a test by which bad oil may be distinguished from the harmless one.

While the problem of the aetiology of epidemic dropsy cannot be said to have been completely solved, a definite advance has been made and a stage has been reached when preventive measures, based on scientifically proved facts, can be recommended, though their application is limited to a certain extent by the absence of knowledge about the nature and origin of the deleterious substance in the mustard oil. It should now be the duty of the health administrator to trace the oil which has caused the disease to its source as soon as he comes across cases of epidemic dropsy, and to prevent its further distribution. He should also prohibit its use for cooking purposes. The discarded oil may be used for oil baths, as it is probably harmless when applied externally. Besides, there are many other uses to which this oil can be put. The length of the incubation period or the lag phase—five days for premonitory symptoms and nine to twenty-three days for development of oedema, as noticed in our human experiments—should be of assistance in tracing the bad oil. By adopting the measures recommended above it should be possible to prevent the spread of the disease among those who have not yet partaken of the oil and to reduce the severity of the disease in those who have taken it in just sufficient quantities to cause premonitory symptoms.

Summary

1. A brief statement is given of the results of epidemiological studies in connexion with outbreaks of epidemic dropsy in seven localities in Bihar, Bengal, Assam, and Orissa, representing rural, semi-rural, urban, and industrial conditions.

2. An epidemiological experiment designed to test the contagiousness of the disease in a semi-isolated community is briefly described.

3. Three principal theories of the aetiology of the disease are discussed, and it is shown that the observed facts fail to support the "diseased-rice" theory and the "contagion" theory. A very satisfactory explanation of these facts is provided by the hypothesis that epidemic dropsy, as commonly seen in these provinces, is caused by a deleterious substance contained in certain consignments of mustard oil.

4. Experiments on human subjects, living under strictly controlled conditions, are described. They show that signs and symptoms of epidemic dropsy are produced in healthy young men by giving them food cooked in a brand of mustard oil which is strongly suspected, on epidemiological grounds, of being responsible for an epidemic—the "diseased" rice having been altogether excluded from the experimental food.

5. Practical application of these findings is discussed.

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AN INEXPENSIVE FLOW METER AND HUMIDIFIER FOR ADMINISTERING OXYGEN

BY

E. P. POULTON, D.M., F.R.C.P.

Physician to Guy's Hospital

For the efficient administration of oxygen the rate of flow must be known, and this is particularly important now that its relation to the percentage of oxygen in the alveolar air has been established for many different methods of administration. The dial flow meter which is often added to the reducing valve of the oxygen cylinder, because it is really a pressure gauge, may give inaccurate results, and the apparatus recently described by Marriott and Robson is expensive since most of the parts have to be specially made and each apparatus must be calibrated by experiment.

The Apparatus

The present flow meter consists of two tins with lids (A) 7 inches high and 3½ inches in diameter, soldered on to a piece of tin plate (see Figure). These tins are con-

nected 1¼ inch below the top by an accurately drawn German silver (nickel) tube (C-C) 3½ inches long, with a diameter between 107 and 108 thousandths of an inch; the tube projects for some distance into each tin. The oxygen passes in and out of the flow meter by the side tubes (B); the nickel tube provides a resistance so that the pressure in the proximal tin is higher than in the distal tin, the flow being measured by the difference between these pressures. The pressure gauge consists of

two short pieces of small-bore metal tubing (D) soldered into each tin near the top, so that they bend downwards into the opening of a boiling-tube (F), 6 inches long, 1 inch in diameter, which is held up against and so supported by the nickel tube; two glass tubes attached by rubber connexions to the tubes D pass down to the bottom of F, which is filled with water, tinted with red ink, to such a height that when in use the surface of the water in the distal tube is level with the zero of graduations marked on one or other of the tins. Then the level in the proximal tube gives the volume of the flow in litres per minute.

Before making up the apparatus the lumen of the nickel tube must be seen to be clear and the openings smooth; when finished the appliance is painted inside and out with several layers of cellulose paint to prevent rust, care being taken that the ends of the nickel tube are not painted over. The apparatus has also been made out of tinned copper. Any slight variation in the length of the nickel tube will not matter, but the diameter should be correct to within a thousandth of an inch. The calibration is as follows:

Pressure difference (mm.)	6.5	9	17	27	40	48	57	67	76	85	95	115
Flow 1 per minute	1.5	2	3	4	5	5.5	6	6.5	7	7.5	8	9

In using the instrument the flow must always be increased up to the value required; too high a reading will be obtained if the flow is diminished from a higher to a lower value. To humidify the oxygen up to 60 or 70 per cent. relative humidity an ounce of water is poured into each tin. The oxygen passes over and not through the water.

Advantages of the Apparatus

Flow meters arranged on this principle have been in use for many years, and the only advantages claimed for the present arrangement are that these flow meters can be made up in quantity in the works department of a hospital for a few shillings each, so that where oxygen is often used there should be no difficulty in supplying two or three to each ward; no experimental calibration is required, and the flow meter is unbreakable apart from the glass parts, which are renewable from stock; the pressure gauge acts as a safety-valve. The flow meter registers from $1\frac{1}{2}$ to 9 litres or more per minute; resistance to outflow—for example, from a small nasal catheter—makes no difference to the accuracy; but peripheral resistance should be as low as possible.

Theoretically the apparatus consists essentially of one narrow tube connecting two wider tubes. I should like to thank Mr. E. M. Poulton for pointing out at an early stage of the work that unless the two wide tubes were large in diameter in comparison with the nickel tube the flow would have an inverse relation to the diameter of these larger tubes; such was proved to be the case, and consequently two relatively large tins were chosen.

The narrow orifice between convergent and divergent conical tubes was developed by Clemens Herschel in 1881 for commercial gas meters. He called it the venturi opening, after E. B. Venturi, the Italian who described it before A.D. 1800. The essential element is the divergent cone which guides the stream of air as it issues from the orifice and modifies by its dimensions the relation between pressure and velocity. The name is hardly appropriate to the present arrangement, because the stream issues into a large open space and is not guided in any way. The flow of air or liquid along smooth round tubes has a stream-

line flow at low velocities with the pressure difference proportional to the velocity of the flow; at higher velocities the stream becomes turbulent and the pressure difference is proportional to the square of the velocity. The velocity at which the flow becomes turbulent can be determined by the expression $\frac{VDW}{\mu}$ (Reynolds's criterion),

where V is the velocity, W is the density, μ is the coefficient of viscosity, and D is the diameter of the tube along which the gas is flowing.

In the present case calculations, for which I am indebted to Messrs. George Kent, Ltd., show that in the ordinary use of the apparatus the velocity of oxygen in the tube is in the "mixed" or "unstable" region between streamline and turbulent flows, and at 8 litres per minute the pressure required to force the oxygen through the tube was due five times as much to turbulence as to viscous resistance between the fluid and the wall of the tube. This indicates that the length of the tube is not of great consequence in determining the velocity; but the diameter and the square-cut, clean, circular nature of the entry are all-important, because most of the pressure difference takes place at this point, while there is little change of pressure at the point of exit. The essence of the venturi opening is that the loss of pressure energy which occurs in the convergent cone is mostly regained in the divergent cone, so that no exceptional head of pressure is required to drive the gas through the opening, and the meter is economical in working. This type of economy is of no importance in measuring oxygen, since there is always excess of pressure available. In calibrating this instrument it was found empirically that when $\log(p+1)$ was plotted on semi-logarithmic paper against V the result was nearly a straight line (p = pressure, V = velocity).

The easiest way to determine the diameter of the tube is to measure the volume of a $3\frac{1}{2}$ -inch length. For this purpose a short piece of pressure tubing is fitted tightly round the tip of a 1 c.cm. graduated pipette so that one end of the tubing is level with the tip. The nickel tube is held just out of the horizontal against the rubber, and ethyl or the cheaper isopropyl alcohol is run into the tube from the pipette. The volume found was 0.52 c.cm., which means a diameter of 0.1076 inch.

The flow meter is made by Down Bros., Ltd., St. Thomas's St., S.E.1. The tins can be obtained from Wyatt and Co., Tanner Street, S.E.1, and the nickel tube from Johnson, Matthey and Co., Hadyn Park Works, Askew Road, Shepherd's Bush, W.12.

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The third international medical week organized by the *Journal Suisse de Médecine* will be held at Interlaken from August 29 to September 4. Among those who will deliver addresses are Professor Hugh Cairns, who will deal with the results of treating intracranial tumours; Dr. Clovis Vincent of Paris, who will discuss the treatment of subacute and chronic abscesses of the brain; Dr. H. C. Hagedorn of Denmark, who will survey the progress made in insulin therapy; Dr. R. Rössle of Berlin, who will consider the hereditary aspects of syphilis and tuberculosis; and Dr. H. von Meyenburg of Zurich, who will lecture on the diseases of cartilages. One day will be spent in an excursion to Berne under the direction of the Faculty of Medicine in that city. The fee for membership is ten Swiss francs, and a full programme may be obtained from the secretary, *Journal Suisse de Médecine*, Klosterberg 27, Basle.