ORIGINAL COMMUNICATIONS.

Further Observations on the Use of Oxygen with Nitrous Oxide.*

By FREDERIC HEWITT, M.A., M.D.Cantab.
ANÆSTHETIST AT THE LONDON HOSPITAL, ETC.

Gentlemen,—Since I had the honour of addressing the members of this Association at the Annual Meeting at Manchester, in 1892, I have been steadily endeavouring to simplify and render more universally applicable the method of producing nitrous oxide anæsthesia to which I then referred—a method with which you are all now familiar, and one which has for many years occupied a considerable share of my attention. I use the word method in a wide sense, applying it not to any particular line of procedure dependent upon the employment of any particular apparatus, but to the administration of oxygen with nitrous oxide, with the object of preventing certain asphyxial symptoms which arise when that anæsthetic is administered in the customary manner, *i.e.*, free from oxygen.

Before I proceed I should like to dispose of an argument which is not infrequently brought against any attempt to improve the customary method of nitrous oxide administration. It is urged that this method is so satisfactory and so free from risk, even in comparatively unskilled hands, that there is no necessity for improvement, no need for advance. But such an argument, even though advanced, as I regret to say it has been advanced by men of experience, must completely fall to pieces when seriously examined. I readily grant that unsatisfactory symptoms under nitrous oxide, as ordinarily given, are extremely rare, and that fatalities are so exceptional that when one does occur it creates the most widespread sensation amongst those who, like ourselves, take no little interest in the best means of preventing pain. But even if accidents and deaths occurred less frequently than is the case; even if there were but one recorded fatality from nitrous oxide as ordinarily given; I submit that it would still be our duty to attempt to find some safer method of administration, in order to minimise the already small risk, and reduce it, if possible, to *nil*.

---

* A paper read at the Annual Meeting at Newcastle-on-Tyne.

The asphyxiating properties of nitrous oxide, when administered free from oxygen, appear to constitute its sole objection and danger as an anæsthetic. The lividity of the features, the stertorous snorting and obstructed breathing, the muscular twitchings, and the congested and swollen state of the tongue and other parts, are one and all due to want of oxygen. A study of the fatal cases which have already arisen under nitrous oxide reveals the fact that in most, if not in all of them, death took place with asphyxial symptoms brought about by oxygen deprivation, so that it is in the highest degree probable that had a suitable proportion of oxygen been mixed with the nitrous oxide, these fatalities would either have been less numerous, or more probably would not have taken place at all. The presence of oxygen robs nitrous oxide of its one disadvantage, and of its one risk.

Let us carry the matter one step further, so that we may fully realise the importance and perhaps the necessity of oxygen in the administration. In order to obtain sufficient anæsthesia from pure nitrous oxide it is necessary, as a general rule, to push the inhalation to the point at which either deep stertor or "jactitation" manifests itself. Now, this point may be safely reached, in fact the administration may even be carried on for a second or two beyond it, in, let us say, 999 cases out of 1,000 without risk, but in the 1,000th case risk will be incurred. Patients cannot be placed in the asphyxiated condition with which all of you are familiar without some risk of suspended respiration. The deprivation of oxygen, which necessarily occurs in the customary method of administration, may, in fact, bring breathing to a standstill, in at least two and possibly in three ways. (1) The air-way may become mechanically obstructed from spasm or swelling of parts within it; (2) the respiratory muscles may be thrown into a state of tonic spasm; or possibly (3) the respiratory centre may simply become paralysed, breathing gradually ceasing without obstruction or spasm.

Mechanical occlusion of the air-tract—a condition to which I have elsewhere[1] drawn special attention, and one which may arise in various ways—is the chief danger to be apprehended

[1] *Trans. Roy. Med. Chir. Soc.*, vol. lxxiv., p. 107.

in administering nitrous oxide free from oxygen. It is an interesting and significant fact that in two of the recorded nitrous oxide deaths the patients had enlarged tonsils. When oxygen is withheld in administering nitrous oxide the venous system becomes more and more engorged, and vascular structures, such as the tonsils, may increase in size to such an extent as to obstruct breathing. When oxygen is mixed with the nitrous oxide the venous engorgement and consequently the swelling of vascular structures is far less, so that obstructed breathing from enlarged tonsils does not occur. I do not mean to say that enlargement of the tonsils is a condition which contra-indicates the use of nitrous oxide, but such a condition should make one cautious. I refer to it here because it serves to exemplify what I am wishing to convey, viz., that the possibility of danger from such a source is removed by adopting the method I am advocating.

There is yet another advantage in the use of oxygen to which I should like to refer. Those of you whose experience with nitrous oxide has extended over many years will find that, almost unconsciously, you have acquired the habit of selecting your cases for anæsthesia. Experience has made you familiar with patients whom you regard as "bad subjects." Now the great majority of patients who are bad subjects for nitrous oxide *per se* will be found to do remarkably well with nitrous oxide mixed with oxygen. The hysterical subject who remains but a brief time under nitrous oxide as ordinarily given and recovers with excitement and screaming, behaves in a totally different way when oxygen is employed. The same, too, is true of anæmic and feeble persons. Very obese subjects and those who have heart or lung affections pass through non-asphyxial nitrous oxide anæsthesia with remarkably little disturbance. And, lastly, the very young and the very old may be far more satisfactorily anæsthetised by this than by the customary method.

I am glad to find that much more interest is being taken in this matter than was the case a few years ago. The new method is gaining ground, not only in England, but in Germany, France, Sweden, and other countries. It is true that it is a trifle more difficult and that it requires somewhat more attention to detail than that customarily employed; but by means of an improved and simplified apparatus which I

have brought with me for your inspection, and which I shall have the pleasure of using before you, I think you will see that the differences between administering nitrous oxide in the usual manner and giving it with oxygen are in reality very slight. The gain is great, not only from the point of view of the administrator, who is able to produce a longer, better, and safer form of anæsthesia than has hitherto been found possible, but from the point of view of the patient, who is not subjected to the often distressing sensations which accompany imperfectly established anæsthesia during dental operations.

The kind of apparatus employed is of the greatest possible importance in successfully inducing non-asphyxial nitrous oxide anæsthesia. In my attempts to obtain an efficient apparatus I have over and over again met with difficulties dependent upon apparently trivial details in construction. I should weary you were I to enumerate the numerous points I have had to consider in bringing the apparatus, which I now show you, to its present state. In administering these two gases as they should be administered we are employing a delicately adjusted process, and the apparatus must be delicately adjusted also, or we shall not succeed as well as we could wish. The apparatus which I described at Manchester in 1892 leaves little if anything to be desired in the results which it produces. But with the object of rendering the method more universally applicable I have been endeavouring to simplify this apparatus, and thus to render the mechanical process of administration easier of performance, and to reduce the cost of manufacture. In attempting this simplification I had before me two problems. One was to make an apparatus which would be as portable as, and in outward appearances similar to an ordinary nitrous oxide apparatus; the other was to devise a stopcock which would, by one continuous movement of a single handle, allow in the first place air, in the second place nitrous oxide, and in the third place nitrous oxide mixed with oxygen to be inhaled. You may remember that in the previous apparatus there were two handles to the stopcock, two separate bags for the two gases, and two separate tubes from the gas cylinders to the bags. The present apparatus has one handle to its stopcock, one bag divided by a septum into two parts, and one apparent tube (in reality two) between the cylinders and bag.

Fig. 1 shows the complete apparatus. There are two cylinders for nitrous oxide, and one for oxygen. The short rubber supply tubes from the cylinders are attached to two arms of a specially constructed metal Y piece. The third arm of this Y piece consists in reality of two concentric brass tubes with a space between them, the inner tube being con-

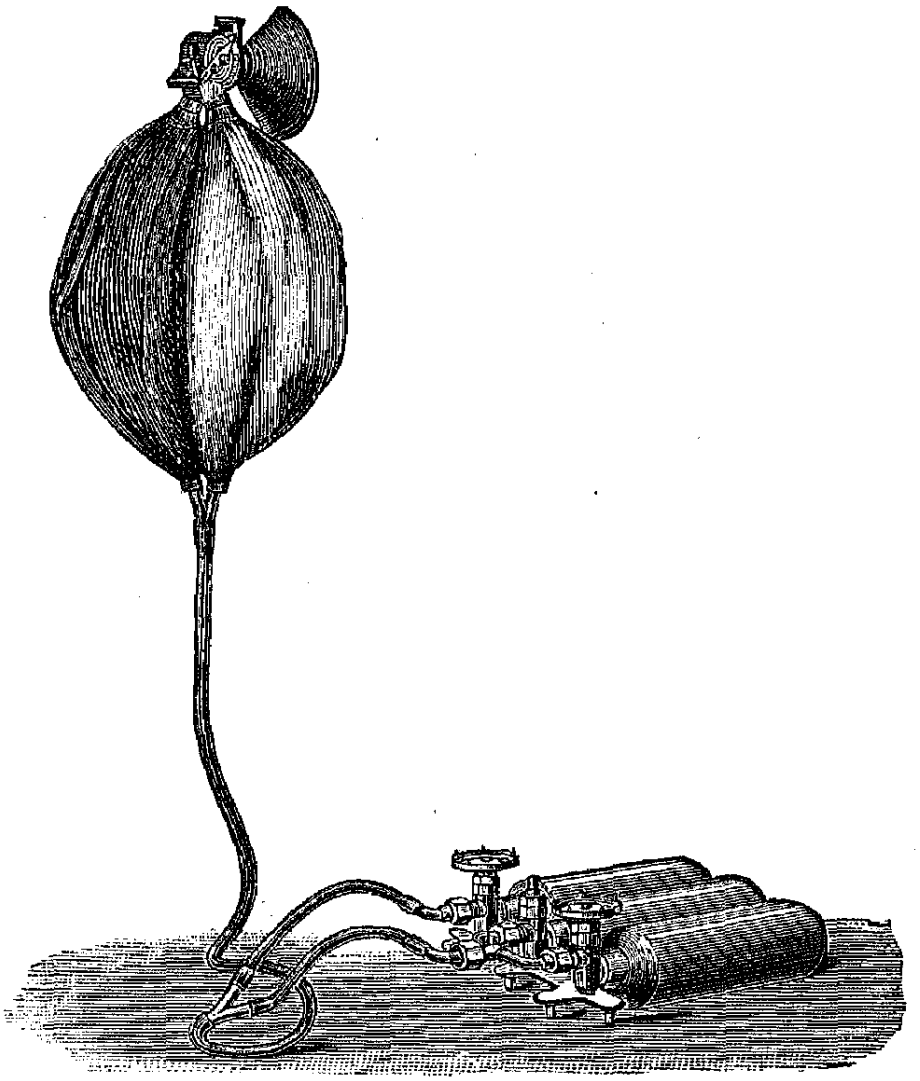

FIG. 1.

tinuous with the arm receiving the rubber tube from the oxygen cylinder, the outer being continuous with the arm receiving the rubber tube from the nitrous oxide cylinders. To this third arm of the Y piece two rubber tubes, one inside the other, are attached, the small inner one transmitting oxygen to the oxygen division of the double bag, the larger outer one transmitting nitrous oxide to the nitrous oxide

division of the double bag. Just before the two rubber tubes, one inside the other, reach the double bag, they are, as it were, split up again into two separate tubes by another Y piece, so that the two gases may be delivered to the respective divisions of the large bag. It will be seen that the large double bag has two necks to it, which fit over the two wide metal tubes coming from the combined stopcock and mixing chamber. The wide metal tube through which the nitrous

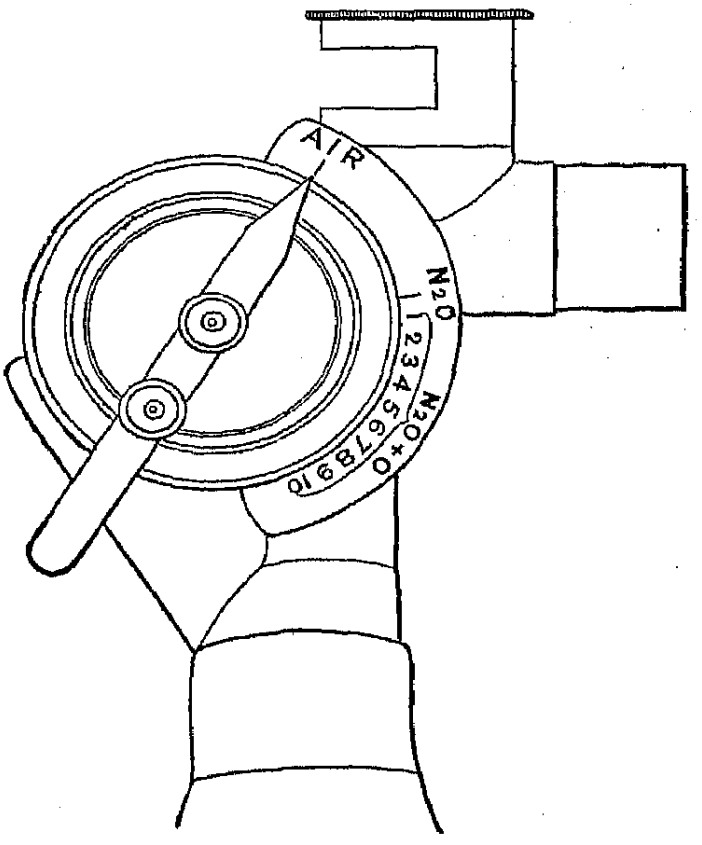

FIG. 2.

oxide is delivered to this stopcock and mixing cylinder (here called stopcock for brevity) communicates by means of a large circular orifice with the interior of the stopcock, so that a wide passage is always open for the supply of nitrous oxide from the bag during the administration. But the wide metal tube through which the oxygen passes on its way from the oxygen division of the bag to the stopcock does not communicate thus freely with the interior of the stopcock. The outer part of the stopcock to which this oxygen tube is soldered is pierced by ten small holes, so that the oxygen tube may be

looked upon as being subdivided into ten small tubes. An inner drum which revolves in the stopcock when the handle is turned determines what shall be breathed by the patient. When the indicator points to "*AIR*," as in both drawings, the air-hole is open and the inner drum covers not only the nitrous oxide inlet to the stopcock, but all the oxygen holes, so that only air is breathed. When the indicator points to "N_2O," the air-hole is closed, the nitrous oxide inlet is freely open, the oxygen holes are closed, and hence only nitrous oxide is breathed. When the indicator is turned still further, so that it points to "1," one small oxygen hole is opened up, one small stream of oxygen being thus permitted to mix with the large and continuous stream of nitrous oxide. When the indicator points to "10," ten small oxygen streams are admitted with the large nitrous oxide stream. There are two rubber valves (inspiratory and expiratory) at the part of the stopcock to which the face-piece is fitted, and there are also two smaller ones in the large metal delivery tubes to which the double bag is attached, the last-named valves being necessary to prevent the contents of the two bags mixing. An audible click takes place each time the indicator is moved to a fresh point. The apparatus can be taken to pieces in a moment, without any screw-driver, by simply turning and removing the milled head screws shown.

To use the apparatus the following directions should be followed. All air or gas should first be pressed out of the double bag, the indicator turned to "*AIR*," and the two divisions of the bag nearly, but not quite, filled with their respective gases, by rotating the foot keys. No further addition of oxygen will be needed. The face-piece should then be very accurately applied. Air will be breathed freely through the apparatus. The valves should be heard to act, otherwise the face-piece is not fitting, or the patient is not breathing as freely as he should. The indicator is now turned to "1," which means that nitrous oxide with a small quantity, possibly 1 or 2 per cent., of oxygen will be inhaled. It is most important that the two divisions of the double bag should be kept *equally and partly distended*, as shown in fig. 1. The anæsthetist must therefore keep his foot almost constantly turning the nitrous oxide foot key in order that the two parts of the bag may remain equal in size throughout. After two or three breaths at "1," the indicator should be turned to

"2," and progressively, after every two or three breaths, to "3," "4," "5," "6," "7," "8," "9," or "10," according to the type of patient. In children and very anæmic persons the indicator may be placed at "2," "3," or even "4," to start with, and turned to a fresh number every breath or two. But in adults in good health less oxygen must be given. I need not here refer to the symptoms which the patient will exhibit —these I have fully described on previous occasions. The symptoms produced will be the same as those met with when employing the previously described apparatus. I may, however, briefly mention two practical points. The first of these is that I find the absence of conjunctival reflex an ever available and usually reliable test of proper anæsthesia. The second is that I have found it better to give rather less oxygen than I originally administered, at all events in the case of adults. You may remember that I pointed out that when nitrous oxide is given with oxygen there is a somewhat greater chance of after-sickness than with nitrous oxide alone. I have found that when such a percentage of oxygen is given that a very tranquil form of respiration results, and especially when the administration is a prolonged one, after-vomiting is more liable to arise than if less oxygen is given, the breathing kept softly snoring, and the administration terminated after about one and a-half or two minutes.

In conclusion, I cannot too strongly recommend every one who administers nitrous oxide to make himself and his patients familiar with the non-asphyxial method of producing anæsthesia. I do not contend that it is possible in every case to obtain the almost ideal and sleep-like condition which is met with in what we may call typical cases. But in the great majority it is possible; and it is with the majority that we are concerned. In those cases in which the use of oxygen, for some reason or another, does not produce such satisfactory effects as one could desire, we must, of course, fall back on the pure gas and terminate the administration with the customary symptoms. But such cases are so highly exceptional that they need not be taken into consideration.

I cannot close these remarks without expressing my thanks to Messrs. Barth & Co., the makers of the apparatus, for their patience in carrying out the work which has been placed in their hands.