CLOCKWORK CONTROL OF THE CARREL-DAKIN TREATMENT.

BY

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AMONG many methods of treating lacerated septio wounds which were tested in the great war the Carrel-Dakin treatment, by intermittent irrigation with solutions of chlorine compounds, proved to be by far the best. Its use saved countless limbs and lives. A nurse, passing from bed to bed, opened a stopcock to allow fluid from a douche-can to flow into the distributing tubes and irrigate the wounds. The fluid was released both day and night, every hour in bad cases, and every two hours in less severe cases. The quantities varied with the size of the wound, on the basis of 1 oz. for every three distributing tubes in the wound.

In order to save the labour thus involved, several surgeons suggested the use of siphons, which, when fed slowly, would accumulate fluid and discharge it at definite intervals. I also tried this method, but found it unsatisfactory, because the slow rate of dropping necessary does not continue for more than a few minutes.

The rates of dropping required to supply definite quantities of fluid per hour are easily determined. Since there are 60 minims in a drachm, and 60 minutes in an hour, the number of drops per minute will yield a corresponding number of drachms per hour. Thus an ounce (8 drachms) per hour would require 8 drops per minute—that is, about 1 drop every 8 seconds. When several different forms of stopcock were tested with pure water (which does not act upon brass), such rates as from 1 to 20 drops per minute steadily decreased in number and soon ceased altogether. A shake of the stopcock would restart them, but they very soon slowed down again and stopped as before. In order to obtain a steady rate of dropping, it was found necessary to begin with about 100 drops a minute—a rate prohibitive for the purpose in view. The use of water with a brass stopcock, moreover, showed that the difficulty does not arise from any corrosive action of the fluid on the metal at the orifice of the stopcock. This behaviour of fluid when made to drop slowly seems to be due to some physical change in the fluid, the nature of which is obscure.

When, as the result of experiment, it seemed impossible to obtain a satisfactory method of intermittent irrigation with a siphon automatically discharged by slow dropping of the fluid, I thought that the desired result might be obtained with a siphon which could be discharged with fluid released, at intervals, by clockwork. This plan, after many experiments, has fortunately proved satisfactory. The clock is used to make and break an electric circuit, which, while closed, actuates an electro-magnet. The magnet, by a simple mechanism (to be afterwards explained), opens a valve and releases quantities of fluid, the amounts of which can be regulated.

The various parts of the apparatus and their relation to one another will be easily understood by an examination of the accompanying illustrations with their explanatory notes.

Fig. 1 shows:

(1) The front of the modified clock. The clock face and the hands have been removed, and a light metal wheel has been fixed to the

FIG. 1.

spindle which normally carries the minute hand. A short brass lever "A" has been screwed into the rim of the wheel. It revolves once in an hour. Other levers could be employed if desired.

(2) Lever "B." This carries a vulcanite knob projecting upwards. When this lever is raised high enough by lever "A" the knob presses the two adjacent springs together to make a

"contact" and so complete an electric circuit. This, in turn, by the action of the electro-magnet lever, raises the piston of the valve and allows fluid to pass (see Fig. 2).

(3) The battery of two dry cells and the ends of the wires which go to, and return from, the electro-magnet. The arrows indicate the direction of the electric current when the circuit is complete (see also Fig. 2).

Fig. 2 shows the essential parts of the stand, with its pole 8 ft. high, and the frame which it supports. Attached to the frame are:

(1) The reservoir, consisting of a 40 oz. bottle, hung upside down, with its mouth within a glass cup, which is attached to the neck of the bottle. (This form of reservoir ensures that the valve is supplied with fluid at a uniform pressure, whatever be the level of the fluid in the reservoir itself.)

(2) The small glass siphon and its rubber tube (C), which conveys fluid to the valve when it is opened by the raising of the piston.

(3) The valve. This consists of a small cylinder and a piston which has a weighted piston rod to make it fall more certainly when released. The upper end of the piston rod is joined to the long arm of the electro-magnet lever by a pin chained to the arm, to prevent the pin from being mislaid. The cylinder is held in position by a thin rod fitting into a socket (not shown). The rod permits of oscillation as the piston is raised. It also holds the valve in its place.

The electro-magnet is of the usual construction. Over the magnets is placed the short arm of a brass lever of the first order, bearing a small piece of steel. When the electric current actuates the magnets they lower the short and raise the long arm, and with it the piston rod attached to it. This opens the valve.

The siphon bottle is shown below the valve. The inner end of the curved siphon tube of exit is seen after it has withdrawn a discharge of fluid and passed it into the receiving funnel. The relative levels of the two ends of the siphon tube of exit should be noted.

Four siphon bottles are supplied with their tubes adjusted to deliver quantities respectively of 1 oz., 2 oz., 3 oz., and 4 oz. of fluid. The quantities discharged are regulated by the distance, inside the bottle, between the openings of the two tubes from one another.

The quantities delivered by the valve are regulated as follows. The clockwork and electric mechanism has been arranged to hold the valve open for twenty seconds each hour. During these seconds the valve can be adapted to deliver either $\frac{1}{2}$ oz., 1 oz., $1\frac{1}{2}$ oz., or 2 oz., according to the aperture of exit which is given to it. The largest size of aperture is the normal exit. The three successively smaller apertures required can be adapted to the valve by means of three separate nozzles (D), any one of which can be screwed on at will over the aperture of the valve itself. (For convenience, these nozzles are screwed on to the side of the frame which carries the reservoir and siphon, as shown in the figure.)

Generally the hourly quantities selected are allowed to double themselves and be delivered by suitable siphons every two hours. Should the quantities for flushing be required hourly, the larger sizes of aperture may be employed or a second lever "A" may be added to the clock. In every case the siphon which is adapted to deliver the required quantity of fluid must be used (see last paragraph of the description of Fig. 2).

Conduction of the Supplies of Fluid from the Siphon to the Wound.

The receiving funnel is used to allow the discharges from the siphon to flow downwards without hindrance from air bells. These, if present, can rise through the fluid in the open funnel, but are held down if the siphon tube is connected directly with the tubes leading into the wound. For a similar reason the tubes leading from the funnel should take the shortest and most vertical route possible to the distributing tubes.

Batteries.—Allow two $1\frac{1}{2}$ volt dry cells for each wound treated. If a number of patients were being treated by irrigation in an accident or military ward it might be advisable to lay an electric circuit round the ward near the floor and supply plugs to tap the circuit at each bed. The strength of the circuit would have to be regulated in accordance with the number of wounds under treatment.

FIG. 2.

Summary.

From the account now given of the working of this appliance it will be seen that:

1. The clock, by its control of an electric circuit, can actuate, hourly or oftener, any required number of electro-magnets for a given number of seconds.

2. Each electro-magnet can, during that time, open a valve which will deliver more or less fluid to the siphon below it, in accordance with the size of exit aperture selected for the particular wound to be treated.

3. The required quantities of fluid, when accumulated, can be delivered by the siphon through a tube of sufficient calibre to flush the distributing tubes in the wound.

This clockwork controlled douche, which has only recently been completed, has been tested on a severe case of compound fracture of the tibia, infected with *Bacillus pyocyaneus*, in Professor John Fraser's ward in the Royal Infirmary, Edinburgh. It irrigated the wound quite satisfactorily. In about a fortnight the wound had improved so much that the clockwork control, being no longer required, was discontinued.

There are many septic surfaces and cavities met with in civil practice, from different causes, for which the Carrel-Dakin treatment will be required. It is hoped, therefore, that this appliance will serve a useful purpose for these, apart from the possibilities of war wounds, which, unfortunately, cannot yet be excluded from the horizon.

In working out the details of this appliance new problems had to be faced and many experiments were necessary. I am much indebted to several co-workers whose services have been invaluable:

To Mr. Hurford, of Messrs. Smith, Hurford, and Drysdale, for adapting the clock for its new purpose and working out the details of the supply valve for me, also for devising and making several experimental stopcocks; to Mr. T. Alexander, the head of the dispensary in the Royal Infirmary, Edinburgh, for testing the action of eusol on metal and keeping me right in chemical questions; and, very specially, to Mr. A. H. Baird, for the electrical outfit and all glass work, and, along with him, his ingenious and skilful mechanic, Mr. George Prentice.

The complete outfit will be supplied by Mr. A. H. Baird, 39, Lothian Street, Edinburgh.

THE PATHOLOGICAL LABORATORY IN GENERAL PRACTICE.*

BY

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THE conception of the pathological laboratory which I wish to put forward is that of a centre for the diagnosis and investigation of disease. By diagnosis I do not mean the mere application of a name to a particular morbid condition or syndrome, but a comprehension of the disordered processes underlying any particular set of symptoms. That correct diagnosis is the first step towards efficient treatment—where such exists—will, I suppose, be universally admitted, and it is as an instrument for the achievement of correct diagnosis that I would regard the pathological laboratory of a general hospital. In spite of the accumulation of physiological and pathological knowledge which has marked the last few decades, it must, I fear, be admitted that the points at which actual contact is established between the science and the art are still few. None the less such contacts do exist, and are increasing. The function of the pathologist in the medical community, as I see it, is to familiarize himself with those points of contact and to place the knowledge won by the workers in medicine the science at the disposal of the workers in medicine the art.

Of the ways in which recent advances in biochemistry have added to our knowledge of disease one of the most important is the devising of a simple and easy method for the estimation of the sugar in a small sample of blood. Several methods have been worked out within the last few years; the one most generally used in this country is that devised by Professor H. Maclean of St. Thomas's Hospital, London.

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Which method is used is of no particular importance. The point of importance is that the introduction of this procedure has brought about a better understanding of that group of conditions having the common symptom of glycosuria than was ever before possible.

Time was when the presence of a reducing substance in the urine was always regarded as an ominous symptom. Soon it became recognized that lactose might appear in the urine of pregnant and nursing women without being of any serious prognostic significance; later the occurrence of pentosuria was recognized. When faced with a reducing body in the urine of a patient it is necessary to make sure that that body really is glucose. A fragment of brewer's yeast will, of course, give the answer. The presence of glucose being established, the question demanding an answer is, Is this, or is it not, a "diabetic" condition? The answer is readily afforded by the examination of the blood glucose.

To make clear how this answer is given, I must go briefly into the variations of the blood glucose level after the ingestion of carbohydrate by a normal subject. In investigating the rise and fall of the blood sugar after the ingestion of carbohydrate it is obviously desirable that some standard method should be employed. All the curves given below are plotted as suggested by Professor Maclean on the results of blood sugar estimations made after the ingestion of 50 grams of glucose following a fast of at least three hours.

The Normal Sugar Curve (Fig. 1).

You will note that from a fasting level of about 100 mg. per cent. the blood sugar rises rapidly to 180 mg. per cent. This height is attained in about one hour, after which there is a rapid fall to the original level or just below it, so that in a normal person within one and a half hours the blood sugar is back to where it started from. The two points to which I particularly wish to draw your attention are this rapid fall and the maximum height of the curve. The rapid fall is due to some mechanism for the storage of glucose in the body, the actual nature of which is not understood; it is apparently the disturbance of this storage mechanism which is the essential lesion in diabetes. The height of the curve is of importance because it represents the level to which the sugar may rise in the blood without passing through the kidney into the urine—that is to say, there is a threshold for glucose in the blood. This threshold occurs at a level of about 180 mg. When below that level in the blood, glucose will not normally appear in the urine; when above, it will.

FIG. 1.—Normal blood sugar curve.

FIG. 2.—Diabetic blood sugar curve.

Ordinates=Blood sugar in milligrams. Abscissae=Time in half-hours from ingestion of 50 grams of glucose by the mouth. T=Normal renal threshold for glucose.

The Diabetic Curve.

The level of the diabetic curve may vary, but its shape is perfectly characteristic (Fig. 2). There is a complete absence of that rapid fall due to the coming into play of the storage mechanism which is characteristic of the normal subject. This, as I have remarked before, is apparently the actual physiological basis of the diabetic condition; the level of the blood sugar rises well above the threshold, and this, of course, accounts for the glycosuria. It may be, and usually is, above the threshold to start with. That is immaterial.

A further very important point in the diabetic condition