more unreasonable because they never suggest how these occurrences could be avoided, beyond reiterating that Ether is safer than Chloroform, Nitrous Oxide is safer than Ether, and that Nitrous Oxide plus Oxygen is safer than Nitrous Oxide.

The fact that all Anæsthetics are dangerous, and that the safest of them when administered by a dangerous method, become distinctly more dangerous, is altogether ignored by these critics. At such times the use of Chloroform in Dental operations is always condemned, and Ether is recommended for those cases in which a considerable number of extractions have to be made; but it is difficult to understand why Ether should be so much recommended, when, even those practitioners who most strongly advocate its use, never, in any case rely on its physiological action. It is remarkable too, that although so many deaths are attributed to the practice of administering Chloroform from a napkin, preference for that method is still so general. It could only be justified by assuming, 1st—that the comparative safeness of this particular method commends its use. 2nd—or that its adherents believe themselves to be more skilful, or more careful, than they in whose hands that mode has led up to such calamitous consequences. 3rd—or that previous casualities were caused by Idiosyncrasies, or predispositions peculiar to those patients who had succumbed to Anæsthetic operations; but, the first of these assumptions is undoubtedly disproved by history, which distinguishes that method, as the most reckless, and the most dangerous of all administrative methods in use, indeed, says Dr. Snow, "the "advocates of this plan, proceed on the sup-"position that there is no occasion to regulate "proportions, and it is only requisite that "the patient should have sufficient air for the "purpose of respiration, and sufficient Chloro-"form to induce insensibility, and all will be "right. The truth is, however, that if there be "too much vapour of Chloroform in the air "the patient breathes, it may cause sudden "death, even without previous insensibility, "and whilst the blood in the lungs, is of a "florid red colour."

Referring to the same method, Dr Quain observes—"The advantages of a more precise measurement of the quantity of chloroform vapour, than is afforded by towels or napkins, will appear when we consider the several circumstances that alter it when given :—

1st.—The extent of surface of chloroform.
2nd.—The temperature of the *evaporating* chloroform, which is constantly changing.
3rd.—The temperature of the air of the room; of the patient's face; and the operator's hands.
4th.—The distance at which the chloro form is held from the face.
5th.—The rapidity of the current of air.
6th.—The height of the barometer."

The second assumption, whose prevalence is signified by the frequent allusions made by practitioners, in reference to the reputed advantages of the napkin, when skilfully used, is an injustice to those unfortunate Anæsthetists, who, though neither less skilful, nor less careful than their censors, have lost a patient; and in consequence have realised that anguish which such an error of judgment too often entails. That supposition is entirely at variance with ascertained facts, for history brings into prominence, the names of practitioners whose skill won the admiration of their profession, and they, unfortunately, are coupled with Anæsthetic fatalities.

The recognized ability of many practitioners whose names have been mentioned connectedly with more recent cases of death from excessive chloroformization, is additional proof of the fact that the cleverest handling of an empirical method could never compare, for safeness, with an intelligent manipulation of those causative principles of Anæsthesia, which a scientific method makes controllable.

Not long ago, a young house surgeon, while discussing Anæsthetics with a few medical friends, said, he believed he could Anæsthetise ten thousand patients with Chloroform administered from a napkin, without losing one case from over-narcotisation. Thereupon one of his friends, reminded him of what had happened in the hands of the best, and most experienced of men. He reminded him too, of the consequences such a mishap devolved upon the institution in which it occurred, and then contrasting the responsibility of a house surgeon, with that of a private practitioner, said it meant ruin to the latter so far as it related to his reputation, in any district where the death took place. About four months from the date of that discussion, the young house surgeon lost a patient; death having been caused by an accidental over-dose of Chloro form.

Such an assumption is pure arrogance; and it richly deserves reproof, as severe and prompt, as that administered in the case referred to. What right has anyone to assume that attitude. It is equivalent to saying "I can "guess quantities, and their effects, with so "much certainty that I shall never trouble to "learn any thing about precise methods, true, "Anæsthetics do not seem to affect all people "in the same way, but then with little variations "indicated at the time, my plan has succeeded "up to the present, and if I were to make one "or two mistakes in the course of a lifetime, it "would be no worse than other good men "have done, and I am by virtue of my "qualifications, and my reputation, exonerated "from all blame;" but that position cannot continue, for as soon as the public have learned that there is a reliable method of getting at all those connections of Anæsthetisation required by law, personal responsibility will become enhanced, all the connections of such cases will become changed, particularly in those cases where culpable disregard of human life, has, under the plea of convenience, interposed a napkin, or any other empirical inhaler; for exoneration is now based on the supposition, that it is impossible to ascertain those facts, and that the Chloroformist has used all available proper means, and exercised his knowledge and skill for the benefit of his patient. On all other topics legal experts distinguish themselves by their evidence, but the sorriest specimen of an expert that ever enters a coroner's court, is a "*skilled* Anæsthetist." It must require more than an ordinary amount of self-confidence, to enable an Anæsthetist to say to a court of intelligent men, "I am a doctor of medicine, "&c., &c. I carefully examined the patient "and failed to discover any condition that "contra-indicated the Anæsthetic; in my "opinion the patient was a good subject for "Chloroform. I admit the drug is poisonous. "I believe 48 minims in the blood would "kill any man. I administered the drug in "the usual way. I could not say what per-"centages were breathed by the patient at "any stage of the proceeding. I could not "say what the total quantity was that had "been inhaled. I did all I could to resusci-"tate the patient. I now believe the nervous "centres were paralysed, and that the lungs "even then contained Chloroform vapour. "My efforts to restore the patient, were continued for a very long time." Of course the Anæsthetist has throughout this unpleasant ordeal, the comfortable assurance that eventually he will be exonerated from all blame, but that satisfaction is minimized when he reflects that judicial cognizance of the usual method of administering chloroform, not long ago, indicated the justice of dismissing a case of manslaughter, which had been preferred against a barber, who in spare moments, turned his hand to doing a little dentistry, with the result that he killed a patient by administering chloroform in the *usual way*. Could anyone reasonably question the justice of that decision; true he was only a barber, but then, he knew that chloroform is poisonous; he did not know how much was inhaled; he did all he could to restore his patient; and failed as successfully as any Anæsthetist could. What more could he have done? Certainly he did not examine his patient, but what necessity was there for doing that, when it was a fact within the knowledge of the court that about all the cases of death ever investigated were those of persons who after *careful* examination had been pronounced good subjects for the Anæsthetic.

Passing on now to a consideration of the third assumption mentioned on page 13, a glance at page 79 of Dr. Snow's work on Anæsthetics, will discover that that eminent author put his ridicule of that supposition into the following words :—"The process of inhaling Chloroform from a handkerchief is always uncertain and irregular, and is liable to confirm the belief in peculiarities of constitution, Idiosyncrasies and predispositions *which have no existence in the patient.*" Dr. Snow's expression of opinion upon that point, makes any further reference to it unnecessary.

It may be correctly inferred from what has already been said, that the practice of Anæsthetics has not made much progress during the last forty years, indeed so far as it relates to the exhibition of Chloroform, Ether, A.C.E., and similar mixtures, no improvement worth the name, has been introduced, and perhaps the only progressive phase of development in this direction, is the plan of Anæsthetising with mixtures of Nitrous Oxide and Oxygen. The conception of that plan, and its first application, is attributed to Professor Paul Bert; but Dr. Hewitt afterward achieved similar results by more convenient, and less expensive means—this, however, will be discussed in a later chapter.

Dr. Buxton in his work on Anæsthetics, intimates on page 206 that in the hands of one skilled in the use of Anæsthetics their danger is minimised; but both controversy and practice reveal that those who claim to be most skilled in the use of Anæsthetics entertain extremely opposite views regarding the physiological action of Anæsthetics, the selection of Anæsthetics, and the propriety of using different methods for administering Anæsthetics.

Some practitioners extol the advantages of Chloroform compared with other Anæsthetics, whilst others are just as pronounced in their condemnation of it. Some are of opinion that high percentages of Chloroform vapour are capable of causing sudden death, others conscientiously deny that Chloroform ever caused that result; their opinion being that respiratory failure, consequent on paralysis of the Respiratory Centre in the Medulla Oblongata in the brain, always precedes cessation of the heart's action. Again, some practitioners assert, that the safeness of Anæsthesia depends in a large measure upon the slowness of Anæsthetisation; whilst others strongly aver that symptoms which are so often regarded as signals of danger, warning that too much Chloroform vapour is being administered; are really indications of the urgent necessity for increasing the quantity of Chloroform, and hastily pushing the patient into an advanced stage of Anæsthesia.

Some practitioners are partial to the use of Ether; whilst others contend that it compares unfavourably with other Anæsthetics. Again! some practitioners recommend mixtures of Ether and Chloroform, which they say exhibit all the desirable qualities of each component, without evincing their undesirable tendencies; whilst others denounce such mixtures on the grounds that they possess all the disadvantages of both components, without the advantages of either.

These different opinions are based upon different results, arising from the irregular operation of uncertain methods, these results not being attributed to their cause, but viewed as the characteristic action of the drug; as exemplified in those opposite opinions which are entertained, regarding the action of Chloroform, and the erroneously ascribed physiological action of Ether, etc. See page 105.

The natural consequences of this error are disaster, distrust, and a general search for an agent of less capricious character; hence, patients have been plied with Chloroform, Ether, Nitrous Oxide, Amylene, Ethylidene dichloride, Chlorethyl, Bromethyl, Chloroform and Amyl Nitrite, Chloroform and Chloral, Chloral and Morphine, Morphine Atropine and Chloroform, Morphine and Ether, A.C.E. mixture, Methylene, Linhart's mixture, Richardson's mixture, Vienna mixture, Billroth's mixture, Carbon Monoxide formulas, Carbon dioxide formulas, mixtures of Nitrous Oxide and Narcotics, mixtures of Nitrous Oxide and Oxygen; Eucaine, Cocaine, and other Anæsthetic agents. Thus the endless round of experiments goes on, the drugs being administered down the throat, up the rectum, and through the skin, separately, and conjointly, their selection, and proportionment, being varied, to appease all the whims of subtle reason. Drugs are not only administered without regard to the proportion of their diluents; but the quantity of the drugs themselves is not known, and the chameleon effects of ever-varying percentages and quantities are accepted as evidence of the characteristic action of the drug exhibited

If the search now being made by Anæsthetists for a safe Anæsthetic, could be considered, as having a reasonable prospect of success, their efforts would be made futile, by their irrational method of conducting the investigation. Would any practitioner desirous of investigating the therapeutic action of any new drug, ever think of conducting his enquiry in a similar manner? Most certainly he would not, on the contrary he would denounce any man who manifested such an absence of regard for his own welfare and such astounding conduct towards his patient.

Enquiries into the physiological action of

Therapeutics are always conducted in a scientific manner. It is considered to be absolutely necessary to use reliable means, for ascertaining the precise quantity of each dose, and by these means it is possible, as you know, to be quite sure that a quantity, representing exactly neither more nor less than a thousandth part of a minum, or of a grain, has been administered, and you are just as certain about the safeness of the action of the dose given to your patient, whatever the proper dose may be, as you are of the accuracy of the quantity prescribed, whether you prescribe a botanic remedy, in Powder, Infusion, Decoction, Extract, Tincture, Alkaloid, or any of the salts of its alkaloid. Moreover than that, you often give a combination of drugs, perhaps all of them poisons, but presented to each other in an order calculated to counteract, intensify, or otherwise modify their peculiarities, and to create by their complex action, a predominating power, which characterises the physiological action of the formula; although it is distinctly foreign to any of the several components separately considered. These formulas may contain the most convenient, but extremely dissimilar, modifications of the active principles which each component represents, and yet, the co-relative doses of the different active principles employed, are just as easily calculated, as are their individual doses. Precise methods have achieved all this, and in doing it have shewn that the workable limit of the characteristic zone of chemical principles, depends upon intensity of action; that intensitv of action depends upon quantity; and that the predetermination of physiological effects depends upon precise methods of administration.

If it is necessary to exercise so much precision in the administration of medicaments intended for introduction into the system through the stomach, whence its passage into the blood, is effected by a comparatively slow process, how much more urgent is the necessity for exactness, when formulating respiratory poisons, which, according to the computation of Dr. Addison, during the process of Anæsthetisation fill about 1,744,000,000 of pulmonary air cells, and are thereby exposed to the absorbtivity of a surface equal to about one thousand five hundred square feet, which practically effects immediate absorption of the drug.

How utterly inconsistent then, with reason, appears that anxious attention, bestowed upon the precise calculation of Chloroform doses intended for the stomach, when contrasted with the comparative indifference, paid to the doses of respiratory poisons, whose physiological action is far more energetic and dangerous. For instance, it is recorded on page 1032 of the 14th edition of the American Dispensatory that Dr. Hartshorn used Chloroform internally in a number of cases as a safe Anodyne and Soporific, altogether free from the dangerous effects which sometimes follow inhalation of its vapour. He ascertained that in the dose of a fluid dram its soporific effect is equal to 35 minums of Laudanum.

It is also recorded that Dr. L. Dalton, and other physicians, prescribed it as an antiperiodic, in intermittent diseases, in quantities varying from half a dram to a dram, given every hour, for two or three hours preceding the expected return of the paroxysm. I certainly should not like to take, nor to give such a dose, for my personal experience is, that a capsule containing ten minums of Chloroform is quite capable of causing a sensation in the stomach, which may be described as more perceptible than pleasant, my objection however does not affect this argument, what we have to consider are the facts recorded in that standard work, and we have to compare them with the facts that twenty-four minums in the blood of an adult, produces a condition bordering on death; that thirty-six minums causes respiratory failure; and that a high percentage of Chloroform vapour might cause inhibition of the heart's action before any degree of Anæsthesia had become apparent. The significance of this comparison is that greater caution is necessary when mixing and administering respirable poisons than is required in the dispensing and administering of therapeutic preparations.

Many practitioners who doubtless would readily admit that methods of administration have a great deal to do with the action of therapeutic agents, nevertheless hold the opinion, that administrative methods cannot modify the physiological action of anæsthetics. What has already been said, makes a separate consideration of this point superfluous, and the absurdity of the supposition makes any serious treatment of it appear ridiculous. This opinion is antagonistic to the views and practices of Therapeutists, who themselves are its most persistent adherents; but I cannot forget that these prejudices are founded on long experience, and it is unreasonable to expect an easy surrender of convictions which careful observations have day by day been steadily forming through years of practice, albeit, judgment has been misguided by the inaccuracy, and varying results of unreliable methods. It is quite true that a given quantity of an anæsthetic or of any other drug could never produce identical results in a diversity of cases, such as extremes of size, age, strength, health, and habits; but although a given quantity of the drug would in such cases produce very different results, a *given percentage* of the Anæsthetic would produce identical results in *all* cases, and in the same period of time.

The respiratory capacity is proportionate to the size, and condition, of the creature. Each creature takes its own respiratory equivalent, within the same period. Hence, it takes as long a time to anæsthetise a guinea pig, as it does to anæsthetise a man; and the smallest tame mouse exposed to the same mixture during the whole period of anæsthetising, only becomes anæsthetised to the same degree. My experiments have proved, that so small an organism as a house fly, is only anæsthetised to the same degree, when subjected to the same mixture, and throughout the whole period, required to anæsthetise a man. The period required for anæsthetising to any given stage, may be stated beforehand, if reference is made to Table 13. My Tables have been experimentally worked out, and I am willing to demonstrate these results to any registered practitioner, if allowed to suit my own convenience in the matter of arranging time.

These experiments require perfectly diffused, precise percentages of the narcotics, such as are formulated by my anæsthetisers, a description of which appears later.

There are only two typical ways of giving anæsthetics—viz., the wrong way, and the correct way; and as the more convenient wrong way has obtained up to the present, it follows that whatever those who adopt it, have to say about the characteristic action of different formulas, none of which they could make, nor administer by ordinary means, relates more properly to their own experience of erratic methods, than to the physiological action of precise formulas. Only a few men have identified themselves with the practising of the correct way, notably amongst them Dr. John Snow, and Dr. Clover, and they were of opinion that there could be no evidence of the physiological action characteristic of any particular formula unless it were possible to make that formula, and ensure its components being inhaled in the exact proportions indicated by that formula. Now let me interpose the question, Have you any method by which you could accurately make a respirable anæsthetic mixture, and ensure its being inhaled in the exact proportions indicated by that formula?

We have heard a good deal about the distinctive merits of anæsthetic compounds such as A.C.E., Billroth's mixture, Richardson's mixture, Vienna mixture, Lynhart's mixture, etc., but have you ever succeeded in making yourself believe that these formulas were being administered unchanged? I think not. You know perfectly well there is nothing to warrant the supposition that the characteristic physiological action of such formulas is demonstrable by the ordinary methods of administering anæsthetics.

Dr. John Snow proved conclusively that methods of administration do most distinctly modify the action of anæsthetics, whether simple or compound. He was led to that conclusion by innumerable physiological experiments performed on animals, and by other observations. He enjoyed an extraordinary scope for the acquirement of knowledge relating to this subject, as for ten years he was anæsthetist to London hospitals. He had an extensive reputation in the medical sphere, which brought him into requisition for the private cases of his medical admirers; and beside that he had an extensive practice of his own. He administered anæsthetics to Her Majesty our beloved Queen, on several occasions, and also to other members of the Royal family. The study of anæsthetics was his life's work, and his biographer, Sir Benjamin Ward Richardson, tells us, "the fact that in almost every fatal case from chloroform, the result had occurred from the action of the narcotic on the central organ of the circulation, was never absent from his thoughts." He further informs us that Dr. John Snow was a man of the strictest integrity and purest honour, and that by his earnest labours Dr. Snow soon acquired a professional reputation in relation to his knowledge of anæsthetics, which spread far and wide, and the people through the profession looked up to him from all ranks, as the guide to whom to entrust themselves. He entertained the belief that sooner or later a safe anæsthetic would be found, and that it would be inhaled with absolute safety, and would destroy common sensation without destroying consciousness. Intent on its discovery, he continued to steadily investigate the effects of various volatile agents for the production of insensibility, and he arrived by frequent experiments, to such a degree of positive knowledge regarding agents of this class, that the composition and boiling point of any new chemical body having been supplied he could predict whether, or not, its vapour would produce narcotism by inhalation. Other than the volatile agents referred to he performed a variety of experiments with Carbonic-acid, Carbonic-oxide, Cyanogen, Hydrocyanic-acid, Dutch-liquid, Ammonia, Amylovinic-Ether, Puff-ball, Smoke, Allyle, Cyanide of Ethyl, Chloride of Amyl, a Hydrocarbon from Rangoon, a Hydrocarbon coming over with Amylene, and various combinations of these. He went to work cautiously, and with precision. First he ascertained the boiling point of the specimen supplied to him, then the point of saturation of air with the vapours at different temperatures; then the effects of inhalation of the vapour by inferior animals, and the quantity required to be inspired with the air breathed to produce insensibility. These were the usual steps, in all his enquiries of this kind. When he had obtained any substance that would produce insensibility favourably on animals, he pushed it in one or two experiments, to its extreme in animals of different kinds, and having produced death by the inhalation, both by giving rapidly a large dose, and by giving a small dose for a long period, he observed the mode of death, whether it occurred by cessation of the heart, or by cessation of the respiration primarily. If the agent seemed to promise favourably from these inquiries, he commenced to try it on man, and the first man was invariably his own self. His friends knowing his courage in the ardour of his experiments, expostulated with him in regard to the risks he ran, but it was all of no avail. He felt the personal trial a duty, and he did it."

His love of precision, and his knowledge of its necessity in the administering of anæsthetics, caused him to apply his attention to the construction of reliable inhalers, but, says his faithful biographer: "Dr. Snow was not ready in invention," and this fact is borne out by the crudeness of the means he used for the mixing of exact formulas ; and also by the contrivances he used in his experiments upon living animals. Dr. Snow saw that satisfactory results, could not be obtained from an unsatisfactory method, and he set about making an apparatus that would enable him to formulate atmospheric mixtures in the same way that he mixed other therapeutic agents. The result was Snow's huge bag mounted with a face piece. Some dispute that Snow ever invented the big bag, but on page 80 of his work on Anæsthetics, Snow himself says : "The most "exact way in which it is practicable to ad-"minister chloroform to a patient about to "undergo an operation ; is to introduce a "measured quantity into a bag, or balloon, of "known size, then fill it up with air, by means "of the bellows, and allow the patient to "inhale from it ; the expired air being pre-"vented from returning into the balloon, by "one of the valves of the face-piece to which "it is attached. I tried this plan in a few "cases, in 1849, with so much chloroform in "the balloon as produced 4 per cent. of "vapour in proportion to the air. The "effects were *extremely uniform*, the patients "becoming insensible in three to four minutes. "I did not try, however, to introduce this "plan into general use, as the balloon would "sometimes have been in the way of the "surgeon, and filling it up with the bellows "would have occasioned a little trouble."

The fact was, that Dr. Snow's Chloroform Bag exceeded in its dimensions, the proportions of comeliness, and, although he always described it as "absolute perfection," or, "the most exact way," he seems to have thought that its contour, and primitive connections, were sometimes regarded with countenances more expressive of levity than admiration. But, to his everlasting praise, Dr. Clover, recognizing the merit of Snow's idea, modified the construction, and then, with perfect indifference to all surrounding influences, he strapped the Bag on his back, and frequented the operation room, with a fixed determination to do what he felt to be his duty towards his patients. The capacity of this bag was sufficient to accommodate a large volume of the anæsthetic mixture, in order to meet the requirements of several cases. Dr. Snow's method of forming his narcotic atmospheres was, as he himself asserts, absolutely perfect. His apparatus, however, was of the crudest and most inconvenient description, a fact which he much regretted, but was unable to alter.

Dr. Snow informs us that previous to 1847, patients were instructed to draw in the medicated air by means of a tube placed in the mouth, which led generally to great awkwardness at first, especially as the patient began to puff, as if he were smoking a pipe;

and it had the further inconvenience, in the administration of ether, that the tube dropped from the mouth, and the patient began to breathe by the nostrils, just as he was getting unconscious; but, Dr. Francis Sibson and Dr. Hawkesley, both independently, and unknown to each other, invented a face-piece early in 1847, both of which Dr. Snow describes as the greatest mechanical aids to the process of inhalation Dr. Snow himself improved those face-pieces, by adding thereto an inspiratory valve, whose function it was to admit the medicated air and vapour from the inhaler and close again on expiration; and also an expiratory valve whose function, he informs us, was to rise and allow the expired air to escape. The expiratory valve was planned to turn more or less to one side, and thus admit more or less of external air, to dilute still further, that which has passed through the inhaler and become charged with vapour. By this means the patient can begin by breathing air containing very little vapour, and more and more of the air which has passed over the moistened Bibulous paper can be admitted as the air passages become blunted to the pungency of the vapour. "A water bath used therewith is to supply the Caloric which is rendered latent, and carried off, as the chloroform is converted into vapour, and thus to render the process of inhalation steady, and uniform. Without the water bath, the evaporation of the chloroform would soon reduce the temperature of the inhaler below the freezing point of water, and limit very much, the amount of vapour the patient would inhale, and if the apparatus were warmed by the hand, the temperature would be too high, and the amount of vapour too great."

This instrument is the one usually, though erroneously, called Snow's inhaler. He, however, made no pretension of having invented either the inhaler, or its face-piece, although he undoubtedly improved them. On the contrary, he honestly disclaims what rightly belonged to others, and modestly adds that he furnished their face-pieces with inspiratory and expiratory valves, an addition which has been fully appreciated ever since; but is never connected with his honoured name; nor did he ever mention percentages in connection with its use. Whenever Dr. Snow used this instrument, he characterised his doing so, as the sacrifice of absolute perfection to convenience, and he never used such an instrument upon animals, which required formulas of known exact proportions; and he always deplored the necessity, whenever circumstances compelled him to use it in Anæsthetic operations performed on a human subject, for the reason that such an instrument is quite incapable of controlling required percentages, or of causing uniform physiological results.

A French gentleman, Monsieur Charriere, invented an apparatus which won for itself a reputation on the Continent. It consisted of a glass vase with suitable valves, and a fabric for exposing a surface wetted with chloroform which passed through it; the controlling principle of this apparatus being identical with that of the preceding Anæsthetisers, distinguishes the ungovernableness of its action and consequent unfitness for its intended purpose.

Monsieur Deroy of Paris contrived an ingenious, but very complicated contrivance, which he called an anæsthesimeter, the object of which was to regulate the amount of chloroform, and this could be varied from four to sixty drops in the minute. This instrument was condemned by Dr. Snow on the ground that controlling quantities of chloroform, without regard to the shallowness, the depth, or the frequency of respiratory operations, could not, by any stretch of reason, be justly described as *controlling respiratory doses* of the narcotic. He says, "for instance, if the inhaler were supplied with 60 drops of chloroform per minute (these drops weigh 20 grains and produce 15·3 cubic inches of vapour), and, if the adult were breathing the average quantity of 400 cubic inches per minute, the air he would breathe would contain nearly four per cent. of vapour, which would answer extremely well; but, if the breathing were slow, or feeble, or if he should hold his breath for an interval, and commence again, he might breathe air much more highly charged with vapour. Indeed, it would depend on the amount of surface moistened with chloroform, the temperature, and other physical conditions, whether or not the air inhaled might not be charged with chloroform to a dangerous degree; whilst on the other hand, if the breathing were deep and rapid, as often happens, whilst the patient is getting slightly under the influence of the chloroform—if, for instance, the patient were to breathe 1,600 cubic inches instead of 400—the air he would inhale would contain less than 1 per cent. of vapour, and he would not become insensible with the utmost supply—namely, 60 drops per minute of the anæsthesimeter, till his breathing should be moderated." Another apparatus, called Dr. Sansom's inhaler, has been wrongly described by an eminent author as a modified Snow's inhaler; but why it has been so described is difficult to understand, for its principle of action is quite as foreign as its appearance, which bears no resemblance whatever to Dr. Snow's apparatus. Dr. Sansom's inhaler is devoid of any novel feature, unless that distinction can be properly applied to the twisting up of any absorbtive material into a spiral evaporation surface, such as Dr. Sansom adopts. One striking, if not commendable, peculiarity of this apparatus, is the gutta-percha non-conductive covering of the receptacle, which Dr. Buxton, with assumed seriousness, assures us Dr. Sansom believes *equalises temperature* better than the cold water jacket of Dr. Snow. It seems strange that Dr. Sansom could so thoroughly forget that the function of the surrounding water is to give up caloric to the evaporating chloroform, and thereby compensate the conversion of its sensible heat into latent heat. The gutta-percha non-conductive covering of the receptacle is worse than useless, for, whilst it cannot prevent reduction of temperature, consequent on evaporation of the contained chloroform, it can, and does prevent the conduction of heat from the external atmosphere, which, if not prevented by the non-conductive covering, would to a considerable extent compensate that conversion.

All the inhalers which I have described might be called draught Anæsthetisers, because, when inhaling from them, the patient draws the medicated air through the reservoir containing the narcotic. There are other inhalers, however, whose action is distinctly different, and inhalers of this class might not improperly be called compound-blast-and-draught Anæsthetisers. We have a well-known specimen of this type in Krohne and Seseman's Anæthetisers, whose intention, its inventors tell us, "is to project varying quantities of a saturated chloroform atmosphere into the air-tract, at the very commencement of each inspiration," presumably to ensure the full charge of saturated air being deposited within the lungs, and thereby prevent that waste of chloroform vapour which would inevitably result from its diffusion with the later inrushing air, which at the close of each act of inspiration is external to the lungs, and is contained within the *Bronchi*, *Trachea*, *Larynx*, *Pharnyx* Oral-cavity and the Face-piece. Now, if the safeness of its physiological action, was as easily demonstrable as is the fact that Snow's theory and method are diametrically opposed to both the means and object of such a practice, that fact would doubtless modify the opinion of those who, in the absence of proof, have to decide unfavourably to pretensions which appear to have no foundation in fact. Its use indicates the propriety of the following questions :

1st.—If pungency is a factor which cannot be safely ignored, how much of an atmosphere saturated with chloroform vapour, or what percentage, would be sufficient to cause a spasm of the glottis, in cases where chronic irritation and consequent hyperæsthesia exist ?

2nd.—What volume of such an atmosphere, or what percentage, would be sufficient to cause cardiac paralysis by direct action upon the heart's substance, supposing that primary cardiac paralysis may be caused by imperfectly diffused vapour reaching the heart?

3rd.—What volume of such an atmosphere, or what percentage, would be sufficient to cause reflex Cardiac inhibition, through irritation of the nerve endings of the pneumogastrics in the lungs?

4th.—If the figures on the graduated bottle were hidden; would a stated number of compressions at each of the rings on the India-rubber ball, at different temperatures, remove from the bottle a volume of chloroform, corresponding with the exact quantity that theoretical calculation required?

It is not necessary to separately consider Junker's inhaler, because the last preceding apparatus may be viewed as an improved modification of it.

I will now direct your attention to Clover's Portable Ether Inhaler, and my references to it will conclude the present criticism of Anæsthetisers.

As your knowledge of the construction of this apparatus renders any structural description unnecessary, I will first follow Dr. Dudley Buxton's directions for using it, and then comment on its action. His directions appear on page 76 of his excellent work on Anæsthetics, and are as follows :

" A Face-piece of an appropriate size having been selected, and two ounces of Ether placed in the Receiver, the Air Bag is removed, and the Indicator turned to 0. The patient is then directed to inspire deeply, and the Face-piece applied gently, but firmly ; uniform pressure is well borne, while hard pressure, if unequally distributed, will not be tolerated.

When the patient has taken two or three deep breaths, the Air Bag is filled by the administrator blowing in air—taking care not simply to breathe into it—and is slipped into its place so that the patient now breathes in and out of the bag. The Ether chamber is now moved so that the Indicator points to the figure 1, and the patient then breathes one-fourth Ether and three-fourths air. A few breaths of such a dilution of Ether, will accustom the larynx, to the irritating vapour, and also obviate coughing, spasm, and the wretched feeling of suffocation which ensues, upon presenting a strong Ether atmosphere at the commencement of an inhalation. This tolerance achieved, the Ether chamber is rotated till the Indicator points to 2, and the patient then inhales half Ether and half air. If this strength of vapour does not distress him, the Indicator by further rotation of the Ether chamber, can, after a few seconds, be made to point to 3, one-fourth part of air, three parts Ether, and then to F, all Ether.

The patient will in from ninety seconds to two minutes and a half, be completely unconscious and ready for operation."

Continuing on page 77 the author remarks that the patient during a prolonged operation requires the inhaler to be taken off his face every sixth breath or so, in order that he may take a few inspirations of air. The necessity for this will be readily recognized by any cyanosis in the face or ears, and by the character of the respiration and the pulse.

It should be carefully borne in mind that the amount of an anæsthetic required to produce narcosis, is much greater than is needed to maintain that condition, *also the degree of narcosis* must be varied in correspondence with the region of the body upon which operative measures are being pursued."

Thus, then, is the safest and most trustworthy of Anæsthetics administered, and this is an illustration of how those who vaunt the superiority of Ether, trust, or rather distrust its characteristic physiological action.

It is self-evident that the complex operation just described, involves so many Anæsthetising factors, that it would be difficult to distinguish the cause of death, if it occurred, although it is invariably ascribed to Ether.

The preceding instructions bring into prominence the fact that pungency causes coughing, spasm of the glottis, the wretched feeling of suffocation and fright. It is affirmed by some authors that death does not result from spasm of the glottis caused by the local action of narcotic vapours, as the spasm always relaxes before asphyxiation becomes complete, but sufficient is known of the vessicating action of imprisoned Chloroform, and Ether, on the mucous membrane, to warrant the supposition that the passage of highly heated concentrated vapours through, or the accidental intrusion of spray into, the larynx, might set up an amount of calorific action, quite sufficient to cause protracted closure of the glottis with fatal result.

On the other hand it is generally admitted that fear, like Chloroform, is capable of causing death. Another factor which always plays an important part in the reputed physiological action of Ether, whenever administered in the manner described, and which may cause death, quite independently of the specific action of that drug, is Oxygen starvation, sometimes called Systemic Asphyxiation, for if, when the Indicator points to No. 1 the atmosphere is composed $\frac{1}{4}$ part of Ether and $\frac{3}{4}$ part of air, it must contain 18·46 of Oxygen; and if when the Indicator is placed at 2, the atmosphere is composed of $\frac{1}{2}$ Ether and $\frac{1}{2}$ air it then contains 10 per cent.

of Oxygen; if when the Indicator is at No. 3, the mixture is composed of Ether 3 parts, and air $\frac{1}{4}$ part, it then contains 1·45 of Oxygen; if when the Indicator points to F, it is all Ether vapour, it then contains absolutely no available Oxygen; and if the patient is allowed to take one inhalation of air at every sixth inspiration from the apparatus, the proportion of 2·85 per cent. of Oxygen is admitted to the lungs. Now, then, although as just stated, there is no available Oxygen in the atmosphere contained in the supplement bag when the Indicator points to F, there is Oxygen present, but only in the form of Carbonic Acid (CO_2), for at this extremity, nature is taxing her last resource and reducing the residual Oxyhæmoglobin of normal venous blood. The causes co-operating in this kind of Anæsthetisation, and those separately capable of causing death are:—Spasm of the Glottis, Fright, Toxic Action of Ether, Systemic Asphyxiation consequent on the absence of Oxygen, and the Toxic Action of Carbonic-acid Gas. Can the issue of this *modus operandi* be, with any degree of propriety, attributed to the characteristic action of Ether? The whole operation may be described as a series of accidental occurrences, always repeated without enquiry into its causes.

By way of recapitulation I should like to remind you that Dr. Snow's method was the exact method, his proportions were exact quantities, whose physiological action were known, and were uniformly demonstrable any number of times in succession. His method is the only one ever expounded which aims at *measuring and fixing the proportions of the diluent.* Other instruments have for their object the more or less accurate measurement of the quantity of the volatile narcotic inhaled during an operation, and that without reference to the modifying power of dilution.

Prescribers never forget that the water added to their mixtures controls the physiological activity of the drug prescribed, according to its displacement of the drug in the volume of each dose, and yet they utterly ignore that principle in the practice of Anæsthetics.

Dr. Snow formulated his aeriform mixtures in the usual way of mixing medicines, for instance, just as any practitioner might prescribe—

℞

Ferri et Quininæ Cit
Spt Chloroform ā ā ʒi
Aq. adde ℥viii.
Misce fiat mist cujus capiat coch
Amplum i bis vel ter die

So Dr. Snow first directs that patients shall be prepared for Anæsthetic operations by a four hours abstention from food, and then prescribes substantially as follows:—Take of Chloroform 6 drams and 56 minims ; place it in a bag whose capacity is 10840 cubic inches, and add thereto 10400 cubic inches of air. When the Chloroform has become converted into vapour (400 C.I.) and the vapour is perfectly diffused, the mixture is then ready for use. Administer to each patient sufficient of this mixture to cause the third degree of anæsthesia.

The distinctly different intentions of their methods as interpreted by the action of so-called improved Snow's Inhalers, may be contrasted in the following manner :

1.—The interpretation indicated by Dr. Sansome's Inhaler, Napkin inhalers, and all open draught contrivances is :—Let an unknown quantity of Chloroform be mixed with an unknown quantity of air, and administer the mixture in any convenient manner, taking precaution, however, to discontinue the administration, if the patient die before anæsthesia is caused.

2.—The interpretation indicated by Duroy's Anæsthesimeter is :—Let from 4 to 60 drops of Chloroform fall into a Face-piece regularly, regardless of the uncertainty and irregularity of breathing, and continue the application so long as occasion may require.

3.—The interpretation indicated by Dr. Clover's Portable Ether Inhaler is :—Place a known quantity of the narcotic in a Face-piece connected with a supplement bag whose capacity is 100 cubic inches or less; apply the apparatus to the patient's face, and let him breathe the ultimate mixture of narcotic vapour, and respiratory carbonic acid, until insensibility, and cyanosis, show that medication of the nervous centres, and oxygen starvation have, by the double process of poisoning, and stifling, ruthlessly taxed the recuperative forces of nature as far as one *dare* go.

4.—The interpretation indicated by Messrs. Krohne and Seseman's apparatus is:—Take of atmospheric air, saturated with chloroform vapour at any temperature, a sufficient quantity; of this, let a small quantity be projected into the air-tract of a patient at the very commencement of each inhalation, varying the quantities of the saturated atmosphere according to the supposed needs of each case, and continue these injections until anæsthesia is produced.

Quite a number of other instruments have been introduced. Their principle of action, however, is identical with that of one, or another, of the typical instruments enumerated in the above selection. Every one of those instruments, represents its maker's best endeavour to put Dr. Snow's idea into workable form, but, although the intelligence of Anæsthetists, and the practical skill of instrument makers, have, for about half-a-century, been focussed upon that need, their results show, how signally that co-operation failed in its praiseworthy enterprise; for not one of them is capable of formulating Dr. Snow's atmospheres, as, indeed, he himself clearly foretold, for he condemned the very principles which govern their action, hence it is obviously unjust to associate such instruments with his honoured name; but in that respect the conduct of instrument makers has been imitated by some eminent authors.

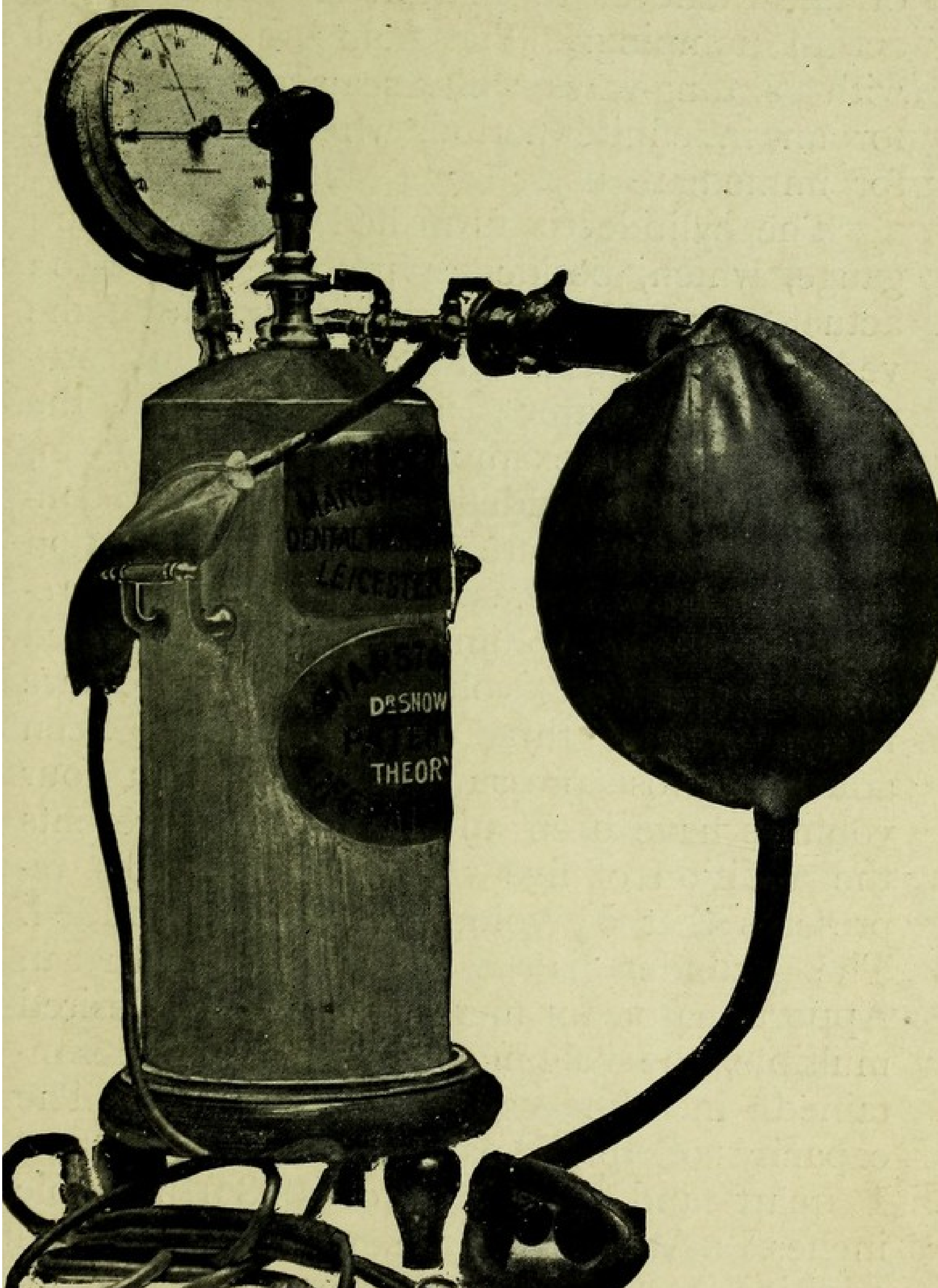
I will now describe my method of formulating Dr. Snow's atmospheres, and others whose components are presented to each other in exact proportions. This method also ensures each mixture being inhaled in the ratio of proportions indicated by its formula. My Anæsthetiser is made in two forms, viz. :—

The Stationary Anæsthetiser, for surgeries and hospitals, and the Portable Anæsthetiser for medical practitioners to take with them on their rounds, whenever circumstances require its use.

Plan of . . . Stationary Anæsthetiser.

The Stationary Anæsthetiser comprises a wrought copper cylinder, provided with a central pump, whose function it is to charge the cylinder, with any quantity of air which may be required. At the bottom of the

Marston's Stationary Anæsthetiser



Complete.

pump is a check-valve, for checking a return of air whenever the piston is raised in the act of pumping. The pump is also fitted with a sealing-valve, which seals up the charge, for an indefinite period, when not required for immediate use.

The cylinder is furnished with a pressure gauge, which, beside serving to indicate the actual pressure exerted on the inside of the vessel, also indicates the quantities and proportions of whatever is pumped into the cylinder. For example, 1lb. pumped in, represents $\frac{1}{15}$th added to the residual contents; 15 lbs. pressure represents the addition of an equal volume; 30lbs. pressure represents that two volumes have been added to the residual volume, 45lbs. pressure indicates that three volumes have been added; 60lbs. pressure indicates that four volumes have been added; 75lbs. represents the addition of five volumes; and 80lbs. represents that $5\frac{1}{3}$ volumes have been added. The cylinder is also furnished with an Apportionator, for increasing, by any desired multiple, the volume of gas or vapour contained in the copper receptacle. The capacity of this Anæsthetiser is 3 gallons 1 quart and 4 ounces or 908·075 cubic inches. At 80lbs. pressure it contains in addition to its residual atmosphere, $5\frac{1}{3}$ indicated or available atmospheres, the whole quantity then being 20 gallons 5 pints $19\frac{1}{3}$

ounces or 5751·141 cubic inches. When the available $5\frac{1}{3}$ atmospheres, leave the cylinder through the apportionator whose pointer has been set at No. 10 on the quadrant, the escaping gas or vapour becomes thereby increased to $53\frac{1}{3}$ atmospheres—that is to say, 174 gallons 5 pints and 6 ounces, or 48430·666 cubic inches.

Sufficient has been said to show that the Apportionator plays a very important part in the general action of this apparatus, but a fuller description of its use, will be given when its construction, and the principles involved in its operations have been explained.

The Apportionator comprises a large tube, a regulator, an indicator, and a central nozzle—the large tube preferably bell-shaped at one end. The small end of this tube is open, but its larger end is provided with a regulating attachment, part of which revolves on a central tube, which terminates in a nozzle, within the bell-shaped chamber. The revolving disc of the regulator, describes a motion of about a quarter circle, as it opens or closes the air vents, in the act of apportionating. That range of motion is divided into tenths—viz., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, each of which is numbered on the stationary quadrant, whose numerals represent the exact multiple added to the volume which is being projected from the central nozzle; these numerals are indicated by a pointer which the revolving disc carries. When this point stands at No. 1 all the air vents are closed, and consequently, any delivery then going on, is simply a supply of whatever the cylinder contains; but when the pointer is placed at 10, the appertures are full open, and then, every volume issuing from the cylinder is being diluted with nine volumes of external air. It is now self-evident that the numerals graduating the quadrant, not only directly indicate the volumes of air being added; but they also inversely indicate the strength of the mixture which is being made, thus: 1, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, $\frac{1}{8}$, $\frac{1}{9}$, $\frac{1}{10}$. See Tables 1 and 2. A careful inspection of the Apportionator will discover how the appertures open and close when the pointer is moved, and also, the position of the internal nozzle, as well as the difference of the internal diameter of the two tubes. It is that difference which fixes the ratio of proportions, and that ratio is not affected in the slightest degree by fluctuations of pressure. This fact is easily proven, for by attaching the cubic foot bag, it will be seen that it requires $3\frac{1}{2}$ lbs. of atmosphere from the cylinder to fill it, whether the cylinder is charged up to a pressure of 80 lbs., or only 10 lbs., on the square inch (the first 5 lbs. indicated on steam guages are never trusted for accuracy). When the indicator is placed at No. 1, then 35 lbs. from the cylinder fills it; when the pointer indicates 2, then $7\frac{1}{2}$ lbs.

Table 1.

Centage Reduced by Apportionator.

Per Cent.	Quadrant Index Numbers. 1	2	3	4	5	6	7	8	9	10
4	4	2	$1\frac{1}{3}$	1	$\frac{4}{5}$	$\frac{2}{3}$	$\frac{4}{7}$	$\frac{1}{2}$	$\frac{4}{9}$	$\frac{2}{5}$
5	5	$2\frac{1}{2}$	$1\frac{2}{3}$	$1\frac{1}{4}$	1	$\frac{5}{6}$	$\frac{5}{7}$	$\frac{5}{8}$	$\frac{5}{9}$	$\frac{1}{2}$
6	6	3	2	$1\frac{1}{2}$	$1\frac{1}{5}$	1	$\frac{6}{7}$	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$
7	7	$3\frac{1}{2}$	$2\frac{1}{3}$	$1\frac{3}{4}$	$1\frac{2}{5}$	$1\frac{1}{6}$	1	$\frac{7}{8}$	$\frac{7}{9}$	$\frac{7}{10}$
8	8	4	$2\frac{2}{3}$	2	$1\frac{3}{5}$	$1\frac{1}{3}$	$1\frac{1}{7}$	1	$\frac{8}{9}$	$\frac{4}{5}$
9	9	$4\frac{1}{2}$	3	$2\frac{1}{4}$	$1\frac{4}{5}$	$1\frac{1}{2}$	$1\frac{2}{7}$	$1\frac{1}{8}$	1	$\frac{9}{10}$
10	10	5	$3\frac{1}{3}$	$2\frac{1}{2}$	2	$1\frac{1}{3}$	$1\frac{3}{7}$	$1\frac{1}{4}$	$1\frac{1}{9}$	1
11	11	$5\frac{1}{2}$	$3\frac{2}{3}$	$2\frac{3}{4}$	$2\frac{1}{5}$	$1\frac{5}{6}$	$1\frac{4}{7}$	$1\frac{3}{8}$	$1\frac{2}{9}$	$1\frac{1}{10}$
12	12	6	4	3	$2\frac{2}{5}$	2	$1\frac{5}{7}$	$1\frac{1}{2}$	$1\frac{1}{3}$	$1\frac{1}{5}$

REDUCED CENTAGE

Minims or part Minims per 100 cubic inches

Per Apportionator.

Table 2.

Direct or Through Apportionator.

Minims or part Minims per Inspiration.

Quadrant Index Numbers.

Per Cent.	1	2	3	4	5	6	7	8	9	10
4	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{10}$
5	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{5}{12}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{24}$	$\frac{5}{28}$	$\frac{5}{32}$	$\frac{5}{36}$	$\frac{1}{8}$
6	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{10}$	$\frac{1}{4}$	$\frac{3}{14}$	$\frac{3}{16}$	$\frac{1}{6}$	$\frac{3}{20}$
7	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{12}$	$\frac{7}{16}$	$\frac{7}{20}$	$\frac{7}{24}$	$\frac{1}{4}$	$\frac{7}{32}$	$\frac{7}{36}$	$\frac{7}{40}$
8	2	1	$\frac{2}{3}$	$\frac{1}{2}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{2}{7}$	$\frac{1}{4}$	$\frac{2}{9}$	$\frac{1}{5}$
9	$2\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{4}$	$\frac{9}{16}$	$\frac{9}{20}$	$\frac{9}{24}$	$\frac{9}{28}$	$\frac{9}{32}$	$\frac{1}{4}$	$\frac{9}{40}$
10	$2\frac{1}{2}$	$1\frac{1}{4}$	$\frac{5}{6}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{5}{12}$	$\frac{5}{14}$	$\frac{5}{16}$	$\frac{5}{18}$	$\frac{1}{4}$
11	$2\frac{3}{4}$	$1\frac{3}{8}$	$\frac{11}{12}$	$\frac{11}{16}$	$\frac{11}{20}$	$\frac{11}{24}$	$\frac{11}{28}$	$\frac{11}{32}$	$\frac{11}{36}$	$\frac{11}{40}$
12	3	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{3}{5}$	$\frac{1}{2}$	$\frac{3}{7}$	$\frac{3}{8}$	$\frac{1}{3}$	$\frac{3}{10}$

Minims or part Minims
Per Inspiration
of 25 cubic inches.

serve to fill it; when the pointer indicates 3, then $11\frac{2}{3}$ lbs. serve to fill it; when the pointer indicates 4, then $8\frac{3}{4}$ lbs. serve to fill it; when the pointer indicates 5, then 7 lbs. serve to fill it; when the pointer indicates 6, then $5\frac{5}{6}$lbs. serve to fill it; when the pointer indicates 7, then 5 lbs. serve to fill it; when the pointer indicates 8, then $4\frac{3}{8}$ lbs. serve to fill it; when the pointer indicates 9, then $3\frac{8}{9}$ lbs. serve to fill it; and when, as before stated, the pointer indicates 10, then $3\frac{1}{2}$ lbs. serve to fill it.

These results are brought about in the manner about to be described. When a stream of compressed air is allowed to rush from the central nozzle, its expansion sweeps, and its impetus drives, before it all the molecules of air contained in the large tube of the Apportionator. This action, which is continuous, creates a partial vacuum at the rear end of the Apportionator, which is supplied by a continuous inrush of external air. The quantity of air, per differential diameter of tubes, being determined by the size of the vents, which depends upon the position of the pointer indicated on the quadrant. What appears like a series of alternated operations is in fact a continuous and unvarying process, the effects of which are manifested in the demonstrable perfect accuracy of percentage of the components, presented to each other in respirable mixtures; for example: supposing the cylinder contains a mixture whose proportion of Chloroform is 10 per cent., if this were passed through the Apportionator and the pointer was placed in successive order at all the numerals on the quadrant, those numerals would then indicate the following percentages: No. $1 = 10$ per cent of Chloroform, No. $2 = 5$ per cent., No. $3 = 3\frac{1}{3}$ per cent., No. $4 = 2\frac{1}{2}$ per cent., No. $5 = 2$ per cent., No. $6 = 1\frac{2}{3}$ per cent., No. $7 = 1\frac{3}{7}$ per cent., No. $8 = 1\frac{1}{4}$ per cent., No. $9 = 1\frac{1}{9}$ per cent., and No. $10 = 1$ per cent. See Table 1. It will be observed that the space between numbers 1, and 2, on the quadrant, is divided into eight, for Gas and Air measurement, which may be effected by passing Nitrous Oxide, or other gas, through the Apportionator, and regulating its proportions by shifting the pointer along the divisions, starting at No 1, which represents one volume of N_2O; the next small division represents one volume of N_2O and $\frac{1}{8}$ volume of air; 2nd division = one volume N_2O plus $\frac{1}{4}$ volume of air; 3rd division = one volume of N_2O plus $\frac{3}{8}$ volume of air; 4th division = one volume N_2O plus $\frac{1}{2}$ volume of air; 5th division = one volume of N_2O plus $\frac{5}{8}$ volume of air; 6th division = one volume of N_2O plus $\frac{3}{4}$ volumes of air; 7th division = one volume of N_2O plus $\frac{7}{8}$ volume of air; and No. 2 represents one volume of N_2O plus one volume of air; No. 3 represents one volume of N_2O plus 2 volumes of air; No. 4

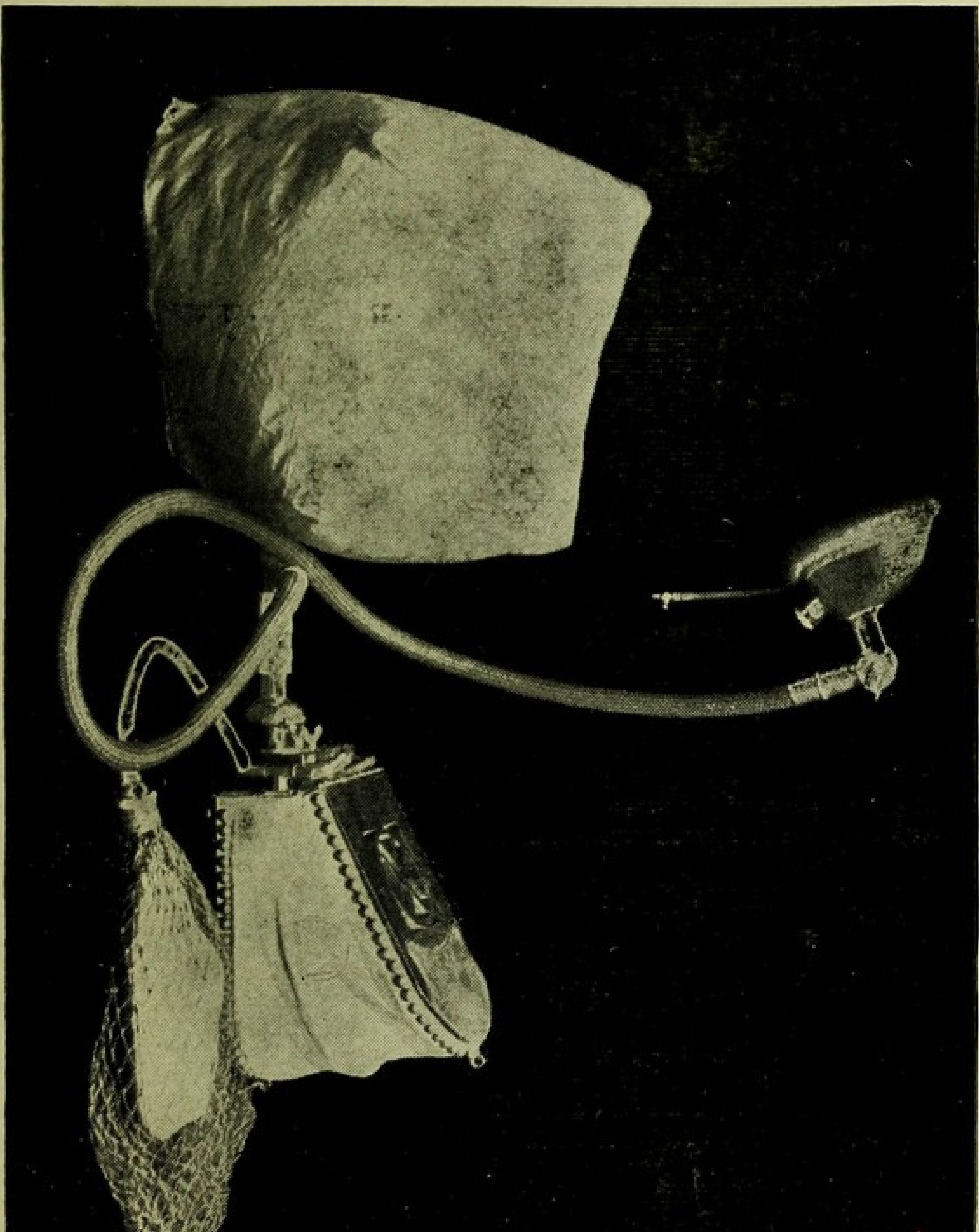
represents one volume of Nitrous Oxide, and 3 volumes of air; No. 4 represents one volume of Nitrogen plus 3 volumes of air, and so on: very large proportions of air, however, would only be required when the N_2O is medicated. The percentages of Oxygen present in such mixtures, will be found on referring to Table 9. The diffusion of gases, by this method, may be demonstrated thus: For this purpose I use a piece of metallic tubing, about $\frac{7}{8}$ of an inch inside diameter, on one end of this I fix a small gong bell, whose centre has been previously bored to receive it; a piece of gauze is cut small enough to adjust to the inside of the bell, but about $\frac{1}{8}$ of an inch below its free edge, which then forms a raised rim all round the gauze; the gauze should be pierced with a central hole, large enough to just receive the tapered end of an ordinary small mouth blow-pipe; when all is ready, the gauze is covered with granulated fumigating pastils, then a disc of paper, moistened with a trace of turpentine, is then laid, on and a lighted match applied. While ignition is proceeding the blow-pipe is inserted in the central hole made for it in the gauze, and when a moderate blast is sent through it, the coloured and distinctly visible atmosphere, will be seen descending from the lower end of the tube, in remarkable volume, and with great velocity. The action of the external air upon the granules, as it rushes through their interstices to destroy the partial vacuum; is indicative of what is going on inside the Apportionator.

My Patent covers other modifications of this principle.

Plan of . . . Portable Anæsthetiser.

The Portable Anæsthetiser is, as its name implies, a convenient embodiment of the principles already described. In this arrangement the blower does the work of a pump, the small metallic receptacle supplants the large copper cylinder, and the pulsating bag takes the place of a pressure gauge; it also prevents jerkiness of action, and maintains continuity of current. These bags are necessarily at least an eighth of an inch thick, and are made of the best quality of india-rubber—a thin bag would not serve the purpose for which the pulsating bag is used. The balloon, or more properly speaking the Cube Bag, is made of very light water and air proof material, which is very strong, durable, and packs into a very small space. It is, perhaps, unnecessary to say, that as the resistance of weight to the lifting pressure of the blast, has to be calculated when adjusting the operative principles of these Anæsthetisers, none but the bags we supply would give identical results. Every one of our instruments is

MARSTON'S PORTABLE ANÆSTHETISER



READY FOR USE.

carefully tested before we send it out, and all their parts are interchangeable, and may be had direct from us without delay.

But although the Portable Anæsthetiser embodies those principles which actuate the Stationary Anæsthetiser; it is necessary to vary the mode of operating them somewhat, owing to several causes, one of which is the fact that we have not in the Portable Anæsthetiser, that surface of *thermal conductivity* which the superficial area of the large copper cylinder presents to the atmosphere of a room. Such a surface of metal is not necessary, however, yet it has to be calculated as a factor when present, and left out of the reckoning when absent—the results in both cases are identical, and perfectly accurate. In order to elucidate what I mean it will be necessary to revert to Dr. Snow's method.

It will be remembered, that he used a large bag, of known capacity, in which he placed a vessel containing so much of Chloroform as would represent 4 per cent. of vapour, in proportion to the volume of air; and the bag was then blown up with a pair of bellows. Now, although he could make a formula of that strength, very quickly, he could not at a temperature of 70° Fahr. have made a large volume of mixture containing 19 per cent. of Chloroform, because its evaporation would have caused a considerable reduction of heat, and therefore resulted in a temperature, no

Table 3.

VOLATILITY.

(Air 100 Cubic Inches.)

ETHER.			CHLOROFORM.		
Fahr.	Min.	Vap. C.I.	Fahr.	Air.	Vap. C.I.
50	64	52	40	94	6
51	66	54	45	93	7
52	69	56	50	92	8
53	72	59	55	90	10
54	76	62	60	88	12
55	80	65	65	85	15
56	84	68	70	81	19
57	88	72	75	78	22
58	93	76	80	74	26
59	98	80	85	70	30
60	102	84	90	65	35
61	107	88			
62	112	92			
63	117	97			
64	122	102			
65	128	107			
66	134	112			
67	140	117			
68	147	123			
69	156	130			
70	165	138			

longer representing that vapour tension of Chloroform which is peculiar to 70° Fahr. See Table 3.

In the process of time 19 per cent. would be taken up, but not until the surrounding Caloric had permeated the whole volume of mixture, and that would not have been accomplished within a workable period. This contention confronts us with the fact that although Dr. Snow's tables of temperatures, and percentages, are undoubtedly correct, they do not represent the practical temperatures, and percentages, obtainable within workable periods. How could they, when the temperature commences to fall as soon as the Chloroform begins to evaporate; and continues to fall so long as evaporation proceeds. I found, by conducting a series of experiments, that if 10 degrees be deducted from any of Dr. Snow's temperatures (see Table 3), the product will represent the practical temperature, that is to say, the correct working temperature ; and the volatility of Chloroform peculiar to the temperature thus found, represents the practical percentage ; that is to say, the correct percentage of a saturated atmosphere. I found by experiment, that the formulation of a cubic foot of saturated air by this apparatus at 70° Fahr. causes a reduction of temperature equal to 20° Fahr., and as some of the mixture was produced at every degree intermediate between the two extremes 70 and 50, it appears self-evident that the accurate temperature, is the mean temperature (see Table 4), and that the correct percentage, is that indicated by the mean temperature. This may be elucidated in the following manner:

Example 1. or Example 2. or Example 3.

1	70°
2	69°
3	68°
4	67°
5	66°
6	65°
7	64°
8	63°
9	62°
10	61°
11	60°
12	59°
13	58°
14	57°
15	56°
16	55°
17	54°
18	53°
19	52°
20	51°
21	50°
21	1260
	60

Example 2:

$$\begin{array}{r|l} & 70^\circ \\ & 50^\circ \\ \hline 2 & 120 \\ \hline & 60 \end{array}$$

Example 3:

$$\begin{array}{l} 70^\circ - 10 \\ 10^\circ \\ \hline 60 \end{array}$$

All temperatures common to hospitals, surgeries, and dwellings operate in this way with perfectly accurate results.

Table 4.

Reduction of Temperature

BY VOLATILIZATION.

(Mean Temperatures).

Quadrant Index Numbers.	Chloroform and Air 1 Cubic Foot.	Fahr.
1	SATURATED	10
2	HALF STRENGTH ...	5
3	THIRD ,, ...	$3\frac{1}{3}$
4	FOURTH ,, ...	$2\frac{1}{2}$
5	FIFTH ,, ...	2
6	SIXTH ,, ..	$1\frac{2}{3}$
7	SEVENTH ,, ...	$1\frac{1}{2}$
8	EIGHTH ,, ...	$1\frac{1}{4}$
9	NINTH ,, ...	$1\frac{1}{9}$
10	TENTH ,, ...	1

Accuracy may be tested thus: Measure in a Burette furnished with a glass tap, the volume of Chloroform about to be put into the receptacle, and then make exactly one cubic foot of mixture, observing however, that the pointer indicates No. 1 on the quadrant; register the fall of temperature, by means of a thermometer, which has been inserted through an air-tight cork into the metallic receptacle, and when the proper quantity of mixture has been made, measure the Residuum of Chloroform left in the receptacle, by means of the Burette, and read off the deficiency, which of course represents whatever quantity has been actually displaced by the absorbtivity of the passing air during the process; ascertain now by reference to Table 7 what percentage corresponds to your own practical temperature, and then, by referring to Table 11 find the quantity of Chloroform required for a cubic foot of mixture at that percentage; now if the comparison shows, that the quantity required, is identical with the quantity, that the air has actually removed from the receptacle, that result will prove the accuracy of this expedient. Any leakage would alter the result.

Practical temperatures, and their percentages, are affected by the action of the Apportionator in the following ratios:

No. 1 on the quadrant represents a reduction of 20 degrees whose mean is 10 degrees for a cubic foot; and No. 10 represents a reduction of 2 degrees whose mean is 1 degree. The mean temperatures then represented by the numerals are:

No. 1—10° Fahr ; No. 2—5° Fahr. : No. 3—$3\frac{1}{3}$° Fahr. ; No. 4—$2\frac{1}{2}$° Fahr. ; No. 5—2° Fahr. ; No. 6—$1\frac{2}{3}$° Fahr. ; No. 7—$1\frac{3}{7}$° Fahr. ; No. 8—$1\frac{1}{4}$° Fahr. ; No. 9—$1\frac{1}{9}$° Fahr. ; and No. 10—1° Fahr. See Table 4. The corresponding percentages appear on Table 7.

Except as satisfaction for those practitioners who desire to know how I got those results, it was not necessary to give the foregoing explanation, for I have worked out a simple and ready rule which has the advantages of being easily remembered, easily worked, it gives accurate results, and puts into operation all that it has taken me so long to make clear. **My rule is: Deduct 10° Fahr. from the temperature of the room, note the percentage of this the mean temperature, then divide that percentage by any percentage that you may require, and place the indicator at that number on the quadrant which represents the product thus found.** For example: Suppose the temperature of the room is 70° Fahr. the mean temperature will be 60° Fahr., and the percentage of Chloroform vapour peculiar to 60° Fahr. is 12 per cent. ; now if a mixture containing 3 per cent. is wanted, divide 12 by 3—3 ÷ 12 = 4, and place the pointer at No. 4 on the quadrant. See

Table 11.

Quantity of Chloroform per Cubic Foot of Mixture.

	Correct Quantities.	Practical Quantities.
1 per cent. of Vapour equals	16·615 Mins.	♏ 16
2 ,, ,, ,,	33·230 ,,	♏ 33
3 ,, ,, ,,	49·845 ,,	♏ 49
4 ,, ,, ,,	66·460 ,,	ʒ1 ♏ 6
5 ,, ,, ,,	83·075 ,,	ʒ1 ♏ 23
6 ,, ,, ,,	99·690 ,,	ʒ1 ♏ 39
7 ,, ,, ,,	116·305 ,,	ʒ1 ♏ 56
8 ,, ,, ,,	132·920 ,,	ʒ2 ♏ 12
9 ,, ,, ,,	149·535 ,,	ʒ2 ♏ 29
10 ,, ,, ,,	166·150 ,,	ʒ2 ♏ 46
11 ,, ,, ,,	182·765 ,,	ʒ3 ♏ 2
12 ,, ,, ,,	199·380 ,,	ʒ3 ♏ 19
13 ,, ,, ,,	215·995 ,,	ʒ3 ♏ 36

Table 5 Theoretical Temperatures and Percentages		Table 6. Practical Temperatures. Quadrant Index Numbers.										Table 7. Practical Percentages (OF CHLOROFORM.) Quadrant Index Numbers.									
Fahr.	Per cent.	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
80°	26	70	75	76⅔	$77\frac{1}{2}$	78	78⅓	$78\frac{1}{2}$	$78\frac{3}{4}$	$78\frac{8}{9}$	79	19	$9\frac{1}{2}$	$6\frac{1}{3}$	$4\frac{3}{4}$	$3\frac{4}{5}$	$3\frac{1}{6}$	$2\frac{5}{7}$	$2\frac{3}{8}$	$2\frac{1}{9}$	$1\frac{9}{10}$
75°	22	65	70	71⅔	$72\frac{1}{2}$	73	73⅓	$73\frac{1}{2}$	$73\frac{3}{4}$	$73\frac{8}{9}$	74	15	$7\frac{1}{2}$	5	$3\frac{3}{4}$	3	$2\frac{1}{2}$	$2\frac{1}{7}$	$1\frac{7}{8}$	$1\frac{2}{3}$	$1\frac{1}{2}$
70°	19	60	65	66⅔	$67\frac{1}{2}$	68	68⅓	$68\frac{1}{2}$	$68\frac{3}{4}$	$68\frac{8}{9}$	69	12	6	4	3	$2\frac{2}{5}$	2	$1\frac{5}{7}$	$1\frac{1}{2}$	$1\frac{1}{3}$	$1\frac{1}{5}$
65°	15	55	60	61⅔	$62\frac{1}{2}$	63	63⅓	$63\frac{1}{2}$	$63\frac{3}{4}$	$63\frac{8}{9}$	64	10	5	$3\frac{1}{3}$	$2\frac{1}{2}$	2	$1\frac{2}{3}$	$1\frac{3}{7}$	$1\frac{1}{4}$	$1\frac{1}{9}$	1
60°	12	50	55	56⅔	$57\frac{1}{2}$	58	58⅓	$58\frac{1}{2}$	$58\frac{3}{4}$	$58\frac{8}{9}$	59	8	4	$3\frac{2}{3}$	2	$1\frac{3}{5}$	$1\frac{1}{3}$	$1\frac{1}{7}$	1	$\frac{8}{9}$	$\frac{4}{5}$
55°	10	45	50	51⅔	$52\frac{1}{2}$	53	53⅓	$53\frac{1}{2}$	$53\frac{3}{4}$	$53\frac{8}{9}$	54	7	$3\frac{1}{2}$	$2\frac{1}{3}$	$1\frac{3}{4}$	$1\frac{2}{5}$	$1\frac{1}{6}$	1	$\frac{7}{8}$	$\frac{7}{9}$	$\frac{7}{10}$
50°	8	40	45	46⅔	$47\frac{1}{2}$	48	48⅓	$48\frac{1}{2}$	$48\frac{3}{4}$	$48\frac{8}{9}$	49	6	3	2	$1\frac{1}{2}$	$1\frac{1}{5}$	1	$\frac{6}{7}$	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$
45°	7	35	40	41⅔	$42\frac{1}{2}$	43	43⅓	$43\frac{1}{2}$	$43\frac{3}{4}$	$43\frac{8}{9}$	44	5	$2\frac{1}{2}$	$1\frac{2}{3}$	$1\frac{1}{4}$	1	$\frac{5}{6}$	$\frac{5}{7}$	$\frac{5}{8}$	$\frac{5}{9}$	$\frac{1}{2}$
40°	6	30	35	36⅔	$37\frac{1}{2}$	38	38⅓	$38\frac{1}{2}$	$38\frac{3}{4}$	$38\frac{8}{9}$	39	4	2	$1\frac{1}{3}$	1	$\frac{4}{5}$	$\frac{2}{3}$	$\frac{4}{7}$	$\frac{1}{2}$	$\frac{4}{9}$	$\frac{2}{5}$
35°	5	25	30	31⅔	$32\frac{1}{2}$	33	33⅓	$33\frac{1}{2}$	$33\frac{3}{4}$	$33\frac{8}{9}$	34	3	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{3}{5}$	$\frac{1}{2}$	$\frac{3}{7}$	$\frac{3}{8}$	$\frac{1}{3}$	$\frac{3}{10}$

Tables 5, 6, and 7. The Apportionator will then automatically formulate a mixture which contains exactly 3 per cent. of the vapour. This rule is reliable, and its accuracy may be proved by measurement in the Burette, as already explained.

Directions for . . . using the Stationary Anæsthetiser.

Having described the construction of my Anæsthetisers, I will show how they should be used. Commencing with directions for using the Stationary Anæsthetiser, I may remark that the residual atmosphere always takes up that percentage of Chloroform, or Ether, which is peculiar to the temperature of the room (see Table 3), as, owing to the large surface of Thermal conductivity it presents to the external atmosphere; the causation of cold by Volatility is wholly compensated. It will be remembered that according to physical law, the compression of a saturated atmosphere into half its normal volume by means of a piston or plunger, condenses into liquid form, half the quantity of vapour which the air had absorbed; such however is not the case when an extra atmosphere is substituted for the plunger; for if 15lbs. of air be pumped into the Anæsthetiser, no liquid can be withdrawn, because the added volume of air has taken up all the vapour which mechanical pressure would have condensed. This action, then, lowers the percentage to the extent of one-half, another 15 lbs. reduces the percentage to $\frac{1}{3}$, another 15 lbs. reduces the percentage to $\frac{1}{4}$, another 15 lbs. reduces the percentage to $\frac{1}{5}$, another 15 lbs. reduces the percentage to $\frac{1}{6}$; this stage of dilution having been attained whenever the hand on the pressure gauge points to 75 lbs. It will be observed in the above example that 75 lbs. of air has been actually pumped into the cylinder; but that is a task which is neither necessary, nor expedient, for it is obvious that if 15 lbs. only were pumped in, and the resulting atmosphere were passed through the Apportionator when its pointer indicates No. 3, an atmosphere containing precisely 2 per cent. would be automatically and accurately formulated, and the expenditure of time and physical energy necessary for pumping 60 lbs. of air would be thereby averted.

A saturated atmosphere may be formed either by pouring into the cylinder the saturation quantity indicated by the temperature of the rooms (see Tables 3 and 8), or by introducing any excess of Chloroform, and afterwards withdrawing the residuum through the syphon when the air has become saturated; before opening the syphon, however, the pressure

Table 8. CHLOROFORM.

Calculated Table for measuring out charges of C H Cl_3 for all strengths of mixtures of from 1—26♏ % for the Stationary Anæsthetiser, the capacity of which is 3 gals. 1 qt. 4 ozs. or 908·075 cubic inches.

A 1%	Mixture	requires	9·08075♏ =		♏ 9
,, 2%	,,	,,	18·16150♏ =		♏ 18
,, 3%	,,	,,	27·24225♏ =		♏ 27¼
,, 4%	,,	,,	36·32300♏ =		♏ 36⅓
,, 5%	,,	,,	45·40375♏ =		♏ 45½
,, 6%	,,	,,	54.4850♏ =		♏ 54½
,, 7%	,,	,,	63·56525♏ =	ʒi	♏ 3½
,, 8%	,,	,,	72·62600♏ =	ʒi	♏ 12½
,, 9%	,,	,,	81·72675♏ =	ʒi	♏ 21¾
,, 10%	,,	,,	90·80750♏ =	ʒi	♏ 30¾
,, 11%	,,	,,	99·88825♏ =	ʒi	♏ 40
,, 12%	,,	,,	108·96900♏ =	ʒi	♏ 49
,, 13%	,,	,,	118·04975♏ =	ʒi	♏ 58
,, 14%	,,	,,	127·13050♏ =	ʒii	♏ 7
,, 15%	,,	,,	136·19125♏ =	ʒii	♏ 16
,, 16%	,,	,,	145·252♏ =	ʒii	♏ 25¼
,, 17%	,,	,,	154·35275♏ =	ʒii	♏ 34⅓
,, 18%	,,	,,	163·4525♏ =	ʒii	♏ 43½
,, 19%	,,	,,	172·52425♏ =	ʒii	♏ 52½
,, 20%	,,	,,	181·61500♏ =	ʒiii	♏ 1½
,, 21%	,,	,,	190·69575♏ =	ʒiii	♏ 10½
,, 22%	,,	,,	199.77650♏ =	ʒiii	♏ 20
,, 23%	,,	,,	208·85725♏ =	ʒiii	♏ 29
,, 24%	,,	,,	217·938♏ =	ʒiii	♏ 38
,, 25%	,,	,,	227·01875♏ =	ʒiii	♏ 47
,, 26%	,,	,,	236·0995♏ =	ʒiii	♏ 56

caused by volatilization of the narcotic, should be allowed to escape by removing the large screw plug, because the full degree of saturation, is not attained until that pressure has been removed. Whether the excess of Chloroform is withdrawn, or allowed to remain, the percentages peculiar to different *rising pressures* are identical, *diminution of percentage proceeds* alike in both cases, *as* air is being pumped in, and the *pressure increases*, but it is different when diminution of pressure follows, *for as volatility is inversely to pressure, percentage uniformly increases, as pressure, decreases*, if an excess of Chloroform be present.

It has already been shown that at the temperature of 60° Fahr. 12 per cent of vapour is taken up by the residual atmosphere of the Anæsthetiser, and that percentage diminishes as the pressure rises, until at 75 lbs. the atmosphere only contains the proportion of two per cent. That percentage, of course, could not increase on diminution of pressure, if the excess of Chloroform had been withdrawn; but if sufficient excess has been allowed to remain, then *the percentage rises* by a simple inverse ratio *as pressure falls*, for if 75 lbs. represent 2 per cent. then 60 lbs. would represent 2⅔ per cent., 45 lbs. would represent 3 per cent., 30 lbs. would represent 4 per cent., 15 lbs. would represent 6 per cent., 7½ lbs. would represent 8 per cent., 5 lbs. would represent 9 per cent. and 1½ lbs. would represent 11 per cent.

This latter example illustrates an automatic, gradual, and precise increase in the strength of the aeriform mixture, whose high percentages indicated by pressures, ranging below 30 lbs. may be diluted to any desirable extent by the Apportionator; for instance, an 8 per cent. atmosphere passed through the Apportionator when its pointer indicated No. 8 would become 1 per cent., No. 4 would indicate 2 per cent., No. 2 would indicate 4 per cent., and so on. See Tables 1 and 2.

Instead of charging the cylinder by pumping air into it, it may be charged with Nitrous Oxide by simply allowing the gas to flow in from any ordinary gas bottle which has been connected with the tap at the back of the Anœsthetiser, the quantity passing in being indicated by the pressure guage, which also serves to show the quantity of gas that has been consumed, from the Anæsthetiser, during an operation. This purpose is achieved by placing the set hand, opposite the indicator, at the commencement of each operation, and reading off the pounds, appearing between the set hand, and the *receded indicator*, at the close of each operation. It is now self-evident, that if Chloroform, or Ether, is put into the apparatus before introducing the gas, proportions of the narcotic will be absorbed by the gas, and the percentages of such mixtures could be easily predetermined, and controlled, by reference to a thermometer, and the pressure guage, in the manner already described on page 72 and page 73.

Mixtures composed of Nitrous Oxide and Oxygen, may be accurately formulated, by adjusting their relative pressures, according to the proportions required. This may be easily accomplished by first introducing the Nitrous Oxide, and placing the set hand at the degree of pressure indicated by the other hand, and then introducing Oxygen until the travelling hand indicates that sufficient Oxygen, to complete the desired formula, has been added thereto, or vice versa. See page 41.

Table 9 shows the percentage of Oxygen, contained in different proportions of N + A which letters, may be understood as symbolical, either of mixtures composed of Nitrous Oxide and Air, or mixtures of Nitrogen and Air, (viz: De-Oxygenated Air plus Normal Air). These formulas may be easily and correctly made, either by pumping the required volume of air into the compressed N contained in the cylinder, or by passing the contents of the cylinder through the Apportionator, whose indicator has been placed at that number which represents the degree of dilution required. Mixtures of Nitrous Oxide plus Narcotics

Table 9.

Oxygen Starvation Anæsthesia.

N	+ A	equals	N	+ O	and equals	0	per cent.	
0	,, 1	,,	4	,, 1	,,	20	,,	(Residual)
1	,, 1	,,	9	,, 1	,,	10	,,	15 lbs.
2	,, 1	,,	14	,, 1	,,	$6\frac{2}{3}$	,,	30 ,,
3	,, 1	,,	19	,, 1	,,	5	,,	45 ,,
4	,, 1	,,	24	,, 1	,,	4	,,	60 ,,
5	,, 1	,,	29	,, 1	,,	$3\frac{1}{3}$	,,	75 ,,
$\frac{1}{2}$6	,, 1	,,	34	,, 1	,,	$2\frac{6}{7}$	,,	90 ,,
$\frac{1}{2}$7	,, 1	,,	39	,, 1	,,	$2\frac{1}{2}$	,,	105 ,,
$\frac{1}{2}$8	,, 1	,,	44	,, 1	,,	$2\frac{2}{9}$	,,	120 ,,
$\frac{1}{2}$9	,, 1	,,	49	,, 1	,,	2	,,	135 ,,
$\frac{1}{2}$10	,, 1	,,	54	,, 1	,,	$1\frac{9}{11}$	,,	150 ,,
$\frac{1}{4}$11	,, 1	,,	59	,, 1	,,	$1\frac{2}{3}$	,,	165 ,,
$\frac{1}{4}$12	,, 1	,,	64	,, 1	,,	$1\frac{7}{13}$	,,	180 ,,
$\frac{1}{4}$13	,, 1	,,	69	,, 1	,,	$1\frac{3}{7}$	,,	195 ,,
$\frac{1}{4}$14	,, 1	,,	74	,, 1	,,	$1\frac{1}{3}$	,,	210 ,,
$\frac{1}{4}$15	,, 1	,,	79	,, 1	,,	$1\frac{1}{4}$	,,	225 ,,
$\frac{1}{8}$16	,, 1	,,	84	,, 1	,,	$1\frac{3}{17}$	,,	240 ,,
$\frac{1}{8}$17	,, 1	,,	89	,, 1	,,	$1\frac{1}{9}$	,,	255 ,,
$\frac{1}{8}$18	,, 1	,,	94	,, 1	,,	$1\frac{1}{19}$	,,	270 ,,
$\frac{1}{8}$19	,, 1	,,	99	,, 1	,,	1	,,	285 ,,

and those of De-Oxygenated Air plus Narcotics, may be made by the rules prescribed on page 72 for mixing various proportions of Air Narcotic vapours. The percentages of these saturated atmospheres will be identical with those appearing on Table 3, and with those appearing on table 1, when the Apportionator is used to effect dilution.

Marston's Terminals.

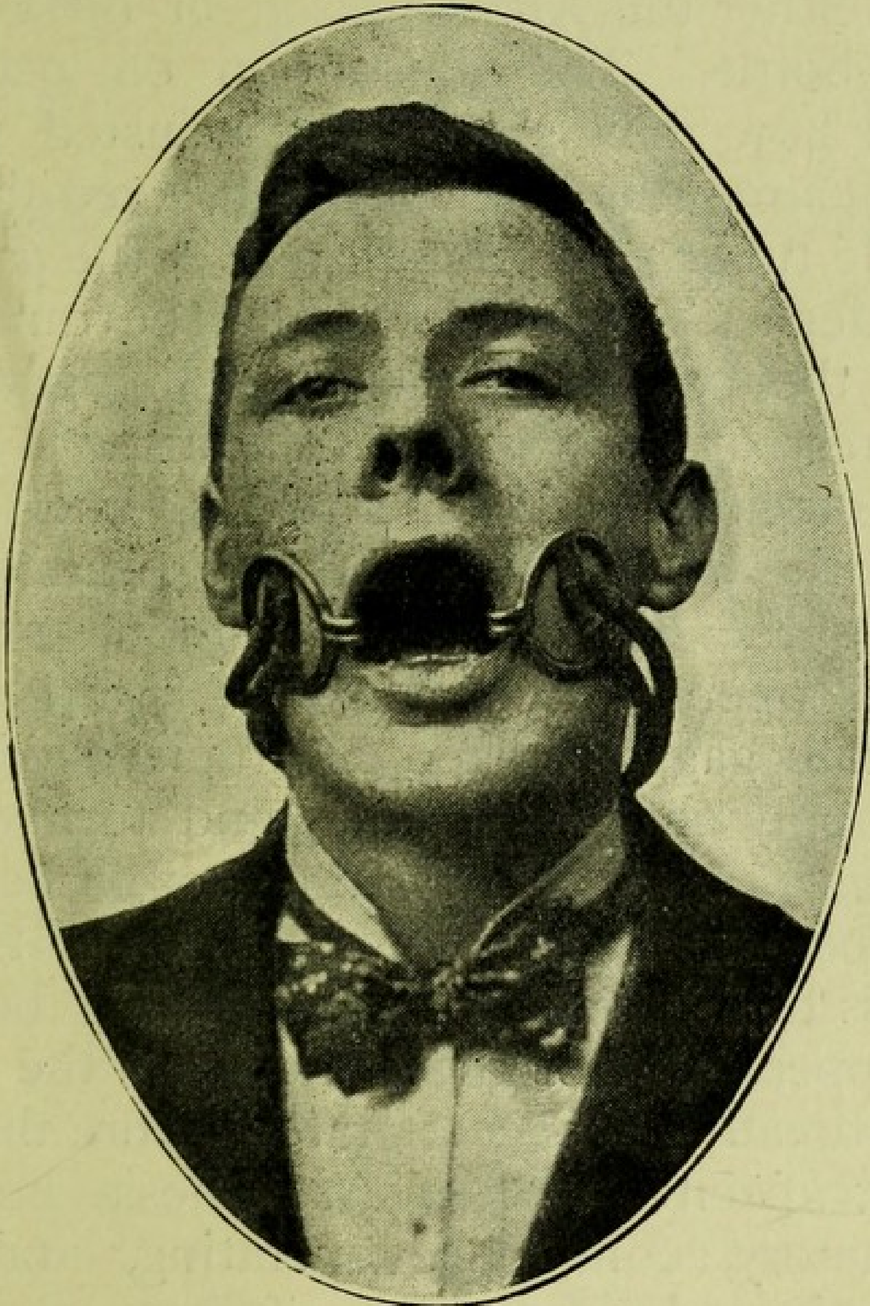
Description and Directions for use.

My Patent includes all bent tubes, single or double, having one or more oral outlets, and one or more facial inlets. Each of the Terminals illustrated on page 79 consists of two separate tubes, externally joined together, so as to form a large facial ring, and a small oral-buccal ring. These rings communicate with each other, through a double labial curve ; which passes round the angle of the lips, and embraces both sides of the cheek. This arrangement of the tubes affords self-retention, it presents a large surface of thermal conductivity, it protects the flesh from abrasion, it delivers the Anæsthetic during operations, without encroachment on the sphere of action, and in many ways it facilitates the dexterity of the operator, and enhances the safety, and comfort, of the patient.

A pair of terminals represents four tubes, which are separate throughout their entire length, and may be jointed up with their rubber tubes singly, doubly, one to three, or all together, for delivering different agents, separately at the same time, but it is not at all necessary to use them in that way.

The fact that these Terminals quickly cause Anæsthesia, unquestionably proves that they are capable of prolonging Anæsthesia until maintained resistance to the vital energies of the body culminates in the ultimate sequence of this physiological process, namely, death from exhaustion; a point beyond which I presume the excellence of no instrument could go. I emphasize this point because, even when narcosis has been produced before their very eyes, some practitioners have enquired how long could anæsthesia be prolonged; evidently forgetful of the fact, that it is more difficult to cause, than to maintain Anæsthesia. Who could say how long? It might be half-an-hour; an hour; or a day; it depends very much upon the condition of the patient, and in no less degree upon the skill of the administrator, but, however long the process could be continued, it is highly improbable that this mode of conducting Anœsthesia could ever supercede Chloroformization, or Etherization, in major surgical operations, for in such cases tranquility is an essential condition, and a brief return to consciousness might shock the patient so much as to cause death from fright or from reflex inhibition otherwise caused. The progressive stages towards recovery, from Chloroform Anæsthesia, are less rapid, and more definable, than those which follow Nitrous Oxide Anæsthesia ; indeed this gas is eliminated so rapidly from the blood, that any distraction, or relaxation of attentiveness on the part of the administrator, may without much premonition, result in a return to consciousness, **but for dental operations, however many the extractions that have to be made, the open method of Anæsthetising conducted by my Terminals, leaves nothing to be desired, the resultant Anæsthesia, is perfect, and may be continued far beyond the requirements of the most extensive of dental operations.** Yet it should be remembered that the point to be observed is not so much *How long can Anæsthesia be continued ;* as *How soon can the operation be satisfactorily completed.* I am of opinion, that it is safer to make a large number of extractions under one such administration ; than it is to extract a few teeth under Anœsthesia produced by inhaling the gas from a face-piece. The question of hœmorrhage does not necessaaily arise as a deterrent, for bleeding can always be arrested,

MARSTON'S TERMINALS



IN USE.

however distinctly typical of the hœmorrhagic diathesis the case may be, but the fact that all such cases of predisposition to excessive bleeding, need prompt, and careful treatment, must not be regarded with indifference. These Terminals may receive their supply from, either the Anæsthetiser, or direct from a gas-bottle. The illustration on page 79 shows how they should be adjusted to the patient's mouth. It will be observed that the flexible tubes pass backward over the patient's shoulders. These tubes must be quite free when the patient's head is reclining on the head-rest of the chair. An adjustable elastic band connects the Terminals, and passes round the back of the patient's head. After placing the Terminals in position, prop the mouth open with, preferably, a fork ended vulcanite gag, attached to a piece of cord, then apply the nose-clamp, and turn on the gas, until the inspiratory intake of air becomes imperceptible. Now place the right hand acrosss the patient's mouth, leaving between the upper edge of the hand, and the upper lip, a breathing space of rather more than the nasal capacity. When Anæsthesia becomes satisfactory, commence operating, and continue the administration of gas until the operation is finished. Any appearance of cyanosis indicates that too much gas is being delivered. The gas pressure must be uniformly maintained, as any interruption of supply, will occasion an intake of air, which will neutralize the effect of whatever quantity of gas has been inhaled, but a little experience enables one to regulate the flow of gas, by observing the size of the Balloon during distension.

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DIRECTIONS FOR USING the Portable Anæsthetiser.

When about to charge the apparatus for an operation, first connect all its parts, and place the Anæsthetiser on the floor; then having removed the cap, introduce two or three ounces of Chloroform into the tank, and replace the cap, *which must then be most carefully screwed home, in order to prevent leakage of vapour;* this done, note the temperature of the room, and refer to Table 6, which contains all the practical temperatures represented by each numeral on the quadrant; next refer to Table 7, which displays all the corresponding percentages; for instance, if the temperature of the room is 60° Fahr. and the pointer is placed at No. 10 on the quadrant it is clear that the mean temperature will be 59° Fahr., and No. 10 on Table 7 shows that the vapour tension peculiar to that temperature is $\frac{4}{5}$ per cent; another glance at Table 6 will discover that if the pointer were placed at No. 6 the practical temperature would be $58\frac{1}{3}$ Fahr., and Table 7 shows that No. 6 indicates $1\frac{1}{3}$ per cent. of Chloroform vapour. Again, Table 6 shows that the pointer placed at No. 3 would indicate $56\frac{2}{3}$ Fahr. as being the practical temperature and it may be seen on Table 7 that $3\frac{2}{3}$ per cent. is the proportion of Chloroform vapour being formulated. Again, Table 6 shows that the pointer when placed at No. 2, indicates 55 Fahr. as being the practical temperature, and Table 7 shows that its corresponding proportion of vapour is 4 per cent. What has been already said makes it unnecessary for me to proceed further with these examples. *Instead of using those Tables, the Rule prescribed on page* 66, *may be applied, for achieving the same purpose*, thus: First ascertain the temperature of the room—if it is 60° Fahr. deduct the before-mentioned 10° Fahr. and call it 50° Fahr. whose vapour tension the Volatility Table 5 shows is 8 per cent.; now if 4 per cent. is the proportion of vapour required, divide the 8 by 4, and place the pointer at No. 2, which both represents the product of the calculation, and works out the correct percentage. If 2 per cent. is preferred, divide the 8 by 2 and place the pointer at 4. If 3 per cent. is required, divide the 8 by 3 and place the pointer at $2\frac{2}{3}$.

When the number that works out the required percentage, has been discovered by one of these methods, place the pointer at that number, then turn on the large tap, and commence blowing with the foot blower, being careful to keep the pulsating bag at least half distended (without intermission) and continue doing so until the square bag has become filled, but not so much as to stretch the cloth very tight; then turn off the tap, to prevent any more air passing from the pulsating bag to the Chloroform, and immediately afterwards put the pointer back to that peg which stands beside No. 1, in order to prevent waste by escapement of the mixture, through the vents, when the Apportionator is not working. If, when the contents of the square bag have been inhaled, more mixture is required, re-adjust the pointer to the same number, turn on the tap, and repeat the blowing until a sufficient volume has been formulated, then quickly turn off the tap, and put back the pointer to prevent waste, as before.

Instead of pursuing this course; which, however, is the best and most economical way, the Apportionator and air tap may, after proper adjustment, be left untouched during the whole period of the operation; and the mixture instead of being made by the bag full at a time, may be supplied in small quantities at intervals, as inhalation may require, precaution should be taken to keep the bag at least half full all the time; but it is self-evident that the adoption of this plan entails leakage from the square bag, by a return flow through the vents of the Apportionator, during the periods of cessation of action, which separate these successive and irregular operations of blowing.

After using the Apparatus, and before returning it to its leather case, all the residuum of Chloroform, must be carefully withdrawn through the small tap, provided for that purpose, at the bottom of the tank. It will now be seen that the Chloroform has become changed in appearance, owing to the presence of foreign matter which it has filtered out of the passing air during the operation; experience has proved that this appearance does not indicate any deterioration of the drug, so far as that relates to its physiological action.

The Physiological Action of Anœsthetics.

Oxygen and Nitrogen.

A safe Anæsthetic never has, and in all probability never will, be known to man. Any agent incapable of neutralizing, diverting, or suspending neurotic functions, would lack the essential quality of an Anæsthetic, and it should be remembered, that neurotic functions are the fundamental principles causative of all the phenomena of life. It is the varying intensity of nervous energy that variously groups in health, and disease, all the vito-chemical equations of the human economy. It is nervous energy that fabricates those normal or abnormal chemical products, into the complexity of tissues composing the body, and tints the fabrication with the hues of health, or the diagnostics of disease. Nervous functions control all the involuntary, and voluntary motions of the organism, therefore no agent possessing the power to swerve these subtle influences, from their original intention, can, consistently with common knowledge, be called safe.

Atmospheric air ceases to be a supporter of life, whenever the ratio of its constituents has been considerably altered, and the physiological action of its dissociated elements may be regarded as distinctly foreign to that of common air.

Oxygen, the reputed vital principle of atmospheric air, Anæsthetises at temperatures above and below those of the atmosphere. When inhaled under pressure Oxygen Anæsthetises, and ultimately causes convulsions. Dr. Richardson kept a rabbit in Oxygen, for three weeks, but although it ate voraciously, it could not assimilate sufficient nutriment, to compensate the inordinate consumption of the tissues of its body, presumably caused by acceleration of respiratory changes, and on that account the experiment had to be discontinued. He verified too, what had previously been observed, viz., that Oxygen when breathed over and over again, soon becomes, not only incapable of supporting life, but distinctly poisonous. This was not owing to the presence of Carbonic Acid, for he assures us, that gas had been removed by passing the current through Caustic Alkali., He thought at first the Oxygen itself had undergone a physical change.

A good deal of interest surrounds that respiratory product, and it is unfortunate for Anæsthetists, that no one seems to have followed up the enquiry, which displays, as an accidental occurrence, a most important physiological fact. Dr. Richardson discovered that an electric spark had power to revivify, devitalized Oxygen, and that flesh placed in it quickly underwent decomposition. Now, however impossible, and absurd, the supposition may appear at first sight, when viewed from a theoretical standpoint, there is only one allotropic form of Oxygen known, that could attack organic matter so energetically, viz., O_3, but the electrical phenomenon which Dr. Richardson observed, seems to negative the supposition that would identify this respiratory product as Ozone ; for although an electric spark sent through a high percentage of Ozone, would generally split up its molecules, it could not remove its presence: on the contrary, an electric spark sent through Oxygen would create a percentage of Ozone; beside this, it is very improbable that the irritating action of Ozone, in the quantity indicated, could have escaped his notice. Could the product have been a percentage of Carbonic Oxide CO? I know this assumption is as theoretically absurd as the other, but sometimes apparently well-grounded theories are unceremoniously upset by the accidental appearance of antagonistic facts, and in this instance we have the appearance of a fact which, on the face of things, seems to have puzzled so great a mentality as Dr. Richardson. The probability is, that he satisfied himself, concerning the identity of the cause of this change, and that the startling nature of the result of this enquiry, indicated to him, the prudence of merely explaining to other physiologists the nature and conduct of the experiment, and then leaving them to work out for themselves the sequel and its significance. When the experiment is closely followed, there seems to be little cause to doubt, that a percentage of carbon monoxide, which the caustic alkali could not remove during the washing of the respired Oxygen, was solely accountable for the change alluded to, nor is the cause of its presence altogether obscure, for if every vital process, whether development, plastic, secretory, dynamic, or nutritive, is absolutely dependent on a free and immediate supply of air, containing one-fifth of Oxygen, it cannot be unreasonable to suppose, that these vital processes would be inordinately stimulated by the inhaling of undiluted Oxygen, and as exalted, depressed, and normal, degrees of nervous energy, variously group chemical affinities, there cannot be any adequate reason for supposing it is impossible that a percentage of CO could be found in the eliminated products of respiration, when undiluted Oxygen is being breathed ; nor could it be maintained that CO in the presence of an excess of Oxygen, would be converted into CO_2, for the increasing emaciation of the rabbit, notwithstanding its voracious consumption of food, proves that oxidisation was proportionate to the quantity of Oxygen absorbed by the blood ; therefore there could be no systemic excess of Oxygen.

It may be contended that CO would not attack flesh more energetically than Oxygen does ; but we have to remember, that the atmosphere of a laboratory furnished with an electrical machine, which is frequently used for experimental purposes, might be quite capable of hastening the putrefaction of flesh, without an intentional application of electricity ; for any percentage of ozone would act in that way.

The electrical phenomenon observed by

Dr. Richardson, proves, that the product was not Carbonic Anhydride, for CO_2 in that circumstance could not have been split up by the spark. On the other hand, when we consider that the toxic power of Carbon Monoxide, is so intense that an atmosphere containing so small a proportion as 2 per cent. will kill a guinea-pig in two minutes; it will be seen, that the growing effect of the specific action of its merest presence, could not have escaped the renowned alertness of Dr. Richardson, although its effect, failed to individualize its cause; and the electrical treatment to which he subjected his devitalized Oxygen would, in the presence of a superabundance of Oxygen, undoubtedly convert the Carbon Monoxide, into Carbonic Anhydride, $CO + O = CO_2$, whose necessarily small percentage from this cause, could not perceptibly assert its inherent power in the presence of a respiratory excess of Oxygen.

If this theory explains the processes of "Devitalization" and "Revivication" of respired Oxygen, it also points to a physiological fact, the importance of which is indicated by what is known of the paralysing power of Carbon-monoxide; the stability of Carbonic-oxide-hœmoglobin; and the possibility of this cause being obscured by its pigmental effect on the blood and tissues; even when its action culminates in death.

If the activity of respiratory movements, vary inversely as their effect on the blood, and Apnœa is that condition which indicates a systemic excess of Oxygen ; the operation of that law is as much a safeguard against an injurious supply of Oxygen; as is spasm of the glottis, which immediately cuts off the intrusion of Carbonic Acid, whenever its inhalation is attempted.

Nitrogen, the other constituent of air, is an inert gas which, mainly as a diluent, modifies the physiological action of Oxygen. It is a negative asphyxiant ; that is to say, it cannot narcotise the nervous centres ; nor paralyse the blood corpuscles, by direct specific action ; and owing to its comparative insolubility, and its indifference to the chemical principles of the circulatory system ; it cannot displace Oxygen in that particular way which distinguishes the behaviour of Carbon-monoxide, Chloroform, and other Toxic-Asphyxiants. Any increase in the proportion of Nitrogen contained in an inspired atmosphere, above the proportion found in common air, represents a corresponding deficiency of Oxygen (see table 9), and consequently a proportionate reduction of arterialization within the lungs. Any reduction from the normal quantity of Oxyhœmoglobin, in proportionto the volume of blood, causes a corresponding degree of Asphyxia, but the rapidity of the process, and the distinctness, and severity, of its effects depend upon whether Asphyxiation is proceeding from a partial, or a complete displacement of Oxygen.

Asphyxial symptoms, consequent on closure of the glottis from any cause; are not identical with those arising from the use of Nitrogen containing variable proportions of air; for in this case the lungs are always satisfied with air, although the blood is not satisfied with Oxygen; whereas in cases where obstruction of the glottis hermetically seals up the air tract, there is exhaustion and other risks consequent on the frightful amount of nervous energy and muscular force, that is spent in an effort to remove the laryngeal obstruction, and restore the mechanical performance of the respiratory mechanism.

Pure Nitrogen (without an admixture of air or Oxygen) like Nitrous Oxide; is capable of causing all the symptoms of suffocation, and completing the process in death, if, regardless of the horrid symptoms which would supervene, its action was wilfully pushed to that extreme. The terms "Internal-Asphyxia," "Systemic-Asphyxia," and "Oxygen-Starvation," have been severally associated with the external evidences of its advanced stages, to designate that form of Asphyxia which ensues when there is no obstruction of any kind in the air tract.

It has long been known that Nitrogen is not a respiratory poison, and that when inhaled it causes Asphyxia by displacing atmospheric Oxygen, but the most important significance of that fact has not been recognised either by physiologists or Anæsthetists. Many years ago I arrived at the opinion that the physiological action of Nitrous Oxide is merely an Asphyxial process, and that the intermediate stage which skill recognises as Anæsthesia, is Asphyxial coma, characteristic of that peculiar mode of conducting Asphyxiation. My subsequent experiments with Nitrous Oxide and air, proved the possibility of getting results from these mixtures, identical with those obtainable from mixtures of Nitrous Oxide and manufactured Oxygen.

I next turned my attention to the production of Nitrogen, and my series of experiments included an instrument for producing Hydrated Ferrous Sulphide, through which finely divided atmospheric air was passed; also a powerful Ozonizer and supplemental means for dissolving the whole molecules of O_3, beside other devices, the products of which were tested on animal subjects.

A long time after, in the year 1895, I wrote an article expressing my reasons for supposing that Nitrous Oxide is a negative Asphyxiant, and that the practice of using Oxygen gas in preference to common air is unnecessary, unscientific, and indefensible from any standpoint of reasoning. About twelve months afterwards Mr. A. S. Aykroye quoted extracts from that article, in his paper read before the

Ontario Dental Association, and the proceedings of that meeting were reported in the "Dominion Journal," whence the report was copied into a later issue of "Items of Interest." I continued my experiments and ultimately patented the application of Atmospheric Nitrogen (De-oxygenated Air) as an Anæsthetic, and also the processes and means for making it. Since then I have, through the kindness of Dr. Thorne and the courtesy of Mr. Steele, Librarian of Burlington House, London, discovered that Sir George Johnson entertained the belief, that by administering Nitrogen through a face-piece it would be possible to produce symptoms identical with those which characterise the physiological action of Nitrous Oxide ; and his paper on the subject, which appears in the proceedings of the Royal Society, A.D. 1892, shows that three bottles of gas were made for his experiments. (I subsequently learned that this gas had been made by an inconvenient, comparatively expensive, and otherwise unsatisfactory process). The sequel to Dr. Johnson's experiments was that while he himself still adhered to the Asphyxial theory regarding Nitrous Oxide, and the possibility of using Nitrogen instead, if it could ever be made cheap enough to compete with the former ; those who assisted him in his experiments discredited his theory, and Dr. Hewitt who administered the gas in these experiments has, ever since, treated

Nitrous Oxide as a narcotic, whose weakness necessitates a large dose being administered at each inspiration, and as such a volume encroaches upon the supply of atmospheric Oxygen, and thereby causes suffocation, he admixes manufactured Oxygen to prevent that dilution, which he assumes, the Nitrogen of the atmosphere would effect, if air were admitted along with the Nitrous Oxide during inhalation.

Since then Dr. Hewitt's assertions relative to this subject, have maintained that an equivalent quantity of atmospheric air, could not be used, satisfactorily, as a substitute for manufactured Oxygen—an argument which obviously puts into a nutshell, his views, regarding the physiological action of Nitrogen, and that of Nitrous Oxide. This point will be further considered in my treatment of Nitrous Oxide. I find, too, that Dr. Dudley Buxton briefly refers to Sir George Johnson's experiments, which he contends were actuated by an error of judgment, and he attributes Sir George Johnson's tenacious adherence to the Asphyxial theory, to a misinterpretation of the evidences adduced by his experiments.

I believe that my Atmospheric Nitrogen will play an important part in the future practice of Anæsthetics ; but it is necessary to remember that its value as an Anæsthetic, depends upon the mode of administering it (see page 79). As it is not free from Helium, Argon, and Crypton, whose presence I regard as essential to the physiological functions of the body, I prefer to designate it by the term De-oxygenated Air. I may explain that this gas is freed from Carbonic Anhydride, as well as Oxygen, by processes which yield it in great abundance, and quite free from noxious contaminations.

As De-oxygenated Air possesses neither taste, nor smell, patients when breathing it from a face-piece, have the impression that the gas has not yet been turned on; and the interval preceding unconsciousness is described by patients, as being free from unpleasantness of any kind: recovery from this species of Anæsthesia is rapid and complete. Percentages of Nitrous Oxide broaden its workable zone. The terminals prolong Anæsthesia to any desirable extent.

Nitrous Oxide (N_2O).

Its Physiological Action, &c.

This gas was discovered by Priestley in 1772. In the year 1799 Davy discovered that this gas was capable of destroying sensibility, and he suggested its use as an Anæsthetic for surgical operations. In the year 1884 Davy's suggestion was put into practice by an American named Mr. Colton, who administered this gas to another gentleman of his own na tionality named Mr. Wells, for tooth extraction. Between that date and the year 1867 no less than 20,000 cases are reputed to have been successfully Anæsthetised with this agent. It is supposed that Nitrous Oxide was first compressed into cylinders in or about 1868. In the year 1878 Professor Paul Bert, believing that the toxic effects of gases upon living organism depended upon their tension when breathed, practised the method of administering mixtures composed of known quantities of Nitrous Oxide and Oxygen *under pressure.* In the year 1883 Bert discovered that identical results were obtainable from mixtures of these gases when administered at the common pressures of the atmosphere, *but his experiments had been limited to the lower animals.* Dr. Hillische, a dentist of Vienna, in 1886 put into practice Paul Bert's suggestion of administering to human subjects, suitable mixtures of these gases at ordinary atmospheric pressures. In that year Dr. Hewitt, of London, adopted Bert's method, and recognising the possibility of improving the apparatus then used, he began a series of experiments which resulted in the appearance of Hewitt's Nitrous Oxide and Oxygen apparatus, at a meeting of the British Dental Association, held at Newcastle-on-Tyne in 1884. The wide-spread popularity which its merits have won for this ingenious construction, makes any description of it unnecessary. Undoubtedly at one time it was the most convenient mixer of gases, and the most manageable of Anæsthetisers, but any claim to its accuracy must refer exclusively to those percentages which subsequent experiment had found to be the result of its operation when set at different notches, and could not refer to its structural plan, for it is impossible to predeterminate the Volumetric percentage of two gases of dissimilar density by means of such a mechanical contrivance. Its principle of construction, moreover, is based upon two assumptions—firstly, that air cannot be used as an equivalent for manufactured Oxygen; and secondly, that the whole quantity of the Anæsthetic should be administered before the surgical operation commences; but, a sense of moral duty rather than a spirit of boastfulness prompts me to say that both assumptions are erroneous, and may be effectually disproved by the action, and physiological effects, of my Terminals. As before stated, in January of 1895 I wrote to the "Items of Interest" an article expressive of my views regarding the physiological action of Nitrous Oxide, which I contended, characterised that gas as a negative Asphyxiant; and that mixtures of Nitrous Oxide and Oxygen possessed no advantage over mixtures of Nitrous Oxide and common air. Referring to the use of Oxygen, I observed that the then common practice of mixing manufactured Oxygen gas was indefensible from any standpoint of reasoning. The practice presupposes one of two things, viz., either that the admixed pure Oxygen enters into chemical relation with the constituents of Nitrous Oxide, to form a definite chemical compound, whose Anæsthetic character is more appreciable than that of Nitrous Oxide. Or else that the admixed pure Oxygen does not enter into chemical combination, but that its disseminated atoms are intended to continue the vito chemical changes of respiration during the supposed process of narcotization performed by its fellow component Nitrous Oxide: the latter plan being analagous to the mixing of air with Chloroform vapour; inasmuch as both methods aim at arterialising the blood, whilst the narcotic accumulates, and asserts its influence, over the human economy.

The first of these suppositions is easily disposed of, for any person possessing a slight knowledge of chemistry would know that any play of affinity between Oxygen and Nitrous Oxide within the lungs would cause death, as shown by the following equations:—One equivalent of Nitrous Oxide plus one atom of Oxygen equals two atoms of Nitric Oxide. Two atoms of Nitric Oxide plus one atom of Oxygen forms one atom of Anhydrous Nitrous Acid. One atom of Anhydrous Nitrous Acid plus one atom of Oxygen represents two atoms of Nitric Peroxide. Two atoms of

Nitric Peroxide plus one atom of Oxygen formulates one atom of Anhydrous Nitric Acid, therefore, to suppose the possibility of chemical union taking place between Nitrous Oxide and manufactured Oxygen, is but to anticipate the gruesome post-mortem evidences of corrosive poisoning.

On the other hand to believe that Nitrous Oxide is a narcotic, is to assume that it either plays the part of a Toxic compound radicle in the system, or else that its dissociated elements separately participate in the play of Vito-Chemical affinities, but if Nitrous Oxide disported itself as a Toxic compound radicle its narcotic power would assert itself in the manner that distinguishes all agents of this class, although air were *freely admitted* with it to the lungs. A result, however, which practitioners know it is impossible to obtain. And if Nitrous Oxide became chemically split up during Corpuscular changes, arterialization of the blood would, in that case, ensue with abnormal energy, owing to the greater proportion of Oxygen, which Nitrous Oxide, $N_2 0$, contains, as compared with the proportion of Oxygen present in common air $N_4 + 0$. That this arterialization does not take place, is proved by the characteristic lividity of gas patients, and other evidences. It may be urged in opposition to this view that the direct specific action of Nitrous Oxide has been mentioned by standard authorities of the past, and also by more recent eminent authors, and, moreover, is easily demonstrable ; replying to such an objection, I would first admit that the so-called hilarious effect of Nitrous Oxide upon the nervous system is demonstrable, and then dispute the reputed cause.

We have to remember, that this peculiar manifestation depends on the joint action of air, or its equivalent, intentionally, or accidentally, administered along with the Nitrous Oxide, and that the so-called Anæsthesia, following Nitrous Oxide inhalations, depends on the exclusion of air, or its equivalent, from the lungs during its administration. It is impossible, therefore, by any stretch of reason to show that this hiliarity, results from the direct specific action of Nitrous Oxide on the brain, and nervous system ; and the fact that pure Nitrous Oxide, free from available Oxygen, is incapable of causing it, is quite as easily demonstrable.

It may be urged that Nitrous Oxide Anæsthesia may be produced without causing deep discolouration, which I readily admit, but that fact should be viewed in the light of others, viz. :—

1st.—The rapidity of Anæsthetising with Nitrous Oxide corresponds with the rate at which Cyanosis shows itself in the patient.

2nd.—The passage of the *whole volume* of blood through the heart and lungs occupies about four minutes, and a uniform *partial* displacement of the oxygenated atmosphere, conducted throughout the whole of that period, produces a better result than a total displacement of air, and consequent total reduction of the hæmoglobin of that portion of the blood, which passes through the lungs in periods of shorter duration. It follows then without saying, that atmospheric air is a better diluent of Nitrous Oxide than manufactured Oxygen.

Dr. Hewitt informs us the duration of the available Anæsthesia obtainable from inhaling suitable mixtures of Nitrous Oxide and Oxygen from his apparatus is about 44 seconds, but in some cases when the patient has been allowed to breathe the mixture for three minutes, he has been able to secure an available Anæsthesia of 50, 60, or even 70 seconds, whereas, *the continuous administration of Nitrous Oxide and air conducted by my Terminals, before and during the operation, produces an Anæsthesia that might be prolonged for perhaps half-an-hour, an hour, or a day*, no one knows, and it would be a supreme act of folly if any dental surgeon ever attempted to find out how long the vital endowments of the body could sustain life under this condition. It is sufficient to know there is no further necessity for Chloroform, or Ether, in dental operations; even if thirty extractions had to be made. During this kind of Anæsthesia the appearance of the patient is normal.

Dr. Hewitt, in his excellent work on Nitrous Oxide and Oxygen administration, remarks "one cannot help being struck by the singular vicissitudes which this agent (Nitrous Oxide) has experienced. That a quarter of a century, should have passed between its discovery by Priestley, and the recognition of its pain-relieving properties by Davy, is sufficiently remarkable. But more curious still is the fact that nearly double this length of time elapsed between Davy's observations and the first administration of the gas for a surgical operation." But I ask, Are those facts more remarkable than the attitude of some Anæsthetists towards Anæsthetics to-day which is fifty-five years later?

Nitrous Oxide plus Narcotics.

When Nitrous Oxide is administered first, and the operation is subsequently continued with Chloroform, or Ether, the resulting Anæsthesia, in that circumstance, is not the effect of the joint action of Nitrous Oxide and the Narcotic; it is purely the effect of the Narcotic, the effect of Nitrous Oxide, having been previously removed by atmospheric Oxygen during inhalation of the Narcotic.

An instance bearing upon this point was related to me by a physician some time ago. After expressing his concurrence, in my opinion which he had seen in a journal, he quoted a case in proof. He had arranged to Anæsthetise a patient for a dental practitioner known to us both. The patient objected to Ether, and Chloroform, and insisted upon the administration of Nitrous Oxide. Both physician and dentist knew perfectly well, that gas would not enable them to accomplish that which the urgency of the case necessitated, and recognising the impossibility of assuaging the patient's fear, thought it consistent with his interests, and theirs, to administer Nitrous Oxide first, and then follow it up with Ether. Accordingly the patient was Anæsthetised, and at the proper moment the inhaler was substituted for the face-piece, but before the patient had inhaled sufficient Ether he had recovered from the gas, and suddenly seizing the inhaler with one hand, thrust it from him, at arms length, while he, ungrateful creature, hurled at his two flabbergasted benefactors, all the most impolite, and expressive adjectives he could command. There was the terrible patient holding the hateful inhaler in his hand, evidently suspecting a breach of faith on their part. How could they disabuse his mind—the thought occurred spontaneously, and they both, simultaneously, embraced their mentally over-wrought patient, soothed him with Chloroform, and completed the operation successfully. I am not quite sure that they proved to the patient, the incident was all a dream, a mere hallucination, but I was told he appeared to be delighted with the result. A more heroic use of Ether might have prevented this occurrence, but there is no doubt the administrator observed some peculiarity, which contra-indicated heroic exhibition in this case.

This example simply emphasises what has been reiterated, concerning the proneness of this method, which is obviously unnecessary, and now quite out of date, **since my Terminals ensure an available Anæsthesia of longer duration.** Therefore, I do not advocate the joint use, nor the consecutive use, of gas and Ether. When gas is considered to be improper, a safe Chloroform mixture should be used.

The True Physiological Action of Ether.

This agent is regarded as the safest of all Volatile Narcotics, but, whilst this opinion prevails, custom everywhere indirectly con-condemns its physiological action.

Those practitioners who urge, sometimes with enthusiasm, at other times with indignation, the claims of the advantages of Ether over those of Chloroform—the true physiological behaviour, and comparative merits of which, ordinary methods of administration never did, and never could, evince—always demonstrate the advantages of Ether, by administrative methods which, self-evidently, depend more upon Carbonic Acid poisoning, and true Asphyxiation, than upon the narcotic action of the drug ; in the earlier stages of the operation at any rate. Reference to Table 10 and page 44 shows the important part which auxiliary factors play in the causation of that phenomenon which custom, rather than common sense, has ascribed to the physiological action of Ether ; but which is distinctly foreign to the drug. "Let every tub stand on its own bottom." If Ether is the best Anæsthetic, surely it must be possible to prove its

Table 10.

ETHER ANÆSTHESIA.

Fahr.	Ether. Minims.	Ether Vapour. Cubic ins.	Air. Cubic ins.	Mixture Cubic ins.	Oxygen. Per cent.
50	64	52	100	152	13·815
51	66	54	100	154	13·636
52	69	56	100	156	13·461
53	72	59	100	159	13·207
54	76	62	100	162	12·9629
55	80	65	100	165	12·702
56	84	68	100	168	12·5
57	88	72	100	172	12:209
58	93	76	100	176	11·931
59	98	80	100	180	11·666
60	102	84	100	184	11·413
61	107	88	100	188	11·17
62	112	92	100	192	10·9375
63	117	97	100	197	10·659
64	122	102	100	202	10·396
65	128	107	190	207	10·144
66	134	112	100	212	9·905
67	140	117	100	217	9.677
68	147	123	100	223	9·412
69	156	130	100	230	9·13
70	165	138	100	238	8·823

advantages by fair methods, but all the phenomena characteristic of the customary methods of administering Ether, could be reproduced with less inconvenience by administering in the same way an atmosphere containing about $1\frac{1}{2}$ per cent. of Chloroform vapour.

One and a-half grains of ether in 100 cubic inches of air, is sufficient to cause the 2nd degree of Anæsthesia ; 3 grains of ether in 100 cubic inches of air, produces the 4th degree of Anæsthesia. Much larger proportions of ether are required to produce insensibility in a convenient time. Thirty per cent. of the vapour of ether being sometimes used, as such an atmosphere, Dr. Snow maintains, is without direct action on the heart. Recent statisticts, however, indicate that the liability to subsequent inflammation of the lungs, increases in a direct ratio with the proportion of ether vapour contained in the inhaled atmosphere.

Two drams 10 minims of ether absorbed into the blood of an average sized adult produces the 2nd degree of Anæsthesia ; 4 drams will produce the 3rd degree of Anæsthesia ; and 5 drams 40 minims is sufficient to cause the 4th degree of Anæsthesia.

The physiological action of Ether will be further considered under my treatment of Chloroform.

Chloroform.

Its Physiological Action, &c.

Chloroform, the sheet anchor of Anæsthetists, is the most abused of all known Anæsthetics. It is condemned on every hand, mainly *because when administered in unknown percentages, and unknown quantities, it sometimes causes unexpected results.* Dr. Snow has shown that *the danger of Chloroform* is *one of strength and quantity*, that it is as manageable as other poisons, when served out in proper doses, and that it is not the aggregate quantity administered to an individual, but the fractional proportion of that quantity, diffused with a proper volume of air, and inhaled at each inspiration, which determinates physiological intensity and effect. Dr. Snow, on several occasions, administered as much as seventeen ounces of Chloroform to a patient, and once he administered to the wife of a professional friend, as much as would have been equivalent to four pounds put on a napkin. Having discovered the *ratio of cause and effect*, he used Chloroform with confidence, in a way that would now be considered reckless and criminal. He tells us on page 249 of his work on Anæsthetics—"I have not myself declined to give Chloroform to any case in which a patient required to undergo a painful operation *whatever evidence of organic disease* I met with on careful examination, and although I have memoranda of upwards of four thousand cases in which I have administered this agent, I have not, I believe, lost a patient from its use."

On page 251 he says—"The first rule, therefore, in giving Chloroform, is to take care that the vapour is so far diluted *that it cannot cause sudden death.*" On page 89 he remarks—"If the precaution be taken to ensure that the air the patient breathes shall *never contain* more than *5 per cent.* of vapour, the pulse can never be seriously affected by the direct action of Chloroform." On page 250 he informs us—"If the person administering Chloroform, was always *quite sure* that the vapour did not constitute more than *5 per cent.* of the inspired air, *it is quite true* that the pulse might be wholly disregarded."

Chloroform when inhaled reaches every part of the nervous system, and it acts on every part of that system from the first. It does not, however, act equally on all parts of the nervous system according to the quantity which is absorbed. Some parts of that system have their functions entirely, or almost, suspended, whilst others are but little under the influence of the vapour. It is owing to this fact that the most severe pain may be prevented *without danger.*

Under **Chloroform** properly administered, as under **Ether,** the nervous centres lose their powers in regular succession :—

1st.—The Cerebral lobes lose theirs, viz., the intellect.

2nd.—The Cerebellum loses its, viz., the power of regulating locomotion.

3rd.—The spinal marrow loses the principles of sensitiveness, and of motion.

4th.—Loss of power in the medulla oblongata terminates life.

Even after breathing has ceased, the ganglionic nerves perform their functions in an effort to revive the principles of life, the heart, and intestines, continuing to move for a time, often with vigour.

Anæsthesia can only be safe when it proceeds slowly through the brain, but this direction of influence depends upon a sufficient dilution of the narcotic. An atmosphere containing 8 per cent. or more of Chloroform does not act in the last named manner ; it exerts a direct action upon the heart paralysing it, possibly before any degree of intoxication or insensibility has become perceptible. Dr. Snow ascertained that the degree of Anæthesia obtained, is proportionate to the degree of saturation of the blood serum. One grain of chloroform in 100 cubic inches of air, produces the second degree of Anæsthesia ; two grains of chloroform in 100 cubic inches of air, produce the third degree of Anæsthesia; three grains of chloroform in 100 cubic inches of air, produce the fourth degree of Anæsthesia; three grains of chloroform in 100 cubic inches of air, arrests respiration; if determinately continued, and 8 to 10 grains of chloroform in 100 cubic inches of air, may paralyse the heart by direct action.

The absorption of 12 minims of chloroform into the blood of an averaged sized adult, would produce the 2nd degree of Anæsthesia; 18 minims would cause the 3rd degree of Anæsthesia; 24 minims would cause the 4th degree of Anæsthesia; and 36 minims of chloroform would arrest respiratory functions.

The results of my physiological experiments, are not identical with those obtained by Dr. Snow, but I attribute the difference to the fact that he always submerged his animals in a stagnant medicated atmosphere, wherein the consumption of Oxygen and accumulation of respiratory products would affect the results of his experiments. My animals, on the contrary, have been treated with a current of medicated air, which removes all respiratory products; and according to my results, one-third of Chloroform must be added to each of Dr. Snow's quantities. Instead of 24 minims inhaled, representing 12 minims absorbed, I find that the absorption of 12 minims of Chloroform requires the inhalation of 36

Table 13. Chloroform Anæsthesia. Periods of Anæsthetisation.

	1st Degree. 12 Minims dissolved 36 ,, inhaled	2nd Degree. 18 Minims dissolved 54 ,, inhaled	3rd Degree. 24 Minims dissolved 72 ,, inhaled	4th Degree. 36 Minims dissolved 108 ,, inhaled
1 per cent. equals	9mins. 0secs.	13mns. 30secs.	18mins. 0secs.	27mins. 0secs.
2 ,, ,,	4 ,, 30 ,,	6 ,, 45 ,,	9 ,, 0 ,,	13 ,, 30 ,,
3 ,, ,,	3 ,, 0 ,,	4 ,, 30 ,,	6 ,, 0 ,,	9 ,, 0 ,,
4 ,, ,,	2 ,, 15 ,,	3 ,, 22½ ,,	4 ,, 30 ,,	6 ,, 45 ,,
5 ,, ,,	1 ,, 48 ,,	2 ,, 42 ,,	3 ,, 36 ,,	5 ,, 24 ,,
6 ,, ,,	1 ,, 30 ,,	2 ,, 15 ,,	3 ,, 0 ,,	4 ,, 30 ,,
7 ,, ,,	1 ,, 17 ,,	1 ,, 55 ,,	2 ,, 34 ,,	3 ,, 51 ,,
8 ,, ,,	1 ,, 7 ,,	1 ,, 41 ,,	2 ,, 15 ,,	3 ,, 22 ,,
9 ,, ,,	1 ,, 0 ,,	1 ,, 30 ,,	2 ,, 0 ,,	3 ,, 0 ,,
10 ,, ,,	0 ,, 54 ,,	1 ,, 21 ,,	1 ,, 48 ,,	2 ,, 42 ,,
11 ,, ,,	0 ,, 49 ,,	1 ,, 13 ,,	1 ,, 38 ,,	2 ,, 27 ,,
12 ,, ,,	0 ,, 45 ,,	1 ,, 7½ ,,	1 ,, 30 ,,	2 ,, 15 ,,
13 ,, ,,	0 ,, 41 ,,	1 ,, 2 ,,	1 ,, 23 ,,	2 ,, 4 ,,
14 ,, ,,	0 ,, 38 ,,	0 ,, 57 ,,	1 ,, 17 ,,	1 ,, 55 ,,
15 ,, ,,	0 ,, 36 ,,	0 ,, 54 ,,	1 ,, 12 ,,	1 ,, 48 ,,
16 ,, ,,	0 ,, 33 ,,	0 ,, 50 ,,	1 ,, 7 ,,	1 ,, 41 ,,
17 ,, ,,	0 ,, 31 ,,	0 ,, 47 ,,	1 ,, 3 ,,	1 ,, 31 ,, Profound Anæsthesia bordering on death.

minims; in other words, only one-third of the inspired quantity is absorbed by the blood, within the average respiratory period. The defect in Dr. Snow's apparatus for Anæsthetising animals is apparent from his own description of his physiological experiments.

Some practitioners contend that Chloroform does not react to all people in a similar manner—I wish to remind them that no instrument capable of measuring both the drug, and its diluent, has ever been placed in their hands, therefore no opportunity has been afforded them to put their supposition to a scientific test, and without such an instrument, the most skilful administrator could never Anæsthetise twice in precisely the same way: that fact proves their supposition to be a mere speculation. A moment's reflection, should suffice to remind any one, that as the atmospheric formula is constant, and common to all forms of animal life, different species, as well as different sized individuals of each species, are provided with a respiratory capacity, which adjusts the intake of Oxygen to the requirements of the metabolism of their body. If then their respiratory capacity gauges the intake of air according to their own individual requirement, it is obvious, that each one takes its own respiratory equivalent within a given period of time. An infant does not take the same volume that an adult requires; nor could a mouse take the inspiratory volume of an elephant; each takes its own equivalent. Thus a fixed percentage satisfies the physiological requirements of creatures so widely diverse, whilst a fixed quantity would kill all round (see page 27). It is exactly so with Chloroform, the different percentages of which may, for all practical purposes, be considered as distinctly different Anæsthetics, some of which are capable of suddenly terminating life by primarily paralysing the heart before any degree of Anæsthesia has been caused; others operate through the brain and nervous system and are incapable of arresting the heart's action, which indeed continues to beat sometimes with vigour even after the respiratory centre has been intentionally paralysed; others are incapable of Anæsthetising beyond the second degree of Anæsthesia; whilst other percentages are only capable of causing various degrees of intoxication.

My Anæsthetisers automatically adjust percentages, and my Tables 2, 12, and 13, show what quantity an average sized adult has breathed within a given period of time. They also foretell the physiological effects of different percentages, namely, the period required for reaching the different stages of Anæsthesia, and causing death. All this may be repeated over and over again with fresh animals, with unvarying results. As before stated, I am willing to demonstrate these results, if allowed to suit my own convenience in the arranging of time.

From what has already been said, it may be inferred that differences of size do not affect the physiological action of fixed percentages of Chloroform, and my way of demonstrating this fact is as follows: I place a large guinea pig and a tame mouse in the animal Anæsthetiser, wash out the atmosphere by hastily flushing about two gallons of the mixture through the apparatus, and then slowly continue the inflow and outflow of the mixture until the desired result is obtained. During this experiment Anæsthetisation proceeds alike in both animals, they reach the different stages of Anæsthesia at the same instant, are Anæsthetised to the same degree, and come out of Anæsthesia at the same time. Table 13 shows that if the mixture contains 2 per cent. of Chloroform vapour, the first degree of Anæsthesia will be reached in $4\frac{1}{2}$ minutes; the second degree in 6 minutes, 45 seconds; the third degree in 9 minutes; the fourth degree, bordering on death, in $13\frac{1}{2}$ minutes. If the mixture contained 3 per cent. the first degree of Anæsthesia will be reached in 3 minutes; the second degree in $4\frac{1}{2}$ minutes; the third degree in 6 minutes; and the fourth degree in 9 minutes. If the mixture contained 4 per cent. the first degree of Anæsthesia would be reached in 2 minutes, 15 seconds; the second in 3 minutes, $22\frac{1}{2}$ seconds; the third degree in $4\frac{1}{2}$ minutes; and and the fourth degree in 6 minutes, 45 seconds.

Table 12.

Quantity of Chloroform inhaled per minute.

1	per cent.	of Vapour	equals	$3\frac{11}{13}$	Minims	⅌ min.
2	,,	,,	,,	$1\frac{9}{13}$	,,	,,
3	,,	,,	,,	$11\frac{7}{13}$	,,	,,
4	,,	,,	,,	$15\frac{5}{13}$	,,	,,
5	,,	,,	,,	$19\frac{3}{13}$	,,	,,
6	,,	,,	,,	$23\frac{1}{13}$	,,	,,
7	,,	,,	,,	$26\frac{12}{13}$	,,	,,
8	,,	,,	,,	$30\frac{10}{13}$	,,	,,
9	,,	,,	,,	$34\frac{8}{13}$	,,	,,
10	,,	,,	,,	$38\frac{6}{13}$	,,	,,
11	,,	,,	,,	$42\frac{4}{13}$	,,	,,
12	,,	,,	,,	$46\frac{2}{13}$	,,	,,
13	,,	,,	,,	50	,,	,,
14	,,	,,	,,	$53\frac{11}{13}$	,,	,,
15	,,	,,	,,	$57\frac{9}{13}$	,,	,,
16	,,	,,	,,	$61\frac{7}{13}$	,,	,,
17	,,	,,	,,	$65\frac{5}{13}$	,,	,,

Average respiratory volume of an adult—**25** cubic inches per inspiration, 400 cubic inches per minute.

A mixture containing 5 per cent. would produce the first degree of Anæsthesia in 1 minute, 48 seconds; the second stage in 2 minutes, 45 seconds; the third degree in 3 minutes, 36 seconds; the fourth degree in 5 minutes, 24 seconds. Reference to Table 13 makes other examples unnecessary. All proportions over 5 per cent. are dangerous, increasingly so as the percentage rises. About 3 or 4 per cent. should be used for the Anæsthetising of human subjects. Some practitioners are of opinion that Chloroform, like Digitalis, Chloral-hydrate, etc., is cumulative, but if it were so, less than one per cent. would Anæsthetise perfectly, though slowly. I disprove this assumption by first Anæsthetising an animal, profoundly, and then supplying a ½ per cent. mixture until the subjeet recovers.

Although I have Anæsthetised many animals over and over again, I have never lost either a large or a small animal from the action of Dr. Snow's "safe percentages." Nor do these mixtures appear to affect their health in any way.

If a patient die whilst breathing a mixture containing a high percentage of Chloroform, that result is not an accident; it is the natural consequence of a deliberate choice; but it is, distinctly an accident if the patient inhaling high percentages does not die.

It should be ever remembered that the

process of Anæsthetisation does not cease when the administration of the drug is discontinued, for at that instant the lungs of an average sized adult contain 250 cubic inches of Chloroform mixture, which continues to give up Chloroform to the blood, after its exhibition has been stopped. Indifference to this fact has been the most prolific cause of Anæsthetic fatalities (see table 14).

250 cubic inches of a Snow's safe mixture within the lungs at that instant when the patient is *perfectly Anæsthetised, would not imperil life.*

It should be borne in mind that although the normal inspiration of an average sized adult is 25 cubic inches, the patient when taking a deep inspiration may inhale four times that volume, namely, 100 cubic inches. Such an inspiration may cause sudden death, if high percentages of Chloroform vapour are being used.

100 cubic inches of Dr. Snow's safe mixture could not cause death, nor endanger life.

Dr. Snow's safe mixtures ensure the unalterablness of percentage, whatever volume is inhaled, or however irregular the breathing may become. Some high percentages of Chloroform vapour do not operate through the brain and nervous system—they act primarily on the heart's substance, and thereby cause sudden death.

Table 14,

Residual Over-Narcotisation

the most prolific cause of Death.

The quantity of Chloroform contained in the Residual 250 cubic inches of Mixture within the lungs at that moment when administration of the drug is arrested, is proportional to the percentage of its vapour contained in the Mixture whice the patient has inhaled.

Chloroform Mixture.				Quantity of Chloroform in the Lungs.	
1	per cent.	equals	...	$2\frac{21}{52}$	minims.
2	,,	,,	...	$4\frac{21}{26}$	,,
3	,,	,,	...	$7\frac{11}{52}$	,,
4	,,	,,	...	$9\frac{16}{26}$	,,
5	,,	,,	...	$12\frac{1}{52}$	,,
6	,,	,,	...	$14\frac{11}{26}$	,,
7	,,	,,	...	$16\frac{43}{52}$	,,
8	,,	,,	...	$19\frac{6}{26}$	,,
9	,,	,,	...	$21\frac{33}{52}$	,,
10	,,	,,	...	$24\frac{1}{26}$	,,
11	,,	,,	..	$26\frac{23}{52}$	,,
12	,,	,,	...	$28\frac{11}{13}$	,,
13	,,	,,	...	$31\frac{1}{4}$	,,
14	,,	,,	...	$33\frac{17}{26}$	,,
15	,,	,,	...	$36\frac{3}{52}$	,,
16	,,	,,	...	$38\frac{6}{13}$	,,
17	,,	,,	...	$40\frac{45}{52}$	,,
18	,,	,,	...	$43\frac{7}{26}$	,,
19	,,	,,	...	$45\frac{35}{52}$	,,
20	,,	,,	...	$48\frac{1}{13}$	,,

Either high percentages, or imperfect diffusion, may cause reflex inhibition of the heart's action by irritating the nerve endings of the pneumogastrics in the lungs.

Dr. Snow's safe Chloroform mixtures are *incapable* of causing sudden death; they always operate slowly through the brain and nervous centres, narcotising them in regular succession, and it is impossible to cause death by this process without wilfully disregarding symptoms which, Dr. Snow informs us, would appeal as much to one's intelligence, as to the skill of a professional man.

Dr. Snow discarded Ether and used Chloroform. He condemned A.C.E. and all similar mixtures.

Concerning the alleged danger of the sitting posture, on page 75 he remarks: "It has been said that it is unsafe to give Chloroform in the sitting posture, on the supposition that it would in some cases, so weaken the power of the heart, as to render it unable to send the blood to the brain. Observation has proved, however, that Chloroform increases the force of the circulation," and on page 76 he says: "I consider that the *sitting posture is by no means a source of danger* when Chloroform is given, if ordinary precaution be used. I have preserved notes of 999 cases in which I have given Chloroform to patients in the *sitting posture*, and no ill-effects have arisen in any of these cases."

Dr. Snow's safe mixtures do not cause gulping, coughing, a sense of suffocation, spasm of the glottis, horror, nervous shock, and demonstrative resistance.

There is no doubt that the practice of rushing patients through the period of that excitement which high percentages and guess methods induce, are solely responsible for the rushing of many patients out of time into eternity. Dr. Snow condemns this practice, and Dr. Quain asserts that excitement and struggling distinctly contra indicate heroic exhibition of the drug.

If it is necessary to rush patients into unconsciousness, why do the advocates of that plan RETARD Nitrous Oxide Anæsthetisation by mixing manufactured Oxygen with their Nitrous Oxide?

My instruments offer a long range of adjustment, but if this desirable facility is at any time wilfully perverted by the deliberate choice of high percentages, Death, in that circumstance, must be expected.

Hœmorrhage.

It would be a case of exceptional urgency if treatment were absolutely necessary sooner than four hours after the operation. It has been my plan to administer a tumbler of milk, and then wait a time, to see whether sickness followed—any indication of sickness points to the advisability of placing the patient in a horizontal position, on her side. In most cases, I have applied the compress at night, and removed it next morning. In all such cases, excitement, exertion, and stimulants, must be avoided during the interval allowed between the operation and the plugging; because anything that increases the heart's action, also increases the pumping out of the patient's blood. In my hands, the following treatment has never failed to arrest bleeding, even when a large number of extractions have been made, in cases distinctly typical of the hœmorrhagic diathesis:—

First of all, soften a sufficient quantity of Hind's Extra-Hard Compo in hot water, and after squeezing it dry in a napkin, knead it over a flame until it becomes adhesive and compact; then roll it between the hands until it is round, and of a proper length, and thickness; this manipulation prevents flakiness of the Compo, a condition which, if present, might lead up to grave consequences. When this result is attained, bend the roll until its outline approximates that of the jaw. Having thus prepared the Compo compress, chill it in cold water to prevent flattening.

Now select a taper-pointed hand plugger, or other suitable instrument bent to an obtuse angle, wrap its point loosely with a cone-shaped covering of cotton wool, made to project a little beyond the end of the instrument; dip this covered end of the instrument into Styptic Colloid, swab out one cavity with it, and then throw the used wool into the spitoon; now quickly cover the plugger point again, and saturate the covering with Styptic Colloid as before, but this time draw the pledget of wool off the plugger, convey it to the patient's mouth, and carefully insert it tightly into the previously swabbed cavity. The pledget cannot be retentively wedged in altogether, its lower end must be carried by the instrument to the bottom of the cavity, and the rest of it fed in afterwards.

Every socket must be similarly treated; and as soon as this is accomplished, the already prepared Compo compress must be dropped into warm water—not too warm.

When the compress has softened somewhat on the outside, and before it becomes soft right through, place it in the patient's mouth, and request the patient to bite, in the act of swallowing, so as to get, as nearly as possible, the natural relative position of the two jaws. While the patient is doing this, the the operator should assist occlusion by firm, but careful, pressure from his hands, which should be placed, one on the top of the patient's head, the other under the patient's chin. It is now obvious that, if the compress was too soft, it would creep away from the occluding surfaces, instead of making satisfactory compact.

In order to prevent displacement of the Compo compress, and upheaval of the plugs, the lower jaw must be kept in contact, by means of a bandage, tightly wound round the chin and head.

This plan of treatment, has to be modified, according to the extent of the operation. If only one side of the mouth has been operated on, then only a side roll is required ; if both sides have been treated, two side rolls will be required ; and if the operation involves the front of the mouth, as well as both sides, then an all-round continuous roll must be used, and a central perforation must be made in the Compo, to allow the saliva to escape, if it becomes troublesome at times. After arranging an appointment for removing the compress at the patient's home, the patient should be cautioned against any attempt to separate the jaws, and then ordered to bed It is my plan, to prescribe a mild purgative on the following day, and then refer the case to the family practitioner.

GENERAL REMARKS.

A watch is a very complicated mechanism; but its proper use, does not depend upon a perfect knowledge of its integrant purposes, or even a superficial knowledge of its general construction; all that the user need know is how to wind it up and how to read its figures.

Neither does the proper use of my Anæsthetisers depend upon a comprehensive knowledge of the various purposes of their several parts; all that the administrator need know about them, is how to charge them, and how to read their figures; and I venture to hope, that that information has been intelligibly imparted. Whatever has been said beyond that necessity, has been said with a view to assisting practical men, to bottom the whole questions for themselves.

By way of re-capitulation, however, I may just say that all the administrator need know about

THE PORTABLE ANÆSTHETISER

is that when an unknown quantity of Chloroform has been placed in the tank; and the milled cap has been carefully screwed home; he must deduct 10 degrees from the temperature of the room; this gives the mean temperature, whose corresponding percentage he must divide by the percentage required; see page 66. If he then places the indicator at that number which represents the product of his calculation, the apparatus will automatically, and accurately, work out the percentage he wants. On page 68 the calculations are already worked out. That rule has to be varied when

THE STATIONARY ANÆSTHETISER

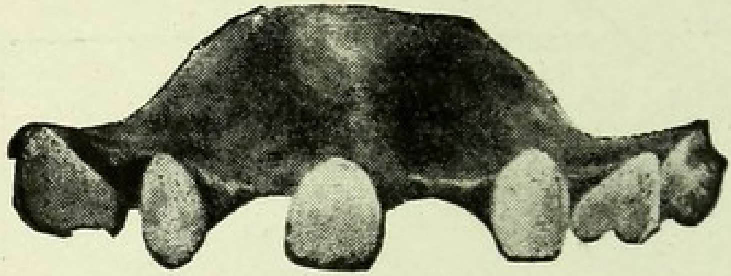
is used; for then the administrator has only to divide the percentage indicated by the temperature of the *room; by the temperature he requires and place the indicator at that number on the quadrant, which represents the product thus found. When this is done, the Apportionator automatically formulates the precise proportions which he desires; or, if he adjusts proportions by pressure, then pages 50, 52, and 56 will show how to read the dial.*

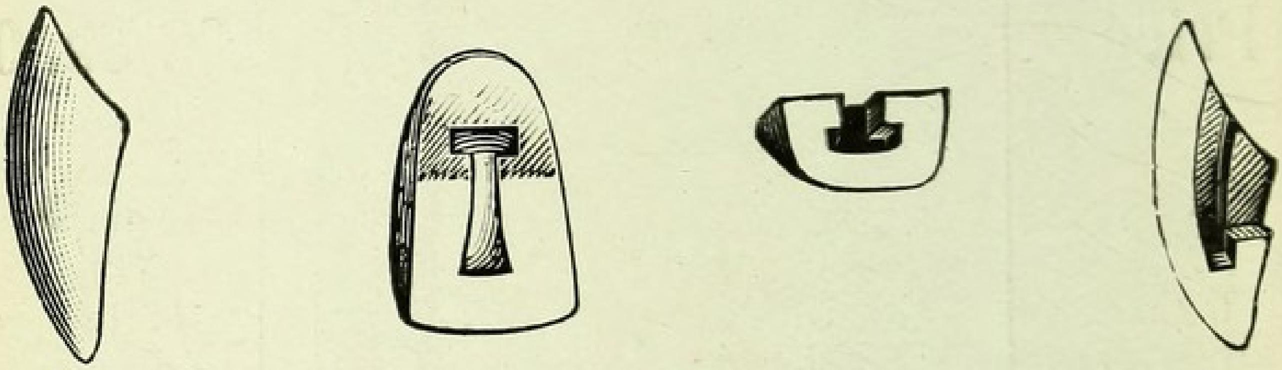
As both the **reduction of temperature consequent on Volatilization;** *and the* **reduction of percentage of the Volatile Narcotic;** *bear a simple direct ratio to each other; and as both are inversely proportional to the volume through which they are equalised, it is self-apparent that identical results can only be obtained by maintenance of that ratio. In other words, the accuracy of my Tables, and ready methods, cannot be tested by totally different means; and it must be remembered that leakage,* *caused by not screwing the milled cap quite home, would upset the results of the Portable Anæsthetiser.*

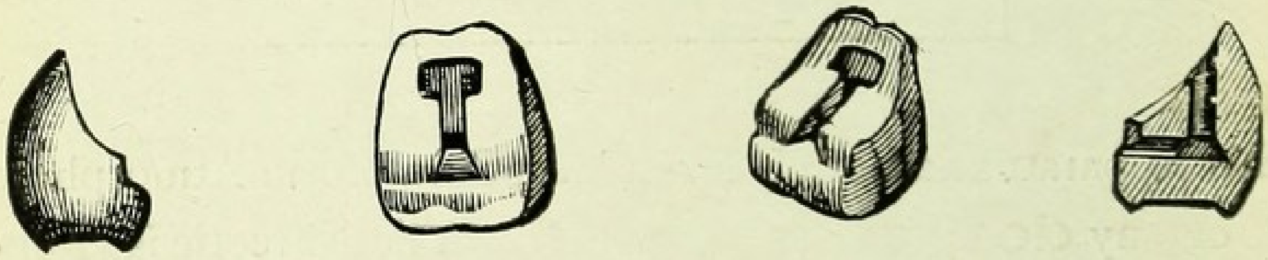
Unless all the residuum of Chloroform is removed from the tank, before re-packing in its leather case, the Chloroform may spoil the check-valve of the blower.

In case of any mishap, from forgetfulness, or any other cause; the apparatus should be returned to us, immediately, for repair.

INDEX.







PATENT PINLESS TEETH

versus

PLATINUM PIN TEETH.

DO you remember Platinum Pin Teeth ever being so comparatively cheap, when Platinum was so dear, as now? Never. The reason is, that until MARSTON & PARR'S Anchorage was materialized, there was nothing in the market to take the place of a pin tooth, hence as Platinum advanced the price of teeth went up too, and when Platinum came down teeth stayed up for more than twelve months afterwards. Dentists ruminated that fact a good deal, but had to pay all the same Tooth makers not only lost nothing, but they made a profit out of the fluctuation. Dentists themselves paid not only the corner price, but also that profit. To-day MARSTON & PARR'S Anchorage has to be taken into calculation, and tooth makers know that to raise the price of pin teeth now, would be a suicidal policy; indeed, some makers have more desire to give away rings of sample teeth, which formerly commanded a fancy price, than to raise their price of teeth. Thus far, dentists are benefitted by our competition; but what is this outcry about Brittle Platinum Pins? Is not that a new condition? Do you—senior practitioners—remember Platinum Pins that were other than Platinum Pins? Platinum is Platinum all the world over. Its chemical and physical properties are characteristic, and constant; Platinum Pins never changed in the past, and they cannot change now. Brittle Platinum indeed! Why, when the welding of Pulverulent Platinum Black was the only commercial source of Platinum there were no Brittle Platinum Pins even then; although the process of manufacture was so primitive, and imperfect. Is there such a thing as Brittle Platinum now? No. When Platinum Pins possess properties other than those which distinguish Platinum, they should be called by some more appropriate name than Platinum Pins; for the metal composing such Pins is Platinum and something else. What that something is, and how it comes there, are now the subjects of enquiry by such able experts as Mr. George Murray, F.R.C.S., Mr. W. W. Noel Hartley, F.R.S., and Mr. Booth Pearsall, F.R.C.S.

Mr. Booth Pearsall, in his paper read before the Annual General Meeting of the British Dental Association, at Ipswich, in May of the present year, stated that "enquiry from the depôt where I had purchased "the teeth, brought out the fact that the amount of "Platinum in the market is limited in quantity, and "there has been, as you all know, a great increase in "the use of Platinum on the part of electricians. It "was suggested some adulterated Platinum had been "used."

He does not imagine, however, that tooth manufacturers would deliberately use unreliable Platinum for Pins.

Mr. Murray, after treating the same subject, asked this question :—Are we to keep Porcelain teeth in glass cases unused, or place them in our patients' mouths to assist them to masticate? Contrast that with this :—

The following unsolicited Testimonial is typical of many that we receive; it was sent by an L.D.S., a shareholder in a London Company, who, he informs us, make the purity of their tooth pins a special feature of their manufacture :—

TESTIMONIAL.

"Gentlemen,

"I herewith enclose cheque in payment of "Account. Kindly send receipt per return. My "experience of your Teeth, after using them "for two years, is, that they are **Stronger "than Pin Teeth, they look very "natural in the mouth,** and in **no "case have they dragged out.**

"In all cases where **extra strain** is "expected, I shall most certainly use them."

"Yours sincerely,

———————

"To Messrs. Marston & Parr,
"Leicester."

MARSTON'S ANÆSTHETIST'S DIARY.

Memoranda.

Date CASE 1.	*Date* CASE 2.
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	

Memoranda.

Date CASE 1.	Date CASE 2.
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	

Memoranda.

Date *Date*

CASE 1. **CASE 2.**

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Memoranda.

Date

CASE 1.

Date

CASE 2.

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Name
Age
Operation
Anæsthetic
Percentage
Total Quantity
Period

Memoranda.

Date CASE 1.	*Date* CASE 2.
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	

Memoranda.

Date CASE 1.	*Date* CASE 2.
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
Age	
Operation	
Anæsthetic	
Percentage	
Total Quantity	
Period	
Name	
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CASE 1. **CASE 2.**

Name
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Date	*Date*
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Memoranda.

Date **CASE 1.**	*Date* **CASE 2.**
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Memoranda.

Date **CASE 1.**	*Date* **CASE 2.**
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Memoranda.

Date CASE 1.	*Date* CASE 2.
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