mucous membrane. A patch test to dentures was strongly positive. He was fitted with "plastic" dentures, and when seen again on March 7, 1949, the cracks had gone and the stomatitis was cured.

Case 6.—A woman aged 39 came to the out-patient department on May 14, 1949, with an infected mole. Angular stomatitis had been present for five and a half years; she had worn vulcanite dentures for about six years, and examination revealed the characteristic redness of the denture-contact area. A patch test when first tried was negative, but when repeated a delayed positive result was obtained. She was fitted with new teeth and the cracks have now healed.

Case 7.—A woman aged 58, seen on July 30, 1949, had had cracks at the angles of the mouth for many years despite many different kinds of treatment. She has worn black vulcanite dentures for 35 years. The mucous membrane showed the characteristic appearance, and a patch test to the denture was strongly positive. She has now stopped wearing dentures and the condition is much better.

Comment

These cases establish the association between denture sensitization and angular stomatitis. It is of interest that all these patients were in the habit of keeping their artificial teeth in at night, and it is reasonable to postulate that such a practice leads more readily to the establishment of a contact sensitization. In view of the numbers of dentures worn this condition is relatively uncommon, but in all the above cases the gum sensitivity was discovered only by direct questioning and examination, so that probably many cases are missed.

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ANALGESIA INHALER FOR TRICHLOROETHYLENE

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Of the births in England and Wales 65% are supervised by midwives (Ministry of Health, 1946). In this circumstance the problem of the relief of pain is of lively interest to nearly half a million mothers a year, but is not easy of solution. The medical practitioner can choose the anaesthetic drug and vary its concentration to meet the requirements of any particular patient at any particular moment. The midwife, however, because of her limited training in anaesthesia, is at present restricted to apparatus set automatically to deliver 50% nitrous oxide and 50% air. This apparatus of Minnitt's (1938) has proved safe, but complaints are common that it is cumbersome, and in some hands the relief from pain it affords is disappointing. This may in some degree be attributable to the fact that the female is not mechanically minded, and gas-and-air apparatus does

indeed need a modicum of attention from time to time. Whether more latitude should be allowed to midwives in the way of new apparatus and drugs is a serious question. Increased relief from pain is easily achieved by raising the percentage of any anaesthetic vapour inhaled, but, quite apart from any noxious effect this may have on the foetus, it carries with it the possibility that unconsciousness and its many attendant dangers may be produced in a susceptible patient; and it must be faced that the midwife is not adequately trained to meet such a situation. With this limitation in mind work is being carried out at various centres with the object of providing better relief of pain with apparatus as safe as Minnitt's, which has rendered such useful service for the past 15 years, but more portable and less likely to present technical difficulties to midwives.

There seems to be a widespread opinion that trichlorethylene is a good analgesic agent; when carefully given it affords very considerable relief of pain without markedly impairing consciousness. In 1943 Freedman introduced a small inhaler for trichlorethylene which, under certain conditions at any fixed ambient temperature, delivers a substantially constant concentration of vapour. This inhaler proved highly convenient and successful in some hands—so much so that on the recommendation of the Anaesthetics Committee of the Royal College of Obstetricians and Gynaecologists extensive clinical trials were carried out at various hospital centres to discover whether the apparatus was suitable for use by midwives in domiciliary practice (Royal College of Obstetricians and Gynaecologists Annual Report, 1947). As a result of these trials the committee reluctantly decided that the apparatus was not satisfactory, and this view was supported by laboratory tests which showed that, even if the apparatus is kept still, the concentration of vapour in the inspired air increases by 60% for a temperature rise from 20 to 30° C. Furthermore, marked fluctuations in concentration result from filling, shaking, or tilting the inhaler.

Constant Vapour Concentration

Before discussing the design of trichlorethylene inhalers delivering a substantially constant vapour concentration, the question naturally arises whether any fixed concentration of this drug in air would improve on the relief from pain afforded by the Minnitt gas-air apparatus and yet not be dangerous.

Special trichlorethylene inhalers in which the concentration could be varied at will in accurately known steps were handed over to our colleague Dr. E. H. Seward, and his observations (1949) suggest strongly that: (a) A trichlorethylene concentration of 0.5% v/v in air can be inhaled intermittently during labour over long periods. (b) After about three hours a slight cumulative effect may become noticeable in some patients. If in these cases the concentration is now reduced to 0.35% v/v this tendency is halted. (c) A very large proportion of patients prefer this method of pain relief to that afforded by gas and air.

In the design of apparatus to deliver a constant concentration of vapour of an anaesthetic liquid one of the main difficulties to be overcome is the effect of variation of vapour pressure with temperature. This can be obviated either by keeping the anaesthetic liquid in a thermostat, as for example in the Oxford vaporizer, or by introducing a compensating device which, for any rise in temperature, reduces the amount of vapour leaving the vaporizing chamber. The latter method was adopted by Goodman Levy (1905) in the design of his chloroform inhaler. During the last war this department was asked to produce a dosimetric chloroform inhaler for paratroops. The resultant

E.S.O. (Epstein-Suffolk-Oxford) apparatus also was based on the second method, and utilized a compensating device which reduces the amount of air drawn through the vaporizing chamber when the temperature of the liquid rises. This apparatus stood up to vigorous tests for robustness, and gave satisfactory results both in the laboratory and clinically. Many of the principles of the E.S.O. apparatus have been incorporated in the analgesia apparatus to be described.

A Hand-operated Inhaler

In our search for a constant-concentration inhaler for trichlorethylene analgesia various experimental models were constructed with devices—some hand-operated, others automatic—to keep the inhaled vapour concentration constant despite any changes in temperature of the liquid or the surroundings. Several of these models have given encouraging results in the labour wards of this hospital for the past year. An apparatus with an automatic temperature control has an obvious advantage, but a hand-operated control is more robust and foolproof, and we incline to the belief that it will be more satisfactory in the long run. On this account we confine ourselves at the moment to a consideration of a hand-operated model, a photograph of which is shown in Fig. 1; the diagram (Fig. 2) is intentionally schematic.

When the patient inspires, the non-return valve (NV) opens and air enters through a variable opening (a2) into the trichlorethylene chamber and emerges mixed with vapour; another current of room air is drawn through the permanently open by-pass of fixed size (a1) and dilutes the mixture issuing from the vaporizing chamber. If for a given size of inlet orifice (a2) and for a given temperature the concentration inspired by the patient is 0.5%, any change in temperature would alter this concentration. In

FIG. 1.—Photograph of a hand-operated model inhaler.

order to maintain a constant concentration despite the change in temperature, compensation is effected by making the size of the air port (a2) variable. In the model illustrated the concentration can be kept constant over a temperature range from 12 to 37° C. (54 to 98° F.).

On the dial of a metal thermometer (Th) are five equal sectors, each of a distinctive colour; the centres of these sectors correspond to the following temperatures: green 15° C., orange 20° C., blue 25° C., yellow 30° C., red 35° C. The movement of the compensator handle (CH) increases or diminishes the inlet (a2) to the vaporizing chamber, and the compensator handle can be set in any of five positions coloured to correspond with the colours on the five sectors on the thermometer dial (Th).

FIG. 2.—Schematic diagram of the apparatus.

The apparatus is so constructed that the patient breathes 0.5% trichlorethylene vapour whenever the compensator handle is set to correspond to the sector which contains the thermometer pointer at that time. If, for example, the thermometer pointer lies within the blue sector, the compensator handle has to be set to the "B" mark. It is obvious that at high temperatures, when the thermometer registers in the red field and the compensator handle is set to "R," the inlet (a2) will be at its smallest; when the temperature is low enough to register in the green sector and CH is correspondingly set at "G," the opening (a2) will be maximal.

The heat capacity of the inhaler and heat transfer are such that the temperature of the anaesthetic liquid drops little during use in a room of reasonably constant temperature. If the temperature of the surroundings changes suddenly the internal temperature of the inhaler will follow, but only slowly. In practice, therefore, CH rarely needs to be reset. The statement that so long as CH is set to correspond to the colour indicated by the thermometer pointer the concentration of trichlorethylene vapour will be 0.5% needs but slight qualification. If the thermometer pointer is at the centre of a sector, say B, and CH is set to position B, the delivered concentration will in fact be 0.5%. If the pointer is in the right half of the sector, as shown in the diagram, the concentration will be slightly higher, and vice versa. If the pointer registers at the extreme right-hand side of a sector the concentration rises to 0.55%. However, we believe that in clinical practice such fluctuations of $\pm 10\%$ in the vapour concentration are of little importance, and in speaking of "constant concentrations" possible variations within these limits are implied. It should be mentioned here that our analyses of vapour-air mixtures were carried out on samples of 2-3 litres.

The mechanism which permits delivery of a "weak" mixture (0.35%) instead of the "normal" concentration discussed so far is not shown in the diagram. It consists of a small disk which when rotated to the "weak" position opens a second air by-pass in addition to the permanent one (a1).

Besides changes in temperature other considerations must be borne in mind when designing an inhaler to deliver a fixed concentration of vapour. Unless care is taken, considerable fluctuations result from variation in the depth or rate of breathing. In the various models we have constructed the concentration remains practically constant for a range of respiratory volumes of from 6 to 15 litres per minute at rates from 12 to 30. Overfilling the vaporizing chamber with trichlorethylene is prevented by an overflow. Slow filling which occurs when the filler is at the low level of the overflow is avoided by placing the filler on top of the inhaler. Liquid does not spill to the outside during transport or if the inhaler should fall over. A glass level gauge permits an estimate of the consumption, and indicates by the "full" mark when no more liquid should be poured in. If this is overlooked the overflow comes into action almost at once. One filling is more than sufficient for a long case.

In view of the considerable cross-section of the vaporizer chamber, a special device is incorporated to give a reasonable movement of the level between "full" and "empty" corresponding to 1½ fl. oz. (42 ml.) of free liquid. The concentration of vapour remains constant whatever the position of the liquid level between the "full" and "empty" marks. Moreover, even if the level sinks out of sight, and the inhaler continues to be used, the concentration of vapour remains constant for at least three hours by virtue of trichlorethylene held in wicks. Despite the fact that the inhaler has a clearly visible liquid level—a not inconsiderable advantage—the concentration of vapour inhaled does not rise when the liquid has just been added to the inhaler, nor after the inhaler has been accidentally shaken, turned on its side, or completely inverted. These refinements would be futile if the permanent air inlet (a1) could be blocked, for the inhaler would then be dangerous in unskilled hands: accidental or intentional obstruction of this inlet has been made practically impossible. A feature of the apparatus is its low resistance to respiration compared with gas-air machines; inspiration is therefore more comfortable, and leaks due to an ill-fitting face-mask will be of less consequence in diluting the mixture reaching the patient. The apparatus is easily portable and weighs 11½ lb. (5 kg.) complete in its transit case, measuring 11 by 7 by 8 in. (27.5 by 17.5 by 20 cm.).

Some Practical Points

In using the inhaler care must be paid to three elementary points: (1) see that the liquid level lies between "empty" and "full"; (2) set the compensator handle to the colour indicated by the thermometer pointer; (3) if drowsiness or uncooperativeness should manifest itself the small disk previously referred to should be turned from "normal" to "weak," thus reducing the inhaled vapour concentration from 0.5 to 0.35% v/v.

It is unlikely that attention will have to be paid to any of these points during the course of an average labour. A very occasional glance at the thermometer pointer and control handle to confirm that the colours still coincide, and a look at the level gauge to see that it contains liquid, are all that is necessary. Movement of the non-return valve underneath its glass dome shows that the face mask fits reasonably well.

We are indebted to Imperial Chemical Industries Limited for a generous grant to meet laboratory expenses, and to our obstetrical colleagues in the United Oxford Hospitals for their willing co-operation. The apparatus in question can be obtained from the Medical and Industrial Equipment, Ltd., 12, New Cavendish Street, London, W.1, who contributed their usual enthusiasm and skill in production.

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Medical Memorandum

Recovery from Botulism

Botulism is a rare condition in this country and has a very high mortality. All of the eight affected persons succumbed in the Loch Maree outbreak of 1922. The mortality is generally considered to be at least 50%.

CASE REPORT

A woman aged 33 had an evening meal of canned tongue shortly after Christmas, 1948. The tin appeared normal, and the contents, which received no further cooking, had no unusual taste. In the early hours of the next morning she awoke with severe headache and nausea, followed by profuse vomiting. In spite of feeling very ill, she got up and went for a drive with her husband. She continued to vomit intermittently throughout the day. On returning home she found that her face was crooked and drawn to the right side. The same night the vision in the left eye was misty and swallowing had become difficult; fluids were regurgitated through the nose. For the next few days she remained in bed with mild pyrexia up to 100° F. (37.8° C.) and continued to vomit. Constipation was severe. On getting up after ten days she noted some weakness of the left leg. The difficulty in swallowing and in using the left eye persisted.

I first saw the patient on February 19, 1949, seven weeks after the onset of symptoms. The condition had not been diagnosed at the onset and consequently no antitoxin had been administered. The following signs were present: moderate dilatation of the left pupil, which was active to light but inactive on accommodation and convergence; slight left-sided ptosis; and complete paralysis of the left masseter, temporal, and pterygoid muscles. There was no facial anaesthesia and the corneal reflex was present. The left facial muscles were completely paralysed, with the exception of the orbicularis oculi, in which there was a faint contraction. Taste was normal on the left, but there was hyperacusis in the left ear. Both sides of the palate were weak. Examination of the limbs showed no abnormality other than a moderate weakness of the dorsiflexors of the left foot. The superficial and deep reflexes were normal, and there was nowhere any change in cutaneous or deep sensation.

Twenty-four hours after eating the suspected meat the patient's daughter had an attack of vomiting which continued for two days. There was no involvement of the nervous system. The patient's husband, who also ate the same meal, was unaffected.

The history of gastro-intestinal symptoms occurring a few hours after the ingestion of tinned meat and followed by paralysis of cranial nerves some hours later is characteristic of affection by the toxin of *Clostridium botulinum*. The site of action of this toxin is uncertain, but its action is probably peripheral (on the motor-nerve endings in striated and non-striated muscles) rather than central, and this theory is borne out by the absence of reflex or sensory disturbance and the ultimate complete recovery in those patients who survive the initial acute phase (Dickson and Shevsky, 1923; Cowdry and Nicholson, 1924).

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