ON

NARCOTISM BY THE INHALATION OF VAPOURS.

By John Snow, M.D.
Vice-President of the Westminster Medical Society.

[Continued from last vol. p. 985.]

Part XII.

Further remarks on Dutch liquid—its chemical constitution -- its physical properties—its narcotic power compared with that of chloroform—Cases of its administration in tooth-drawing, in midwifery, in cholera—Conclusions.

In a former paper* I gave an account of two or three experiments on small animals with Dutch liquid, by which it was shown that its narcotic properties were of a favourable kind, but that it caused inflammation of the lungs. This latter effect, as I have since ascertained, was occasioned by some impurity—probably sulphurous acid gas—in the specimen of Dutch liquid I then used. I made it myself, by getting the olefiant gas and chlorine to combine in a glass globe, as recommended in Fownes' Chemistry. The olefiant gas was passed through sulphuric acid to separate ether and alcohol, but the sulphurous acid was not separated from it, and I endeavoured to separate that and the hydrochloric acid from the products, when formed, by washing it two or three times in water, but did not succeed, as it since appears. On Mr. Nunnelly recommending Dutch liquid for inhalation last February, it occurred to me that neither the specimen which I had made, nor that used by Dr. Simpson, could have been pure. I accordingly made some more in the same manner as before, but washed it in a weak solution of carbonate of soda previous to distilling it from chloride of calcium. I now got a much less pungent substance,—similar, in fact, to that which I have since received from Mr. Morson and Mr. Bullock. On performing some experiments with it, I found that it possessed the properties which I previously described, with the exception of the irritant ones. I inhaled a little of it myself; but the process of making it being very troublesome and tedious, I had not enough to try its effects in practice till half an ounce was kindly given to me by Mr. Morson on the 20th March, which I used in four cases of tooth-drawing in St. George's Hospital, on the following morning. I have since received several supplies from Mr. Bullock, and have used it in a variety of cases; but, before I describe the results of its application, it will be more convenient to give an account of its chemical constitution, and of those of its physical properties which are intimately connected with its physiological action.

It was discovered in 1795 by the associated Dutch chemists, Bondt, Deiman, Vantroostwyk, and Lauwerenburgh. It is formed by the combination of two volumes of chlorine and two of olefiant gases. The latter, representing one atom, contains four atoms of carbon and four of hydrogen, and is considered to be a hydruret of acetyle,—acetyle being a hypothetic base consisting of four carbon and three hydrogen. When the two atoms of chlorine combine with the hydruret of acetyle, the following is, since the investigations of Regnault, believed to be what takes place. One atom of chlorine displaces an atom of hydrogen, and the hydruret of acetyle is converted into chloride of acetyle, whilst the other atom of chlorine combines with the displaced hydrogen, forming hydrochloric acid, and the two products at the same time uniting, hydrochlorate of chloride of acetyle is the result; and this is the chemical name of Dutch liquid in recent authors. This body is curiously connected with the discovery of chloroform, as was pointed out by Dr. Pereira in a communication on the history of the latter medicine.* Dr. Thomas Thomson, in the edition of his Chemistry published in 1810, gave the name of chloric ether to Dutch liquid, and stated that a solution of it in spirit was useful in medicine as a diffusible stimulant. Some years after this, Mr. Guthrie, a chemist in America, obtained a liquid by the distillation of spirit and water with bleaching powder, which he considered to contain the chloric ether of Dr. Thomson dissolved in spirit; and this product,

* Vol. xlii. p. 331.

* Med. Gaz. vol. xl. p. 953.

which, in fact, consisted of chloroform and alcohol, was used for some time in medicine under the name of chloric ether. In 1831, Soubeiran found that this preparation did not contain Dutch liquid—the chloric ether of Dr. Thomson; and the following year Liebig also made an analysis of it; but, failing to discover the hydrogen in the chloroform, he considered that it was composed of chlorine and carbon; and after this time the medicine was often called ter-chloride or sesqui-chloride of carbon. There are various chlorides of carbon which have been discovered by Faraday and Regnault; but they are very difficult to make, and I believe that none of them have ever been on sale, either for medical or other purposes, and that the so-called chlorides of carbon which have been used in medicine were all of them solutions of chloroform, of which body Dumas was the first to ascertain the true nature and composition.

Dutch liquid is somewhat heavier than water, having a specific gravity of 1·247. It boils at 180° Fah. It is very sparingly soluble in water, and the specific gravity of its vapour is 3·4484. In sensible properties it very nearly resembles chloroform; and hence probably the reason of Mr. Guthrie, when he discovered the latter substance, mistaking it for Dutch liquid. The odour is not quite so fruit-like as that of chloroform, and the vapour feels less pungent; but the reason of this is that a smaller quantity of vapour is given off from Dutch liquid than from chloroform; for I find that when the two vapours are diluted to the same extent—for instance, till the air contain five per cent., and inhaled from a balloon, there is then no difference in the pungency. The physical properties of Dutch liquid which are most intimately connected with its narcotic action, when inhaled, are its volatility and solubility. From some experiments before related it was concluded that in the second degree of narcotism the blood contains one-fiftieth part as much as it would dissolve, and in the fourth degree one twenty-fifth part. These experiments have been repeated with the liquid quite free from impurity, and the results obtained were the same.

I have endeavoured to ascertain the solubility of Dutch liquid as accurately as possible, by admitting small quantities of water to air saturated with the vapour, and confined over mercury in a graduated receiver. The average of a number of experiments gives 1·7 volume of vapour as the quantity that one volume of water will dissolve; and, the liquid being 321 times as heavy as its vapour at 100°, it results that, at this temperature, one part of the liquid would require 189 parts of water to dissolve it.

If the average quantity of serum in the body be assumed to be the same as in treating of chloroform, and a calculation be made of the kind there given,* it will be found that the amount of Dutch liquid in the blood, in the second degree of narcotism, is rather more than twenty minims, and in the fourth degree forty-one minims. In the third degree the amount would be intermediate, viz. about thirty minims. These quantities are nearly twice as large as in the case of chloroform; and this agrees exactly with what I have met with in practice, since nearly twice as much Dutch liquid has been required to cause insensibility as would have been required of chloroform. To estimate the strength of this substance when inhaled, its volatility requires to be taken into account, in addition to the above data. Whilst 100 cubic inches of air at 60° will take up 14 cubic inches of chloroform, they will only take up seven cubic inches of Dutch liquid; and the vapour, moreover, is not so heavy as that of chloroform,—consequently it is not half so volatile. This makes the difference in strength between the two agents still greater. To exhibit more accurately their relative power, the quantity of air may be calculated that a patient would require to breathe, when saturated by either of the two vapours at 60°, in order to be rendered insensible. Eighteen minims is the average amount of chloroform in the blood in the third degree of narcotism, the stage usually required for a surgical operation, and as about as much is expired again without being absorbed, thirty-six minims is about the quantity inhaled before an operation. This would require only 257 cubic inches of air to take it up if saturated at 60°, the air becoming expanded to 294 cubic inches.

* Vol. xli. p. 850.

Thirty minins of Dutch liquid require to be absorbed, as stated above, to induce the same amount of insensibility, and sixty minims would have to be inhaled. This quantity requires 904 cubic inches of air to allow it to be converted into vapour at 60°, the air being expanded to 967 cubic inches, an amount more than three times as great as requires to be inhaled in the case of chloroform; and consequently Dutch liquid has less than one-third the power of the former when inhaled in a similar way. Sulphuric ether is rather stronger than Dutch liquid—the quantity of air saturated with its vapour that is required to induce insensibility being rather more than 800 cubic inches.

For the reasons given above, Dutch liquid is much slower in its action than chloroform;* and whilst the chief endeavour in giving chloroform is to prevent the air from getting too strongly charged with the vapour, in giving Dutch liquid the endeavour is to get the air to take up sufficient of it. In one case, indeed, that of an infant in King's College Hospital, on which Mr. Fergusson operated for nævus, it failed to induce insensibility with the inhaler I was using (one contrived for chloroform), although continued for three or four minutes, and rather than cause further delay chloroform was used.

For reasons similar to those which render Dutch liquid slower in its action, when its effects are once produced they are more persistent than those of chloroform. Medicines so volatile as these escape from the system almost exclusively by the lungs; and as the quantity of Dutch liquid in the blood during insensibility is greater than that of chloroform, it would be longer in escaping, even if it could be exhaled at the same rate; but, being less volatile, it cannot. There is a continual tendency to equilibrium between the elastic force of the vapour in the blood and that in the air contained in the pulmonary cells: and if the blood contain, for instance, one-thirtieth part as much of a volatile liquid as it could dissolve, each cubic inch of air which reaches the cells of the lungs is capable of taking up one-thirtieth part as much as would saturate it at 100°; but this quantity is twice as great in the case of chloroform as in that of Dutch liquid. The longer duration of the effects of the latter substance as compared with the former has been very marked in a number of experiments on animals, as well as in practice.

Although, as above stated, a greater quantity of Dutch liquid than of chloroform is required to induce insensibility in the first instance, yet in cases requiring the continued inhalation of the vapour there is but little difference in the amount used; since, from the more persistent effect of Dutch liquid, it does not require to be repeated so often.

The following are the cases in which I have tried the effects of Dutch liquid:—

1. On March 21, 1849, a young woman, about 25 years of age, inhaled it, in the out-patients' room of St. George's Hospital, previous to having a tooth drawn. She was nervous and hysterical, and was alarmed at the inhalation, although very anxious to avoid the pain. She inhaled from the apparatus described before,* between one and two minutes, when she strongly requested to leave off. The tooth, a first lower molar, firmly fixed, was immediately extracted with the forceps by Mr. Parkinson, dresser to the surgeon for the week. The patient cried out slightly as the tooth came out. She said afterwards that the removal of the tooth did not hurt her so much as the lancing of the gum on a previous occasion. In a few minutes the partial stupor caused by the vapour had subsided. This patient was not rendered quite unconscious, but the sensibility, and consequently the pain, were apparently diminished.

2. Another young woman inhaled the Dutch liquid immediately afterwards. She breathed it very steadily. The pulse became increased a little in frequency and force soon after she began to inhale, and the face at the same time became slightly flushed. There was no further symptom, and no alteration in her appearance till nearly four minutes had elapsed, when volun-

* A preparation consisting of equal parts of chloroform and spirit was fraudulently introduced into the drug-market last spring, and sold to a considerable extent as Dutch liquid, although not containing any of that body. This counterfeit liquid would cause insensibility with nearly the same rapidity as chloroform.

* Vol. xlii. p. 843.

tary motion ceased in the eyes and eyelids, and the pupils were turned upwards. The inhalation was now discontinued when she had inhaled just four minutes. The muscles of the jaw were rather rigid, but the mouth was easily opened by making a little pressure on the chin, and a bicuspid tooth was extracted with the forceps by Mr. Parkinson, without causing the least flinch, cry, or altered expression of countenance on the part of the patient. Immediately after the tooth was extracted she opened her eyes, looking bewildered at first, but in one minute after the inhalation ceased she regained her usual expression, and began to wash out her mouth. She said that she had felt nothing. Three minutes afterwards she left the hospital feeling well. The narcotism, in this case, just reached the third degree, and there was complete immunity from pain, as indeed there generally is under the effects of chloroform carried to the same extent, when it is inhaled slowly. The recovery was as prompt as it usually is from chloroform; but it should be noticed that when the inhalation of that vapour is left off just when the symptoms reach the point indicated in the above case, the patient usually begins to recover immediately, even before there would be time to extract a tooth. Two fluid drachms of Dutch liquid had been put into the inhaler, and it was not quite all used by these two patients. A drachm more was added when the next patient commenced to inhale.

3. This patient was a labouring man, between 30 and 40 years of age. Soon after beginning to inhale he commenced to laugh, and he kept the corners of his mouth stretched so widely apart that it was difficult to make the face-piece fit exactly. In about five minutes he appeared to have lost his consciousness, and he muttered incoherently. He soon afterwards became unruly, and was with difficulty kept in the chair. The conjunctiva remained sensible, and he flinched when a hair of his face was pulled. Although he inhaled a few minutes longer, he did not become further affected; the reason of this being, as I afterwards found, that the Dutch liquid in the inhaler was finished. There was great difficulty in getting the mouth open, not from spasm but from voluntary resistance exerted under the influence of some obscure dream. The patient flinched as the tooth was extracted; but on recovering his consciousness two or three minutes afterwards, he said that he had felt nothing. The truth probably is, that the feeling had been obscure, and there was no recollection of it. He complained, however, of giddiness, and began to look pale and sick. In a few minutes he vomited, and then complained of headache. He was complaining of headache and sickness half an hour afterwards, when I left him, expecting that these symptoms would soon subside. But I afterwards found that they continued so severe, with occasional vomiting, that he was kept in the hospital till the following morning, when he left, but came back in the forenoon, complaining that he could not go on with his work. Mr. Hammerton ordered him some medicine containing ammonia, and directed him to return the next morning if he should not feel well. He did not apply again.

This is the only case in which I have seen Dutch liquid followed by distressing sickness or headache; and the result might have been the same if chloroform or ether had been used, as such symptoms do now and then follow their use, though rarely to the same extent as in this case.

4. In the above cases the water bath of the inhaler was at the temperature of 60°; in this case it was raised to 70°. Fifty minims of the medicine were put into the inhaler, and a little girl, six years old, inhaled for two minutes. At the end of this time she became insensible, the pupils of the eyes being turned upwards. A decayed molar tooth was extracted without causing the least flinch or cry. In about a minute after the inhalation ceased, the child became conscious, but staggered on attempting to walk. She vomited a little, two or three minutes after this, but in a few minutes more was free from sickness, and pretty well. The fifty minims were not all consumed by this patient.

5. The subject of this case was a patient of Mr. Marshall, of Greek Street, in labour with her second child, on April 24. I exhibited twenty minims of Dutch liquid (all I had with me at the time) during the last three or four pains which expelled the fœtus. The

patient ceased to complain, but continued her expulsive efforts. She was not rendered quite unconscious, but her sufferings were greatly alleviated, being, as she said afterwards, much less severe than before, whilst without the inhalation they would have been much greater. Mr. Marshall was present and attending to the labour. In this and the next three cases the vapour was administered by means of a small inhaler, which I commonly use for giving chloroform in midwifery cases; it consists of the same face-piece which forms part of my other inhalers, and of a short curved metallic tube, lined with bibulous paper.

6. Having expressed a wish to Dr. Murphy, Professor of Midwifery in University College, to try Dutch liquid in some cases of labour, I was called on by him on the day on which the last of the above cases occurred, and accompanied him to a patient of Mr. Jakins, of Osnaburg Street, who had been forty-eight hours in this, which was her first labour. Dr. Murphy, who is about to give the particulars of this and the next case to the profession, found it necessary to divide a thick dense band, extending across the vagina, and also to make an artificial os uteri, and deliver with the forceps. Half a drachm of the liquid being inhaled, it gradually induced a state of unconsciousness, during which the speculum vaginæ was introduced; the uterine contractions and slight expulsive efforts continued as before. A little more Dutch liquid was put into the inhaler, from time to time, so as to keep the patient unconscious. The pupils of the eyes were turned upwards during part of the time. No mental excitement or muscular rigidity was occasioned. Dr. Murphy proceeded to make an artificial os uteri, and to divide the ligamentous band. These operations were partly performed when my stock of Dutch liquid, about three fluid drachms, was all used. It had kept up insensibility for about an hour. Chloroform was now given, so as to keep the patient constantly insensible to the end of the delivery. There was little appreciable alteration in the symptoms on passing from the use of one vapour to that of the other. The effects induced were of the same kind, but they were produced with much less inhalation in the case of chloroform; a few inspirations, now and then, with the valve partly open, sufficed instead of the previous more lengthy inhalation, with the valve closed. The delivery was effected with the forceps about an hour after the inhalation of chloroform commenced, half a fluid ounce of which was used, being a larger quantity than was used of Dutch liquid in the same period; but the patient was kept more deeply insensible during the whole of this latter period than in some part of the first hour, when the operation had not yet commenced. The child was born alive, but breathed feebly, and died next day. The placenta was expelled without hæmorrhage a few minutes after the birth of the child. The patient was quite conscious ten or fifteen minutes after the inhalation was discontinued; and after being bandaged and placed in a comfortable posture, she fell asleep, and slept almost uninterruptedly for twelve hours. She recovered very favourably.

7. On May 18, I administered the Dutch liquid at the request of Dr. Murphy, to a primipara, 35 years of age, who had been 48 hours in labour, when he resolved to deliver with the forceps. Half a drachm was put into the inhaler: the patient objected to the vapour at first, on account of its pungency, but afterwards inhaled readily, and in about two minutes appeared unconscious, the pupils being turned upwards, and the eyelids firmly closed, and resisting the attempt to open them. Dr. Murphy now began to introduce the forceps, and the patient cried out a little: another half drachm of the liquid was put in, and she soon became quiet, and was kept insensible till the birth of the child, which was effected in less than half an hour. She talked in a rambling manner about some ordinary topic once or twice during the inhalation, and also a few minutes after it was discontinued. Two fluid drachms were used in all. The placenta was expelled ten minutes after the birth of the child; soon after this the patient vomited; and fifteen minutes after the birth (the time when the inhalation was left off), the patient began to regain her consciousness. She recovered very favourably, and the child is living.

8. The Dutch liquid was administered in a case of cholera that Mr.

Marshall, of Greek Street, requested me to see with him. The patient was a child seven years old, which had been ill twelve hours. The stools were copious and watery, and devoid of fæcal colour or odour; the vomiting was constant and severe; the features were sunken, and the pulse was about 160 in the minute, and so feeble as to be felt with difficulty. There were jactitation and great uneasiness, the latter probably resulting from cramps. Twenty minims were inhaled, which produced a state of unconsciousness and quiet, from which the little girl awoke in ten minutes. The same quantity was again inhaled, with a like effect, and of rather longer duration. The pulse was improved by the inhalation, being rendered stronger and less frequent; but the chief symptoms of the disorder went on as before. The child recovered.

The relief from inhalation of chloroform in cholera has generally been greater than this in the cases I have witnessed, the unconsciousness having generally merged into a natural sleep, of from half an hour to two hours and a half in duration, during which time of course the patients were free both from sickness and spasm. Two of the cases were also under the care of Mr. Marshall. I attribute the different action in the above case to some difference in the state of the patient, rather than in the properties of the narcotic.

9. On July 18, a boy, nine years old, inhaled Dutch liquid in the out-patients' room of St. George's Hospital, from the balloon described in my last communication. Each hundred cubic inches of air in the balloon contained four minims of the liquid, or a small fraction over four cubic inches of the vapour. In two minutes consciousness was removed; he then began to resist the further inhalation, but with a little trouble was got to inhale two minutes longer. He was not narcotised beyond the second degree. Voluntary motion was never abolished, but the sensibility of the conjunctiva was diminished. Two incisor teeth of the first set were extracted without being felt (probably without the inhalation there would have been no great pain). He was laid on the bed, and in two minutes recovered his consciousness, but staggered on getting up. In about ten minutes the effects of the vapour had apparently gone off. He inhaled about 1000 cubic inches, and consequently 40 minims of Dutch liquid; this quantity of chloroform would have rendered an adult of twice his weight fully as insensible as he was, if not more so.

The result of my observations and investigations is, that I cannot unite with Mr. Nunnelly in his general praises of Dutch liquid. The only advantages which it possesses over chloroform, in any case, are such as are connected with its slower action and more persistent effects, — properties that Mr. Nunnelly failed to recognize. In all other respects its effects appear to be the same as those of chloroform. It is undoubtedly a very safe anæsthetic; but I doubt very much whether practitioners would be content to wait for its slower action, after they have been accustomed to use chloroform, even if it could be obtained at the same cost, of which there is no prospect. In whatever way Dutch liquid might be used, it would not suddenly occasion a fatal accident without giving due warning; in this respect it resembles ether. Advantage might be taken of its more persistent effect in some operations in the face, in which it is difficult to administer a vapour after the surgeon commences; and also in cases in which the operator is without an assistant, and has to make his patient insensible first, and then to perform his operation. In obstetric practice it would perhaps be more convenient than chloroform, when only one medical man is present, as he might intrust the inhaler to the nurse, and look up two or three times in a minute to give directions; but when there is a practitioner entirely to superintend the inhalation, chloroform has the advantage, as it can be given to the requisite extent just as each pain commences, and the patient can be allowed to recover from its effects, more or less, between every pain.

[To be continued.]

ANALYSIS OF BLOOD RECENTLY SUCKED BY LEECHES.

M. Reveil having by compression expelled the blood from several leeches that had recently sucked, states that having analysed it he found it to be free from fibrin, which he supposes was so far separated by digestion, that the pressure did not expel it from their bodies.—*Journal de Chimie Médicale.* X