The anaesthetic effects of nitrous oxide & oxygen : when administered at ordinary atmospheric pressures with remarks on 800 cases / by Frederic Hewitt.

The administration of

Nitrous Oxide and Oxygen

(without pressure).

HEWITT.

To Dr. Grenville MacDonald
with the authors
Compts

THE ANÆSTHETIC EFFECTS

OF

NITROUS OXIDE & OXYGEN

WHEN ADMINISTERED AT ORDINARY ATMOSPHERIC PRESSURES

WITH REMARKS ON 800 CASES

BY

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On the Anæsthetic Effects of Nitrous Oxide when administered with Oxygen at ordinary Atmospheric Pressures: with Remarks on 800 *Cases.*

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A.—Preliminary Considerations.

Mr. President and Gentlemen,—When nitrous oxide, free from all oxygen, is administered to a patient by means of an accurately fitting apparatus possessing two efficient valves, so that, at each inspiration, nothing but the pure gas is breathed, and each expiration escapes into the surrounding air, certain phenomena, with which you are all familiar, make their appearance. In some cases these phenomena are very rapidly developed; whilst in others a greater tolerance of the gas is observable, and a longer inhalation is necessary for their production. Now in order that I may make my subsequent remarks clear, I must ask you to picture to yourselves an average patient fully under the influence of nitrous oxide administered as above described; and to briefly consider with me the chief symptoms displayed by such a

patient during the two or three seconds immediately preceding the removal of the face-piece for the performance of a dental operation. I am fully aware that different administrators carry the inhalation of nitrous oxide to somewhat different points. I do not ask you, however, to picture to yourselves a patient who has received an unnecessarily large dose of the gas, but one to whom the usual quantity has been given.

It is taught by our leading anæsthetists, and I venture to agree with them, that for dental operations, nitrous oxide should be administered till the so-called "stertor" is produced, or till some twitching in the extremities is observed. Now, in examining the phenomena of a patient at the juncture to which I have alluded, we shall, in the first place, be struck by the peculiarity of his respiration. During the earlier stages of the inhalation the breathing, although deeper and quicker than normal, will have been performed regularly, and in most cases without snoring or other sounds. But it will now be noticed to be irregular, jerky, or even tumultuous, and to possess a characteristic and irregular sound of a guttural or of a snorting character. The irregularity in the respiratory movements, has, I believe, as its immediate cause one or other of two conditions. It is either due to spasmodic elevations and depressions of the larynx, so that the superior

aperture of this organ comes at short intervals into contact with the epiglottis and base of the tongue, or to irregular spasm of thoracic and abdominal muscles. The guttural sound, which indicates that the full effects of the gas have been produced, is doubtless due to the former of these two conditions. To this sound the term "stertor" is often applied, but as it is not a snoring sound the name is hardly appropriate. Snoring sounds may, of course, be present, in which case they are liable to mask the deeper and more characteristic guttural sound. Loud irregular snorting is sometimes met with, more especially if the gas has been pushed very freely—perhaps a trifle too freely. At the acme of the respiratory changes alluded to the pulse will be found to be considerably increased in rate. Although it is frequently taught that slowing of cardiac rate occurs during gas administration, experience leads me to an opposite view. I find that it is more common for the initial acceleration (from mental excitement) to persist and in many cases to increase, and that slowing of the pulse rate does not occur till air is admitted, when an abrupt fall in rate is almost invariably to be detected. At or about the same moment at which these respiratory and circulatory phenomena appear, it will usually be noticed that the patient exhibits evidences of irregular clonic muscular spasm in the peripheral parts

of the body. To these clonic muscular twitchings the term "jactitation" is often applied. The face, the fingers, the arms, the legs, and even the trunk itself may share in the clonus. Micturition not infrequently occurs, more especially in children, during these jerky movements. Children are particularly prone to exhibit the muscular phenomena here referred to; and, as every dental surgeon will know, such movements may occasionally interfere with the efficient performance of the operation. Clonic movements are often followed or accompanied by tonic, and a state of opisthotonos may be induced. Although anæmic patients, like children, are very susceptible to the action of nitrous oxide, and quickly exhibit the respiratory and muscular phenomena described, florid and vigorous persons may unexpectedly, though rarely, prove equally susceptible subjects. I shall have occasion to refer to a healthy and florid female patient, who, after from twelve to fifteen breaths of nitrous oxide, immediately exhibits the so-called "stertor" and "jactitation" in a very marked and inconvenient degree. In addition to the respiratory and muscular symptoms which follow the free use of undiluted nitrous oxide, there is always some change in the natural colour, and the features assume a dusky, livid, or even a cyanotic aspect. The altered colour is always most noticeable in

ruddy faced or plethoric patients, and is greatest at the acme of the administration, *i.e.*, at the juncture we are considering, and when respiratory rhythm is most interfered with. Those patients who are very susceptible to nitrous oxide and quickly display jerky respiration and muscular movement will also quickly display lividity, the intensity varying with the previous colour. Dilatation of the pupils is nearly always present when a full dose of nitrous oxide has been administered, the degree of dilatation varying in different cases. A maximum dilatation is very common at the height of the changes in respiration already described. Lastly, the tongue and adjacent mucous membranes become dark, engorged, and swollen, when the administration of the gas is carried to the point which has been indicated.

Nitrous oxide has proved such an excellent anæsthetic in dental surgery that it seems almost ungracious to draw attention to the few and comparatively unimportant disadvantages which are connected with its employment. Its great safety, its rapidity of action, and its remarkable freedom from after effects, all combine to render it superior to other anæsthetics for brief operations. But like every other therapeutic agent it has its drawbacks; and it is with the object of lessening or removing these that the admixture of oxygen with nitrous oxide has been suggested. If we can

obtain nitrous oxide anæsthesia without the occurrence of "stertor," "jactitation," and lividity, so much the better. Now, without entering at length into any physiological details I may say, and I think without fear of contradiction, that by the addition of a comparatively small proportion of oxygen to nitrous oxide the three symptoms mentioned may be more or less completely prevented without interfering with the anæsthetic effects of the nitrous oxide. I am aware that this Society has lately had before it a very able and thoughtful paper from Dr. Buxton, in which he has attempted to show that nitrous oxide administered in a proper manner produces no asphyxial phenomena —that the latter only supervene when the agent is unduly pressed. I will not therefore re-open any discussion on this point. All I state is this, that the three phenomena referred to—which are, to a greater or less degree, essential to success in ordinary nitrous oxide administration in dental practice—do not appear when oxygen is used with nitrous oxide. And let me remind the Society that these three symptoms do appear and in a very marked degree when pure nitrogen is inhaled. At the instigation of Sir George Johnson, Mr. Braine and myself administered nitrogen, not only practically free from oxygen but with known and small percentages of this gas, to several patients at the Dental Hospital of London; and the phe-

nomena were to the by-standers indistinguishable from those of an ordinary nitrous oxide administration. No one can, I think, deny that the "stertor," "jactitation," and lividity produced by nitrogen are of asphyxial origin. The interesting and significant results which we obtained have already been published in the medical journals.

Ordinary atmospheric air, when mixed in sufficient proportion with nitrous oxide, will prevent the three phenomena under consideration, but is not nearly so suitable as oxygen itself for this purpose. In nitrous oxide mixed with air, we have to consider two factors: (1) the anæsthetic, and (2) the oxygenating factor. In the case of patients requiring large doses of nitrous oxide, it is not possible to have the oxygenating factor present to any great extent, otherwise intoxication rather than quiet anæsthesia results. But in weakly and fragile subjects the oxygenating factor may be present to a greater extent, and the proportion of the nitrous oxide may still be sufficient to produce tranquil anæsthesia. I have often anæsthetised children and others with nitrous oxide and air, without producing, save perhaps in a minor degree, "stertor," "jactitation," or cyanosis. The unsuitability of atmospheric air as an oxygenating agent is due to its useless nitrogen. If we administer with nitrous oxide a percentage of air capable of preventing the three symptoms, we

shall, in most cases, also prevent deep anæsthesia, owing to the too small precentage of nitrous oxide in such a mixture. For example, a mixture of 50 per cent. of air and 50 per cent. of nitrous oxide would contain about 10 per cent. of oxygen and about 40 per cent of nitrogen; and although the 10 per cent. of oxygen might be sufficient to prevent marked cyanosis, "stertor," and clonic muscular spasm, the 50 per cent. of nitrous oxide would probably be insufficient to produce tranquil anæsthesia. If, however, instead of using air for oxygenating purposes we employ oxygen, we shall be able to replace the 40 per cent. of useless nitrogen by a corresponding quantity of useful nitrous oxide; and the proportion of the latter will now rise to 90 per cent. With such a large percentage of nitrous oxide anæsthesia is almost certain to become established, and the percentage of oxygen remaining the same as in the nitrous oxide and air mixture, "stertor," "jactitation," and other evidences of extremely deficient blood oxygenation will be prevented.

Perfectly pure nitrous oxide, administered as described at the commencement of this paper, is only respirable for a very brief space of time. When the phenomena to which I have referred make their appearance the inhalation must be discontinued, and oxygen, in some way or another, admitted to the lungs. It is this want of

available oxygen which makes pure nitrous oxide an irrespirable gas, save for a very short period. Should the administration be persisted in respiration would come to a standstill, and the standstill, in most cases, would have as its immediate cause spasm rather than paralysis of muscles directly or indirectly concerned in the performance of respiration. When nitrous oxide is administered in such a manner that the air originally present in the lungs is not removed as rapidly as has been indicated (as for example, when a facepiece with but one valve is employed, or a so-called supplemental bag is used), a longer time is taken for the production of the respiratory changes described. A similar increase in the period of inhalation may be secured by allowing a small percentage of air to become admixed with the gas. Too much air would of course reduce the anæsthetic properties to a minimum, and give rise to intoxicating but not anæsthetic effects. But the best plan to render nitrous oxide respirable is to administer it with oxygen, as will be presently described.

In administering anæsthetics for dental operations, one is frequently struck by the fact that the available period of anæsthesia, after removing the agent employed, is, to a great extent, dependent upon the length of inhalation. Now, as we have seen, this period of inhalation is, in

the case of undiluted nitrous oxide, often very short; and the resulting anæsthesia is often correspondingly transient. I am well aware that exceptional cases occur, and that by administering the gas in such a way that a short period of re-breathing is allowed towards the close of the administration, a longer anæsthesia than usual may be produced. But by the use of oxygen with nitrous oxide we present the anæsthetic to the patient in a respirable form. Large volumes of the gas can thus be thrown into the patient's circulation—far larger quantities than one can administer in the absence of oxygen—and thus the resulting period of anæsthesia becomes appreciably prolonged. It may be said indeed, but more especially with regard to exceptional cases, that nitrous oxide does not have a fair chance, when administered in the absence of oxygen, of producing its anæsthetic effects; for at or about the moment of commencing true anæsthesia, symptoms dependent upon oxygen-starvation assert themselves, and the inhalation has to be stopped.

There is yet another important advantage in the employment of oxygen with nitrous oxide. Although the use of the latter gas, administered in the ordinary manner, is, as you well know, practically free from risk to life, every one who has had a large experience with it must have met with exceptional cases in which threatening

symptoms have arisen. Without entering more fully into this part of the subject, there is every reason to believe that when such symptoms do arise, they are dependent upon the want of oxygen. Obstructed, shallow, or arrested breathing, cardiac depression, &c., will be far less likely to occur when oxygen is used with nitrous oxide.

B.—Earlier attempts to produce satisfactory Anæsthesia from Nitrous Oxide in the presence of Oxygen.

The late Paul Bert was the first to attempt to secure tranquil anæsthesia from nitrous oxide in the presence of oxygen. After numerous experiments, he arrived at the conclusion that an increase in the ordinary atmospheric pressure was necessary in order to obtain good results. He regarded nitrous oxide as an agent which, at normal pressures, could only produce anæsthesia when administered by itself, that is, free from all other gases. He therefore contended that, in order to obtain the anæsthetic effects of nitrous oxide in the presence of oxygen, it was necessary to administer the mixed gases under an increased pressure, in order that the blood might take up more of the nitrous oxide than would be possible in any such mixture administered at ordinary

pressures. Specially constructed chambers, in which the atmospheric pressure could be raised, were made. Time will not permit me to describe them or the details of Bert's ingenious and successful process. The results, so far as the anæsthesia was concerned, were in the highest degree satisfactory. Not only was there an absence of all asphyxial phenomena, but the addition of the oxygen rendered the nitrous oxide so respirable that a continuous administration was possible, and surgical operations of considerable duration and magnitude were performed. But owing to the costliness of the apparatus, to its being cumbrous and somewhat complicated, and to the discomfort experienced by the operator and his assistants by reason of the increased pressure to which they were necessarily subjected, Bert's chamber is now very rarely employed.

Bert's results were so remarkable that attempts were subsequently made to secure equally satisfactory effects without the employment of the increased atmospheric pressure which Bert had regarded as essential. Klikowitch appears to have been the first to succeed in this direction; Zweifel soon followed; and Hillischer has lately recorded a large number of cases to which I shall subsequently allude. The last-named observer has given the name "Schlafgas" (sleep-gas) to

the mixture, in consequence of the sleep-like condition which it produces.

C.—An account of 805 Administrations of Nitrous Oxide and Oxygen conducted at ordinary atmospheric pressures.

In 1886, having been informed by Dr. Cunningham of the attempts which were being made in Germany to obtain satisfactory anæsthesia from nitrous oxide and oxygen, without employing an increased pressure, I commenced a series of experimental administrations. Up to the time at which I am writing (June 6th, 1892), I have administered oxygen with nitrous oxide in 805 cases, and with your permission I will relate, as briefly as I can, the various plans which I have tried and the results which I have obtained.

Series 1 (21 *Cases*).

The so-called "supplemental-bag" of an ordinary nitrous oxide apparatus was filled with 20 per cent. of oxygen and 80 per cent. of nitrous oxide. When the full effects of nitrous oxide had been induced, the tap of the "supplemental-bag" was turned and the oxygen mixture was respired. The tumultuous respiration, "stertor," and "jactitation," of nitrous oxide quickly subsided as this was done. The results, however, were not satisfactory.

Series 2 (7 *Cases*).

A small bag filled with oxygen was interposed between the face-piece and the nitrous oxide bag, and by means of a three-way regulating tap I was enabled to divert any desired proportion of the inspired nitrous oxide current through the oxygen bag on its way to the patient. The results, however, were equally unsatisfactory.

Series 3 (16 *Cases*).

Nitrous oxide and oxygen were mixed in varying proportions in an ordinary gasometer, and a chemical analysis was made of the mixture which answered best. The analysis showed a percentage of 12.77 of oxygen.

Series 4 (121 *Cases*).

A mixture containing 12½ per cent. of oxygen with nitrous oxide was administered from an ordinary gasometer. In all these cases the natural colour was preserved, the so-called "stertor" and "jactitation" were completely absent, and the mixture could be respired continuously without difficulty. Good and tranquil anæsthesia occurred in most cases, but in a certain number an undesirable degree of excited movement, screaming, &c., were met with rather early in the administration; so that the percentage of nitrous oxide in the gasometer had to

be quickly increased. In two or three cases I completely failed to secure quiet anæsthesia. The average period of inhalation was 126 seconds; the average available anæsthesia was 44 seconds; and the average quantity of the mixture used was $8\frac{3}{4}$ gallons.

Series 5 (11 *Cases*).

I now had made a regulating apparatus consisting of a mixing cylinder supplied from two bags. The cylinder had a dial and indicator, and the orifices leading from the bags could be opened to any desired extent. The apparatus, however, did not work well, and the results were not good.

Series 6 (13 *Cases*).

I next tried two india-rubber bags, one for nitrous oxide, the other for oxygen, and made according to accurate measurements to contain, when full, the two gases in the proportion which I now believed would answer best, viz., that of 90 per cent. of nitrous oxide and 10 per cent. of oxygen. The bags were filled with their respective gases, the stop-cock connecting them was opened, the oxygen thrown into the nitrous oxide, and the mixture was then administered. I found that this plan answered well if pressure was exerted upon the bags during the administration, but not otherwise.

Series 7 (14 *Cases*).

I therefore next devised an oblong dry gasometer, and weighted it during the administration. It had mackintosh sides, and measuring rods at each end. It was not successful, as it did not work freely.

Series 8 (131 *Cases*).

I therefore next tried a circular dry gasometer, with a central vertical measuring and steadying rod, and weights as before, and found that it answered very well. With this apparatus one could easily prepare the proportion of oxygen required. It had an arrangement by which the percentage of nitrous oxide in the gasometer could be increased, or, if deemed advisable, nitrous oxide *per se* could at any moment be administered instead of the mixture. I was gradually finding out the fact that patients varied considerably in the percentage of oxygen which was requisite. The large majority of these cases were successful, but in several I had to have recourse to pure nitrous oxide.

Series 9 (29 *Cases*).

Wishing to find an explanation of the much better effects which were obtained when the mixed gases were administered from a distended bag, and thinking that such effects might possibly

be due to the mixture of the gases being forced, as it were, into the pulmonary passages, I next made a series of experiments, in which I controlled the free action of the expiratory valve by weighting it, thus decreasing the freedom of expiration. The results were, however, of a negative character.

Series 10 (67 *Cases*).

I next had made a wedge-shaped reservoir to rest upon the ground, and capable of holding about twelve gallons. A long wide tube led from the thin end of the wedge-shaped reservoir to the bag and face-piece. The inhaling bag was one-tenth the capacity of the reservoir, so that it was first filled with oxygen and then nitrous oxide added till the whole apparatus was charged. The foot of the administrator kept up slight pressure upon the reservoir during the administration. I still found 10 per cent. of oxygen gave good results; it answered in nearly every case. When I met with a patient in whom this proportion of oxygen proved too high, it was easy to add more nitrous oxide; and so every case could be terminated successfully.

Series 11 (88 *Cases*).

Still aiming at greater portability, I next had constructed for me a regulating apparatus, somewhat similar to that which I had tried some years

previously. Two india rubber bags were kept supplied with the two gases, and the tubes leading from the bags joined at a regulating tap and dial, so that, as one tube was more or less opened the other was more or less closed. I found I had to employ as many as four flap valves in this apparatus in order to make it efficient. There was a difficulty, however, in admitting the oxygen in very small quantities at a time. There is precisely this objection to the apparatus used by Dr. Hillischer. The oxygen inlet does not admit of fine enough sub-division—in other words, by a very slight movement of the indicator too great an increase or decrease in oxygen is effected.

Series 12 (125 *Cases*).

I overcame the difficulty last mentioned, to a great extent, by making the oxygen come up through small holes, any number of which could be opened or closed at a time. Of the 125 administrations thus conducted 119 were in dental practice. An analysis of these 119 gives the following results:—

(1) *Sex:* 84 females, 32 males, 3 not stated.

(2) *Age:* oldest patient 59 years, youngest 13 years.

(3) With regard to the *general result.* Deducting 4 cases of which the notes are imperfect, 115 cases remain; of these 79 (or 68.7 per cent.)

are described as typical, *i.e.*, they displayed good colour, no "jactitation" or "stertor," more or less complete muscular relaxation and quietude during operation.

(4) Of the 36 atypical cases, 9 were typical except for duskiness; 6 were typical except for rigidity; 7 were very good, but in some respect or another not quite typical; 1 was typical except for some excitement; 6 were only moderately successful; and 7 were terminated with symptoms of ordinary nitrous-oxide narcosis.

(5) *Period of inhalation.*—This was taken accurately by the métronome in 46 cases. The average was 116.2 seconds.

(6) *Available period of resulting anæsthesia.*—This was taken in 45 cases by the métronome. The average worked out at 42.6 seconds.

From the above analysis it is clear that the results were not as satisfactory as could be wished, for although no failure to produce unconsciousness to pain occurred, several cases were only partially successful so far as a quiet anæsthesia was concerned, and in as many as seven instances the administration was terminated by means of pure nitrous oxide. In many of the earlier administrations with this apparatus I gave a certain number of breaths of the pure gas and then admitted oxygen in increasing quantities. I subsequently found, however, that this plan was

not nearly so satisfactory as that adopted later, viz., commencing with a small percentage of oxygen and gradually increasing it. I also found that although this apparatus answered much better than all its predecessors, it yet allowed rather too much oxygen to come through as each hole was turned on. By a series of experiments I found, for example, that when five holes were open, as much as 13 per cent. of oxygen was breathed.

Series 13 (162 *Cases*).

The apparatus* used in this, the last series, differs only from that just described in that its oxygen holes are about one-half the size. This slight alteration has proved a very important one. The accompanying drawings show the apparatus with which the cases have been conducted.

Two india-rubber bags are employed: one for nitrous oxide, the other for oxygen (fig. 1, ON_2 and O). These, which are fed from cylinders worked by the foot, are attached to two metal tubes T' and T. Where the tubes join there is an arrangement by which oxygen may be added to the current of nitrous oxide to the desired extent. Above this regulating arrangement with

* Messrs. Barth &. Co., of Poland St., Oxford St., who have most patiently constructed various forms of apparatus for me, are the sole makers of that which I now use.

its dial (D), indicating handle (H), and indicator (i), there is a two-way stop-cock, which allows, by the movement of its handle (H′) either of air or of the mixed gases being breathed. In order

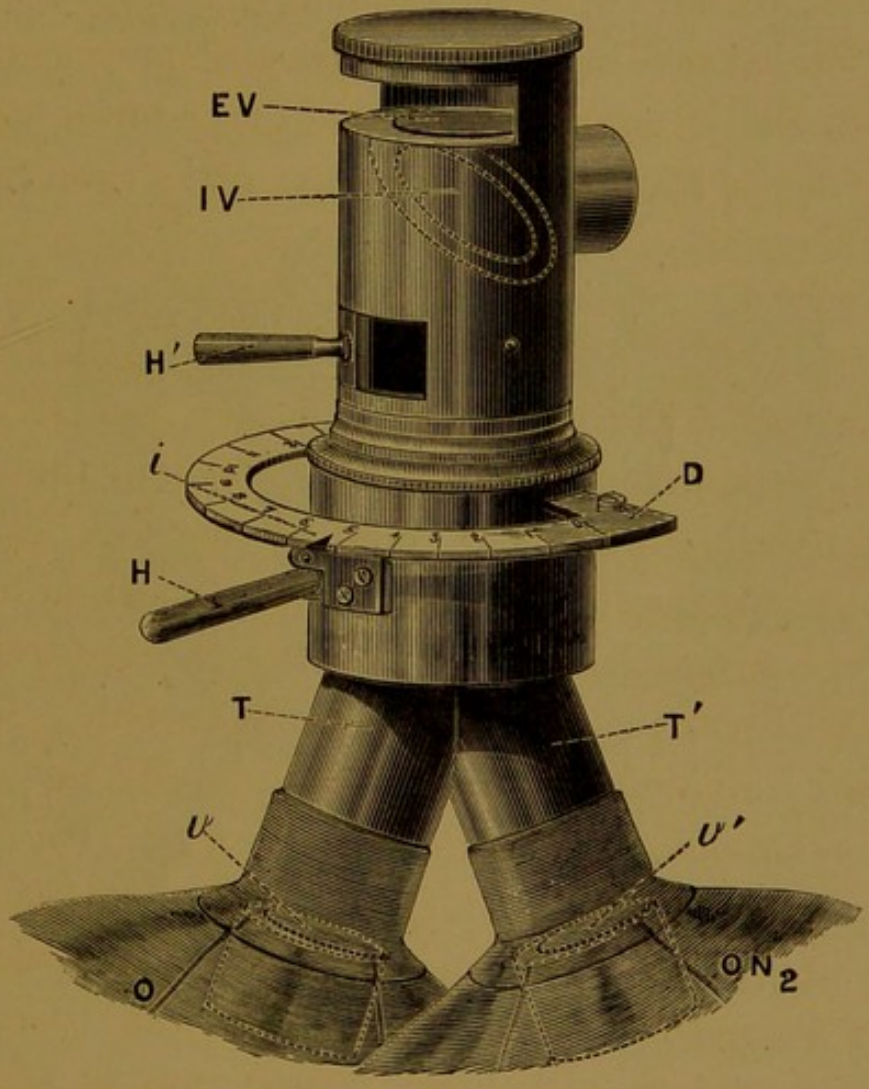

Fig 1.

to permit the free escape of each expiration, two flap-valves, one an expiratory (EV), and one an inspiratory (IV) are provided. The tubes (T and T′) also possess flap-valves (v and v′)

to prevent the contents of one bag passing over to the other. The oxygen tube T is considerably expanded above, so that the nitrous oxide tube may pass up through its middle. Oxygen thus travels along the circular channel left between the tubes, whilst nitrous oxide passes along

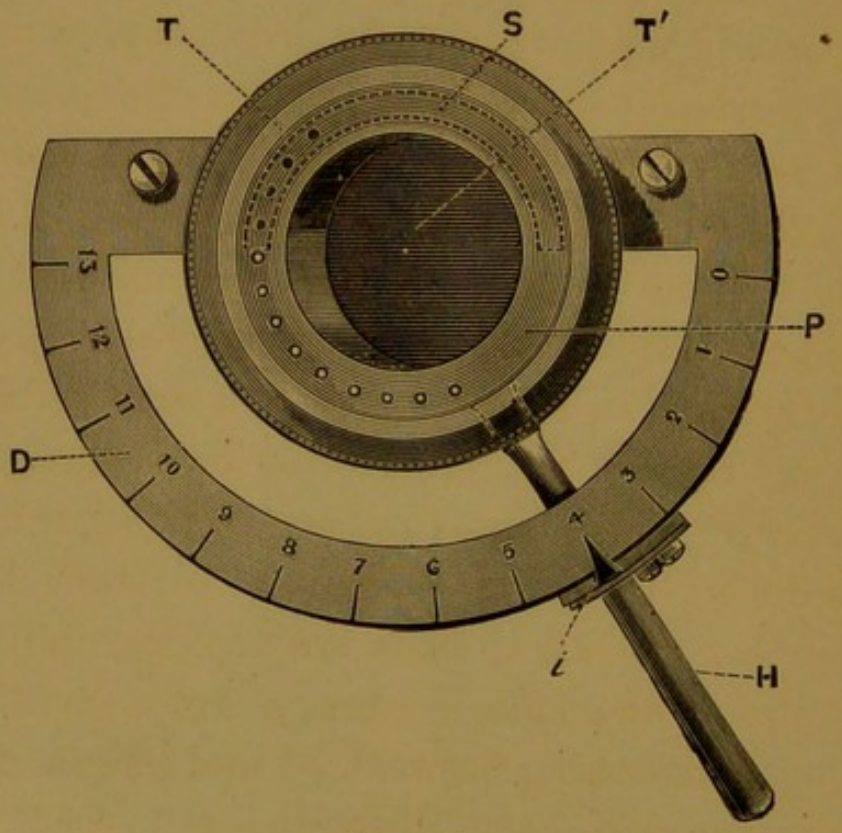

Fig. 2.

the inner tube. Fig. 2 shows the central nitrous oxide tube (T′) and the expanded oxygen tube T. The space left between the nitrous oxide tube and the expanded oxygen tube is closed in by two circular plates, the upper of which (P) revolves by means of the handle (H) upon the

lower, which is fixed. The upper plate has 13 holes in it. The lower has a long slot (S) shown in dotted lines. Now when the handle (H) is turned, so that (P) revolves, one or more holes can be brought over the slot in the lower plate, and be thus rendered available for the passage of oxygen. In Fig. 2 the indicator points to "4" on the dial: *i.e.*, four holes are opened for oxygen and nine are closed. *By this plan a very small increment or decrement in oxygen is represented by a very considerable excursion of the indicator along the dial plate.* Notwithstanding that I have made a large number of experiments with the object of ascertaining what percentages of oxygen pass through these holes, I find it impossible to give any reliable averages, owing to the variations in pressure which must to some extent occur in the bags during the administration. All that I can say is that when both bags are kept partially distended and one hole is open, a very small percentage (something between $3\frac{1}{2}$ and $6\frac{1}{2}$ per cent.) of oxygen will come through, and that each additional hole turned on represents something like an additional 1 per cent. or $1\frac{1}{2}$ per cent. of oxygen. In actual practice all we require is an apparatus which will allow of very small increments and decrements of oxygen. Should one bag ever be allowed to become fully distended the regulating apparatus will, of course, fail to

work as such. If one bag be allowed to become more distended than the other the percentage of its gas will, of course, be higher than when the bags are of equal size. The apparatus here de-

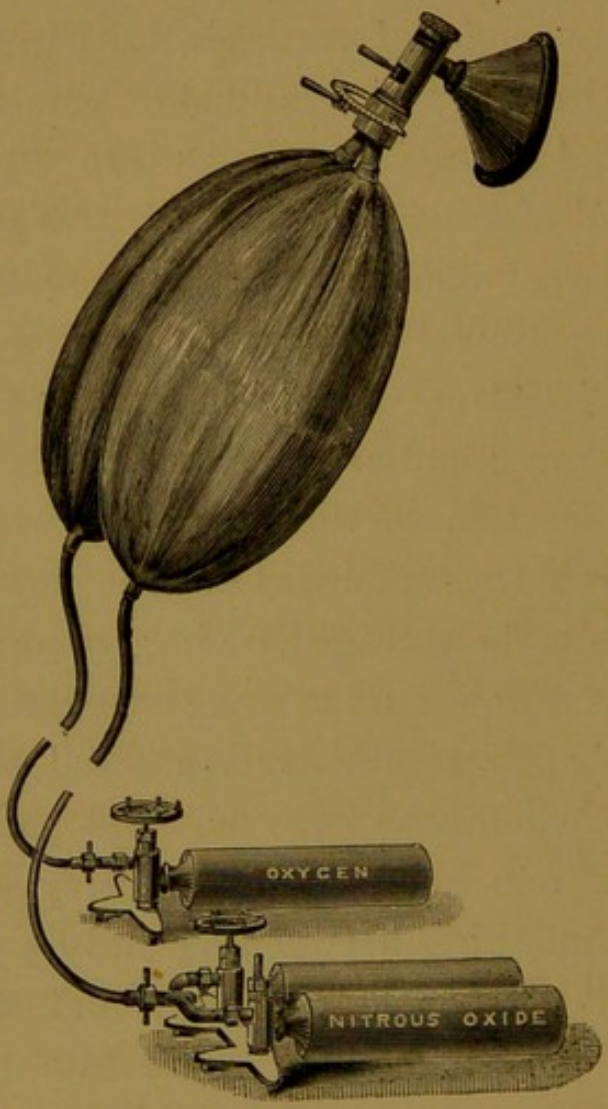

Fig. 3.

scribed allows (1) air, (2) nitrous oxide, or (3) nitrous oxide mixed with a proportion of oxygen, to be freely respired through valves at the will of the administrator.

When ready for use the apparatus has the appearance represented in fig. 3.

Before commencing the administration the anæsthetist should make sure that he has a sufficient supply of the two gases in the cylinders. In the next place, it is important not to charge the bags till immediately before the inhalation. The face-piece should be one which is capable of being applied to the face with the utmost accuracy, as a want of co-aptation which, in the case of nitrous oxide alone would not be detrimental, would, in the case of the mixture, be likely to lead to partial or complete failure. The valves of the apparatus should work efficiently and freely. After passing a small quantity of the gases through the bags, in order to free them from all traces of air, the anæsthetist should turn off the two-way stop-cock, and place the oxygen indicator at "0." Both bags should now be filled to about one-half with their respective gases, and the face-piece applied. Air will now be breathed freely through the apparatus, and the sound of the acting valves will prove that the face-piece fits well. The patient should be instructed to breathe freely and moderately deeply, "in and out through the mouth." This is important, for as he commences to breathe, so he will probably continue when the mixture is admitted. When the administrator sees and hears

that breathing is free, and not till then, he should fix the oxygen indicator at "2" and turn on the mixture at the two-way stop-cock. Nitrous oxide with a small percentage of oxygen will now be breathed. After a few seconds the oxygen indicator may be turned to "3," and in a few seconds more to "4." In children, anæmic subjects, and debilitated persons, the indicator may be moved to "3" and "4" more quickly than in strongly-built or alcoholic individuals. During these manipulations the two bags must be kept as nearly as possible equal in size. It is rarely, if ever, necessary to replenish the oxygen bag during the administration, but the foot must be constantly kept on the nitrous oxide key. Considerable practice is necessary to keep both bags equal in size throughout. Should phonation, laughter, excited movement, or struggling assert itself, the administrator should withhold more oxygen for the present, or even give less of this gas, by turning back the indicator for a few breaths. In forty or fifty seconds from the commencement of the inhalation the indicator may usually be got as far as "5," and in twenty seconds or so more may be allowed to point to "6," "7," or even "8." Generally speaking, it is not advisable to give more oxygen than this. The administrator must judge from the symptoms of the patient the extent to which oxygen should be

given. It is impossible to formulate any definite rules as to the extent to which this gas should be admitted. Considerable practice is necessary, not only to get the face-piece to fit with extreme accuracy and to keep the bags *half distended*, but to know when to give more, and when to give less oxygen. The analysis of my last 153 dental administrations, together with a careful study of the five illustrative cases in the table, will, perhaps, be of service in this connection. Whilst too much oxygen will be likely to induce laughter, excited movement, stamping, screaming, &c., and whilst it is right, should such symptoms appear, to give less oxygen, the anæsthetist must be careful not to proceed too far in the opposite direction. In regulating the increase or decrease of oxygen we must reckon what the *future* effects of any procedure will be. For example, if some phonation occurs we should give somewhat less oxygen for a short period, but not necessarily till the phonation has ceased. We may usually turn back to the previous proportion of oxygen *before the symptoms of excitement have actually subsided*, knowing that they will subside in obedience to the lessened proportion of oxygen admitted several seconds previously.

Of the 162 administrations which I have conducted with the last-mentioned apparatus, 153 have been in dental practice. By the kindness

of Dr. Cockburn Smith, Mr. George Rowell, and numerous house surgeons and students—to all of whom I now beg to express my very great indebtedness—I have been able to obtain good notes of most of these 153 cases. Whenever time and opportunity permitted I adopted a plan which was suggested by my friend the late Dr. C. E. Sheppard, whose loss we must all so deeply deplore. A métronome was used and was set to ring its bell every third second. One assistant counted aloud at each bell, whilst another took notes on ruled forms at my dictation. From the five illustrative cases which will be given later on, it will be seen that I was thus enabled to obtain records of the effects produced by variations in the proportions of oxygen and nitrous oxide.

An analysis of the 153 dental cases of this series gives the following results :—

(1) *Sex.*—123 females; 29 males; 1 not stated.

(2) *Age.*—Oldest patient, 61 years; youngest 7 years.

(3) *Typical cases, i.e., cases with good colour, no "jactitation" or "stertor," more or less complete muscular relaxation, and quietude during operation.* These numbered 117, *i.e.*, 76.4 per cent. of the total number.

(4) Of the 36 *atypical cases*, 20 showed variable degrees of lividity but were otherwise typical; 10 were rigid but otherwise typical; 1 showed lividity

with rigidity ; 1 lividity with very slight clonus ; in 2 cases the ordinary symptoms of nitrous oxide were accidentally allowed to appear ; and 2 cases were intentionally terminated by nitrous oxide free from oxygen.

(5) With regard to the *signs of readiness for operation :* deducting the 4 cases which were terminated by nitrous oxide itself, and 12 cases in which the notes on this point are imperfect, we are left with 137 cases for examination. Of these 137 cases in which notes were taken as to signs of readiness, it is stated in 104 that the conjunctival reflex was absent. In 9 cases this reflex was not abolished, but there was either softly snoring breathing, or muscular relaxation to testify to good anæthesia being present. In the remaining 24 the conjunctival reflex was not noted, but other signs were relied upon. Of these 24 cases 4 displayed widespread muscular rigidity with an increasing, though not inconvenient, tendency for the head to come forwards or to the side ; the administration being discontinued at this point, a good anæsthesia always followed. In 19 the character of the respiration, or the relaxation of muscular system afforded good indication of proper anæsthesia. In one case only was there a slight tendency to "jactitation," and in this the patient was known to be peculiarly susceptible to nitrous oxide itself.

(6) *Phonation* was noted in 29 of the 153 cases, but it was usually not excessive. In 8 cases it occurred during the administration only; in 8 during extraction only; in 6 after extraction only; in 4 throughout the administration, extraction and afterwards; in 2 during the administration and extraction; in 1 during extraction and afterwards. Violent screaming was met with in 2 of these cases only.

(7) *Muscular excitement, struggling or kicking* were observed 8 times only. (Rigidity is not reckoned.) In 5 cases slight movements in the chair were stopped by giving less oxygen; in 1 case kicking occurred during extraction; in 1 there were movements of legs during and after the administration, the former being easily controlled by more nitrous oxide; and in 1 resisting movements were made early in the administration, but soon subsided.

(8) With regard to *the 4 cases terminated by nitrous oxide itself.* In two of these too much oxygen was given to start with, and this error could only be corrected by a rapid increase of nitrous oxide. In one of the other two, nitrous oxide came in with an unexpected rush from its cylinder. In the other I had allowed the oxygen bag to become too full, so that more oxygen than was expected came through the holes; and evidences of excitement coming on I at once finished successfully with nitrous oxide.

(9) *Period of Inhalation.*—This was taken accurately by the métronome in 67 cases, and works out as 110.5 seconds on the average. The longest inhalation was 186, the shortest, 66 seconds.

(10) *Available period of resulting anæsthesia.*—This was taken by the métronome in 69 cases. The average works out as 44 seconds. The longest anæsthesia was 90; the shortest 21 seconds.

(11) *The number of teeth or roots extracted* was recorded in 129 cases. The average works out as 2.7 per patient.

(12) *Pain.*—Patients were always questioned as to pain. With the exception of 3 cases, every patient denied the slightest pain. In one of the 3 cases, however, it is questionable whether any was really felt. Of the remaining 2 cases, in one of them (No. 735) the patient certainly felt the last tooth, but the operation lasted 66 seconds, so that in the preparation of the averages I have entered 60 seconds anæsthesia instead of 66. In case No. 794 the anæsthesia was very perfect, but was of insufficient duration for the extraction of a very difficult wisdom tooth. Although no pain was felt in Case 781 the patient was conscious of the removal of the last two stumps.

(13) *After effects.*—There was retching in one case, and a transient feeling of nausea without

retching in another. Recovery is not quite so speedy as after nitrous oxide alone.

In 69 of the 153 cases the metronome was used and very full notes taken. I therefore give in a tabular form five of these metronome cases. Each one illustrates some point or another. Those interested in the subject will thus be able to see at what intervals oxygen was turned on, as well as the effects which more or less of the gas produced.

D.—General Remarks on the Anæsthesia produced by Nitrous Oxide and Oxygen adminstered at Ordinary Atmospheric Pressures.

From the foregoing facts it will be obvious that patients vary a good deal in their behaviour under nitrous oxide in the presence of oxygen. In most cases a very satisfactory and tranquil anæsthesia, free from "stertor," "jactitation," cyanosis, and excitement, results. These may be termed typical cases (see Case No. 699 in table). Of the last 153 administrations in dental practice 117 were typical. On other occasions we meet with symptoms midway, as it were, between those of the typical cases and those of ordinary nitrous oxide cases. We may find, for example, that it is necessary to give less oxygen

TABLE OF FIVE ILLUSTRATIVE CASES.

Case No. 699.

A typical case.

Sex and Age.—M. 18.

Description.—Fairly nourished; good colour. A postman.

A.—*Period of inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
18	3	Six breaths taken.
33	4	
39	4	Deep respiration.
51	5	
72	5	Quieter breathing.
78	6	
90	6	No conjunctival reflex.
99	6	Pupils 3½mm. in diameter.
108	6	Inhalation stopped.

B.—*Available anæsthesia after removal of face-piece.*

Secs.	*Symptoms.*
3	Good colour.
9	No movement or phonation.
21	Opposite side of mouth being operated upon.
30	Operation over.
42	Anæsthesia at an end.

Teeth or stumps extracted.—4.
General result.—Typical.
Remarks.—No pain. No phonation or movement; no stertor or muscular twitching; good recovery; dreamt he was at his work.

Case No. 702.

A typical case except for slight duskiness. See remarks.

Sex and Age.—F. 33.

Description.—Spare; sallow.

A.—*Period of inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
12	3	
24	4	
39	5	
51	6	
57	6	Twitching of eyelids.
66	6	Conjunctival reflex not abolished.
72	7	
78	7	Restless movement in chair.
81	5	
84	3	
87	2	
93	3	Movement ceased.
96	5	
108	5	Slight conjunctival reflex.
120	5	No conjunctival reflex.
123	5	Breathing quicker and more audible.
126	5	Inhalation stopped.

B.—*Available anæsthesia after removal of face-piece.*

Secs.	*Symptoms.*
3	Distinctly dusky.
9	Very slight phonation.
12	Normal colour returned.
24	Some movement of legs.
30	Anæsthesia at an end.

Teeth or stumps extracted.—4.
General result.—Good but not typical.
Remarks.—Restless movements probably due to too much oxygen at 72 secs. Movements quite controlled by less oxygen (more N_2O); but some duskiness at end due to this diminished quantity. Otherwise typical. No "stertor" or "jactitation."

Case No. 703.

Long inhalation and long anæsthesia after.

Sex and Age.—F. 33.

Description.—Fairly well-nourished; fair complexion.

A.—*Period of inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	
18	3	
30	4	
36	5	Quicker breathing.
54	6	
60	6	Quieter breathing.
72	6	Soft snoring.
84	6	Ditto
96	7	Distinct conjunctival reflex.
108	7	Snoring passing off. Slight rigidity of neck.
132	7	Tendency to turn head to left. Conjunctival reflex still present.
150	8	Very slight snoring.
171	8	Conjunctival reflex slight.
177	8	Some phonation.
180	8	Breathing quicker and more audible.
186	8	Inhalation stopped.

B.—*Available anæsthesia after removal of face-piece.*

Secs.	*Symptoms.*
9	Some phonation.
18	Phonation ceased, operation proceeding.
27	Slight rigidity, good colour.
48	Movement of hand towards head.
66	Extraction finished.

Teeth or stumps extracted.—4.
General result.—Very good, barely typical.
Remarks.—She slightly felt the last stump. Probably deduct 6 secs. from 66 above mentioned. Instance of long administration and long anæsthesia. A good deal of oxygen given.

Case No. 711.

The effects of the mixture in an alcoholic subject. Muscular rigidity marked.

Sex and Age.—M. 42.

Description.—A club servant. Tremulous; average height; in a low state of health; alcoholic.

A.—*Period of inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	2	Breathes freely.
18	3	
30	4	
45	5	Deep breathing.
63	6	Quicker breathing.
72	5	
	4	
	3	
75	2	Very quick breathing (panting).
84	3	
87	4	Quieter breathing.
93	5	
99	5	Rigidity coming on, with tendency to turn head to right.
105	6	
111	6	Inhalation stopped.

B.—*Available anæsthesia after removal of face-piece.*

Secs.	*Symptoms.*
15	Fine tremor.
27	Muscular system rigid.
48	Anæsthesia at an end.

Teeth or stumps extracted.—1.
General result.—Very good, barely typical.
Remarks.—Panting breathing controlled by less oxygen. The rigid condition of neck muscles was taken as the guide that anæsthesia was present. There is no note of conjunctival reflex or colour of face.

Case No. 757.

Too much oxygen given intentionally for purposes of demonstration. Excitement thus produced easily controlled.

Sex and Age.—F. 37.

Description.—Healthy appearance. (Pulse 120 before prop inserted.)

A.—*Period of inhalation.*

Secs.	Oxygen Indicator at	*Symptoms.*
0	3	
6	3	Pulse 132.
18	4	
21	4	Pulse 144.
33	4	Average breathing.
36	4	Tranquil breathing.
42	5	
51	5	Very calm breathing.
54	6	
66	5	Slight evidences of approaching excitement.
69	4	
72	4	Some phonation.
78	3	Restless movement in chair, with tendency to slip forward.
81	3	Pulse 120.
84	4	
93	5	Quite quiet.
102	5	Inhalation stopped.

B.—*Available anæsthesia after removal of face-piece.*

Secs.	*Symptoms.*
3	Colour a trifle dusky.
15	No phonation.
21	Conjunctiva insensitive.
36	Anæsthesia at an end.

Teeth or stumps extracted.—1.
General result.—Very good, barely typical.
Remarks.—Started with oxygen indicator at "3" instead of "2," and turned it to "4" in 18 seconds.

than usual, and, therefore, to produce a slight degree of duskiness; or the patient may be rigid throughout and not relaxed, as in the typical cases; or a certain degree of phonation and excited movement may occur; and lastly, in very exceptional cases, we may be obliged to resort to the undiluted gas in order to finish the case satisfactorily.

The symptoms of the patient will, of course, largely depend upon the proportion of oxygen which is used; with large percentages we shall not obtain good anæsthesia, but shall meet with hilarious excitement, laughter, screaming, gesticulation, stamping, struggling, &c. With smaller percentages, such as those advocated in this paper, we shall in the vast majority of cases obtain tranquil or softly snoring breathing, a florid colour, a good though rather accelerated pulse, more or less complete muscular relaxation, an insensitive conjunctiva, and a fixed condition of the globes. With smaller percentages still, the colour of the features will be a trifle dusky, the breathing rougher and more audible, but still quite regular, the pulse more accelerated, and the pupils larger. Should the percentage of oxygen be still further reduced the colour will be dusky, the breathing irregular and jerky, the peculiar "stertor" or snorting sound already described will be heard, and muscular twitchings will be

witnessed—in other words, we shall have all the phenomena of an ordinary nitrous oxide administration. Jerky breathing and muscular twitchings are never met with except when the percentage of oxygen is small, or when this gas is wholly absent.

In order to successfully administer oxygen with nitrous oxide, considerable care, watchfulness, and attention to detail are indispensable. A great many points have to be borne in mind during the administration. No fixed percentage of oxygen will answer in all cases, and the percentage must be varied in accordance with the behaviour of the patient. I find it best to commence with a mixture containing a somewhat smaller percentage of oxygen than that which may be subsequently given. If we commence with a large proportion of this gas (10-12) excitement will be not unlikely to arise. By starting with, say, 5 or 6 per cent., consciousness is destroyed with sufficient rapidity, and the chance of intoxicating effects is less than if a larger proportion had been allowed. The objection to giving pure nitrous oxide itself at the beginning is that it is sometimes difficult to quickly neutralise the effects thus produced without going to the other extreme, and administering too much oxygen. The accurate fitting of the face-piece is a matter of the highest importance. I once met with

unmanageable excitement from an ill-fitting face-piece, but on subsequently administering the same percentage of oxygen with an accurately adapted face-piece perfect anæsthesia resulted. In administering the mixture silence should be maintained, and the patient should be left perfectly undisturbed. I have more than once seen excitable movements initiated, even in the middle of an administration, by touching or raising the arm of a semi-anæsthetised patient. I have already referred to the importance, in using the apparatus last described, of preventing any distension of the bags. The behaviour of the patient must be watched with the greatest care, in order that we may observe and appreciate the significance of every symptom displayed. We have to pilot our patient along a narrow channel. On the one side we wish to avoid the clonic respiratory movements, &c., which prevent a free and lengthy intake of the anæsthetic; and on the other any inconvenient signs of incomplete anæsthesia. We must be sparing in our addition of oxygen in the case of those patients whose appearance suggests that they will be likely to require what we may call, for want of a better term, a strong dose of the anæsthetic. Patients who are easily affected by anæsthetics—such for example as children and debilitated persons of both sexes—may invariably be anæsthetised by nitrous oxide with a consider-

able percentage of oxygen; and as such patients are prone to "jactitation" and a short anæsthesia, the mixture has great advantages over the ordinary gas.

When I first drew attention to the advantages of this mixture of gases I was unable to definitely mention the signs of true anæsthesia. The appearance of the patient in the typical cases is such that it is difficult to believe that anæsthesia is really present. From the experience of the last two years, however, I may say that the gases should, as a rule, be administered until the conjunctival reflex has disappeared. Should this sign persist for a considerable length of time, other symptoms must be relied upon. Amongst these are complete muscular flaccidity, a fixed condition of the globes, and softly snoring breathing, such as that met with in good chloroform anæsthesia. In a few cases I have met with muscular rigidity, but the subsequent anæsthesia has been very satisfactory. When a very long anæsthesia is desired the inhalation should be kept up for some little time after the signs of narcosis have appeared; for, within reasonable limits, the longer the administration, the longer will be the resulting unconsciousness. The use of oxygen is particularly advantageous when a long anæsthesia is required; for by its presence nitrous oxide may be passed through the patient

in far larger quantities than would otherwise be practicable.

At the first application of the forceps, the patient anæsthetised by this mixture often displays slight reflex tonic movement in the chair. This however is rarely, if ever, inconvenient, and as a rule quickly subsides. Reflex phonation during operation is far less frequently met with than in the case of ordinary nitrous oxide.

In a considerable number of instances I have administered nitrous oxide *per se*, and nitrous oxide with oxygen to the same patient on different occasions. We learn a great deal from these comparison cases, and I therefore propose to briefly refer to a few of them.

On two occasions I gave nitrous oxide to a lady 29 years of age. She was very tall, thin, of nervous temperament, and of dark complexion. Though she felt no pain, she experienced each time a most distressing and horrible "nightmare." The sensations were so vivid that her mother wished she should take ether for a subsequent dental operation. Against our advice ether was given, and I administered it to very deep anæsthesia. A good deal of nausea, malaise, &c., followed. A further operation being required, the patient, although she dreaded the unpleasant dream under nitrous oxide, preferred this to the malaise of ether. Without permitting

her to suspect any difference in the administration, I gave her oxygen with the nitrous oxide, and, as before, left her quite quiet after the extraction. The first thing she said was that she had not experienced any unpleasant sensations. She was astonished, and asked for an explanation. On carefully questioning patients who have inhaled oxygen with nitrous oxide, I find it quite exceptional for any distressing dream or sensation to have been experienced. This may account for the less frequent screaming under the mixture. At the Dental Hospital we find the greatest difference in this respect. Whilst it is not at all an uncommon thing for the majority of a batch of patients to scream violently during extraction under ordinary nitrous oxide (although no pain is experienced), it is quite the exception for anything more than slight phonation to be heard during operations under the mixture. It seems as if by the use of oxygen a somewhat deeper anæsthesia is rendered possible.

I have noticed a better colour and less depression after the mixture than after nitrous oxide itself. I gave the latter gas to a boy of 15 on one occasion. He was put deeply under, and two teeth on the same side of the mouth were removed. Without saying anything as to the change of procedure, I administered oxygen

a week or two later. Good anæsthesia followed; two teeth were removed. The father of the boy and also the surgeon noticed after the operation that the boy had a better colour than he displayed on the former occasion, and the boy himself said he felt better.

But the principal advantages of the mixture are those which affect the operator. I have given the mixture rather recently to two patients with very large tonsils. To one of these, a little girl, nitrous oxide had been administered in the ordinary routine of practice at the Dental Hospital a week previously. The house surgeon reported that when the patient was well under gas she was much convulsed, her back became arched, her breathing temporarily arrested, she slipped down in the chair, and the operation was impossible. The child took the mixture well (Case 733), passed into the typical anæsthesia, and three teeth on opposite sides were removed. There was no difficulty in breathing or alteration in colour.

There can be no doubt that oxygen is specially useful in children in preventing "jactitation;" and is more especially useful in such cases as these. The tongue and adjacent parts do not appear to become nearly so swollen as with ordinary nitrous oxide—another point for the operator to bear in mind. An enlarged and swollen

tongue is often very inconvenient to the surgeon.

Furthermore, I have often given nitrous oxide and oxygen to patients who, on previous occasions, have shown such susceptibility to the pure gas that it had been found difficult to secure anything but a very short anæsthesia. Now, in such cases as these the addition of oxygen to nitrous oxide seems to me to be extremely useful. Several months ago I administered nitrous oxide in the ordinary manner to a female domestic servant, about 25 years of age, of very florid colour and good general physique. She was rather nervous, but not more so than the average patient. To my surprise I found that after about twelve breaths of the gas she displayed marked "stertor" and even more marked "jactitation." The movements were so inconvenient that the operator had to wait a few seconds for them to subside. A very short anæsthesia with screaming followed. No pain was felt. I gave her nitrous oxide again on a subsequent occasion and exactly the same symptoms occurred. On three subsequent occasions I administered oxygen with the gas, and with marked benefit. Not only was it possible to prolong the period of inhalation to almost any desired degree, but the resulting anæsthesia, though still somewhat shorter than is usual, was two or three times as long as it had been with nitrous oxide alone.

The following figures, obtained by the use of a métronome in one of these comparison cases, may be of interest. The patient was a healthy young woman of 23 (Case 541). With nitrous oxide and oxgyen she quickly passed into the typical state. Inhalation eighty-four seconds; resulting anæsthesia fifty-six seconds; two teeth extracted; no pain; no reflex movement or phonation. Subsequently I administered nitrous oxide in the usual manner. The inhalation took forty-eight seconds. Two teeth extracted. The second tooth was removed at the twentieth second after the withdrawal of the face-piece, and at this point she screamed. The anæsthesia was reckoned to be twenty-four seconds.

With regard to the use of this mixture in patients suffering from visceral or other diseases, little need be said. Of the cases in which I have myself administered oxygen with nitrous oxide, I have never seen the slightest approach to any dangerous condition, and I have taken all patients indiscriminately. I have given the mixture to a patient with advanced morbus cordis, and to one or two with pulmonary affections of a serious nature. I once anæsthetised a patient who, about a quarter of an hour previously, had fainted two or three times during the attempted extraction of a tooth without an anæsthetic. When I gave her the mixture her pulse was very small and

feeble, and her face quite blanched. She had had no stimulant in the meantime, and was placed vertically in the chair. I gave somewhat more oxygen than usual (Case 713). There was no excitement; the pulse and colour greatly improved as the inhalation proceeded; the administration lasted ninety-six seconds, and the resulting anæsthesia was of sixty-three seconds' duration. The patient's normal colour was completely restored at the termination of the operation.

I also have notes of a very feeble patient, to whom I gave gas with a small quantity of ether a few years ago. The ether was added because the circulation was so depressed. The operation was successfully performed, and without any pain, but the pulse was so weak afterwards that the patient had to be placed on a sofa for some time. Subsequently I anæsthetised her with nitrous oxide and oxygen, and the circulation—not only during the administration, but afterwards—never showed the slightest sign of flagging (Case 408).

Though I have not administered the mixture to any very old patients, I feel convinced that it would be preferable to nitrous oxide itself, as less stress would be thrown upon respiration during the inhalation owing to the presence of oxygen.

Between the time of reading this paper and correcting the proofs, I have given the mixture with much advantage to two patients of 71 years

of age; and I shall certainly continue to employ oxygen in such cases.

With regard to the after effects I cannot speak quite so favourably as I could wish. Speaking generally, we may say that the larger the quantity of any anæsthetic given, the longer will be the time taken for the effects to pass off. Whatever may be the disadvantages of ordinary nitrous oxide, we must all admit that it has one great point in its favour, viz., that the return to perfect consciousness after its inhalation is, with the rarest exceptions, remarkably quick and satisfactory. The speedy return to intellectual activity is connected with the short period of inhalation. As already indicated, we possess in oxygen a vehicle for nitrous oxide—we can introduce any desired quantity of the anæsthetic into the circulation of the patient. But the long period of inhalation thus rendered possible has its drawbacks. Although this prolonged inhalation leads to a longer available anæsthesia, it necessarily also entails a more tardy return of the normal faculties than in the case of nitrous oxide alone. Thus patients are not able to leave the chair quite as quickly as under ordinary circumstances. A feeling of drowsiness and disinclination to move may often be observed. If the patient attempt to walk immediately after the operation he will be liable to exhibit more unsteadiness of gait than

is usual after nitrous oxide free from oxygen. Nausea, retching and actual vomiting, although very rare, are certainly somewhat more liable to occur than after the usual administration of nitrous oxide. It is difficult to speak positively upon this point; and further inquiry is needed.

E.—Conclusions.

So far as my experience has gone, I am inclined to regard the use of oxygen with nitrous oxide as of distinct advantage in the large majority of cases in dental practice. But we cannot shut our eyes to the fact that the administration of the mixed gases involves more time, more attention to detail, and more skill than are essential for the employment of nitrous oxide in the ordinary manner; whilst the risks of unpleasant after-effects are a trifle greater. It hence follows that unless we can show that the gain is considerable, we are hardly justified in advocating any departure from the usual lines of practice. I have attempted to point out that *in many instances* this gain is considerable, and for my own part I shall certainly continue to use the mixture in preference to ordinary nitrous oxide for such cases. But when a very short operation has to be performed upon a patient who has taken nitrous oxide itself on a previous occasion with the best results, when

any additional preparation might alarm a nervous subject, or when time is a matter of great consideration, the use of nitrous oxide *per se* is possibly preferable to that of the mixture. I need hardly remind you that it is not always an easy matter to prophesy the duration of an operation. A tooth which is looked upon as easy of removal often gives trouble, and under these circumstances an additional fifteen or twenty seconds in the anæsthesia may make all the difference in the result of the case.

By the use of the apparatus brought before your notice, an attempt may be made in every case to secure the satisfactory form of anæsthesia which has been described. Should the case turn out to be an exceptional one, nitrous oxide alone can at once be substituted with the best results. In this way every case may be brought to a successful issue. The extra trouble incurred by having a bag full of oxygen in communication with the ordinary nitrous oxide apparatus is very small, whilst the benefits that will result in the majority of cases from the addition of a proper proportion of this gas are very great.

The mixture is to be chiefly recommended, as preferable to nitrous oxide itself—

(1) In children:

(2) In anæmic and debilitated patients:

(3) In any one who has previously exhibited

great susceptibility to nitrous oxide, and has remained a very short time under the influence of the gas :

(4) In patients who, under nitrous oxide itself, have experienced unpleasant sensations :

(5) In patients very advanced in years, and in those suffering from such serious visceral disease that ordinary nitrous oxide seems unadvisable.

In conclusion, I feel that I must tender you my best thanks for having so patiently listened to this communication. I can only hope that others will give this plan of producing anæsthesia an extensive trial, and thus throw fresh light upon the subject.