nycthémérale. La réaction est forte pendant le jour, faible pendant la nuit. Chez les souris soumises à des conditions qui empêchent l'hypothermie ordinaire de se produire pendant l'anesthésie, l'amplitude de périodicité diminue. La périodicité disparaît le plus souvent lorsqu'on éclaire les souris sans interruption. L'amplitude de la périodicité diminue lorsque les souris sont parquées individuellement plutôt qu'en groupes. Les mécanismes physiologiques répondant à ces observations sont suggérés.

W. M. Davis

University of Oklahoma College of Pharmacy, Norman (Oklahoma USA), February 22, 1962.

PRO LABORATORIO

A Pump for Use in Measuring Arteriovenous Differences in Concentration[1]

Accurate discrimination of arteriovenous differences – for instance of pH, oxygen saturation or concentration of labelled substances – calls for knowledge of the time relation and the blood volume between the arterial and venous blood samples. Important factors are the blood volume of, and rate of flow in, the organ from which the samples are drawn, and the sampling technique. The blood volume and flow must be determined or estimated for the individual organ and on each occasion of measurement, whereas the sampling method can be standardized.

The simplest way of standardizing the sampling procedure is to withdraw the blood at the same rate simultaneously from the respective sites of measurement. This can be effected by means of a pump that can draw blood through two channels at the same speed irrespective of pressure fluctuations in, or pressure differences between, the vessels from which the blood is withdrawn. To avoid variations in blood volume during continuous measurement, the blood should be returned at the same rate as it is withdrawn. Of the numerous pumps hitherto available for extracorporeal circulation and for perfusion of organs[2], none has been found that meets these requirements.

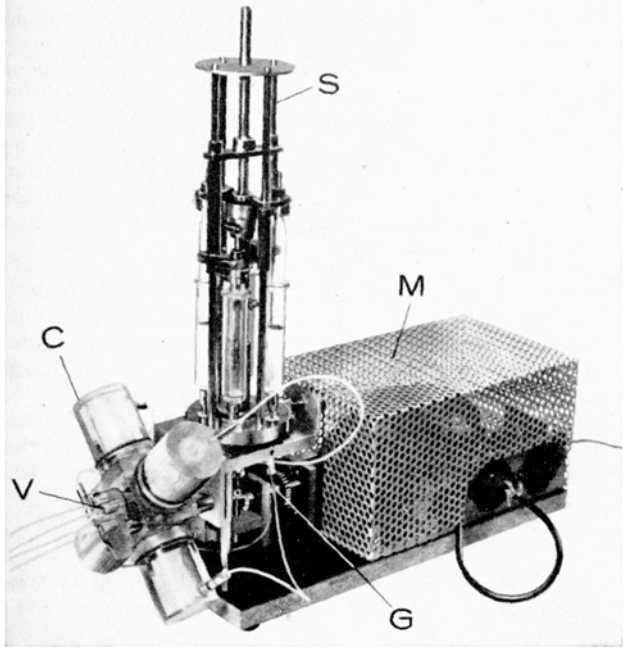

Fig. 1. General view of the pump. *M* motor, *S* stand for the syringes, *G* gear transmission system, *C* Perspex cylinders, *V* valve.

The pump described in this paper was designed to overcome the prevailing deficiencies.

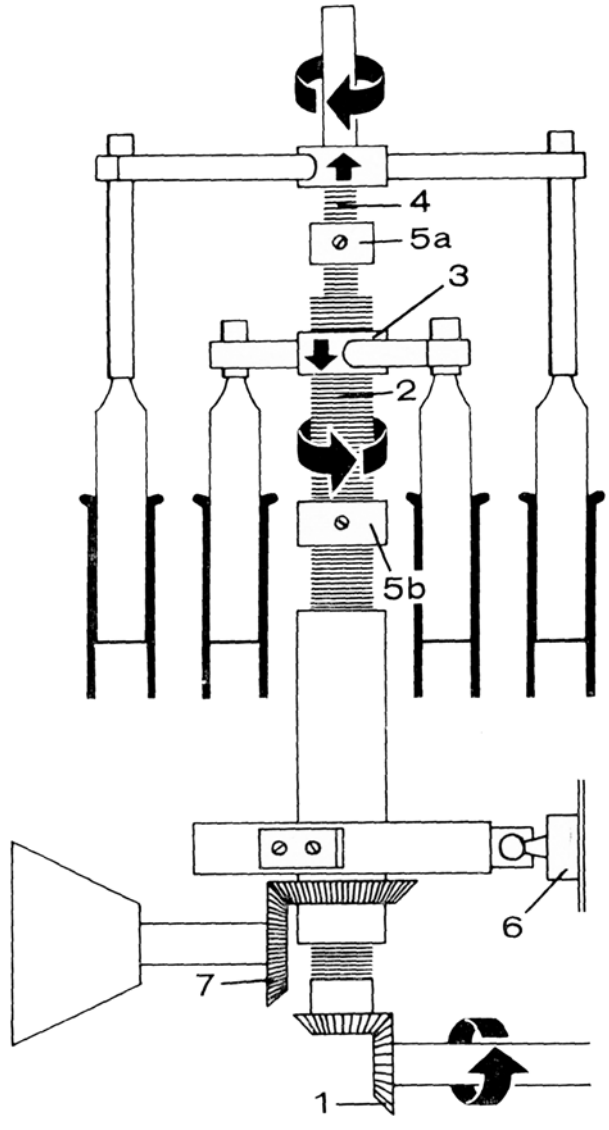

Fig. 2. Schematic view of the pump's mechanical construction. 1 gear, 2 rotating tube, 3 threaded block, 4 rod that screws into tube 2, 5 adjustable stop nuts, 6 switch for reversing the motordirection, 7 mitre gear.

[1] A grant from 'Reservationsanslaget' of the Karolinska Institutet is gratefully acknowledged.

[2] A comprehensive review of the literature on pumps designed for extracorporeal complete or partial substitution of heart function has been published by G. H. A. Clowes, Jr., Physiol. Rev. *40*, 826 (1960). – M. Berlin, Acta phys. scand., to be published (1961).

Design. The pump is illustrated in Figure 1. To avoid haemolysis and coagulation, only polythene and Perspex were used for the blood path through the pump. Sharp bends and angles were eliminated by using a hydraulic system driven by a reversible electric motor. This motor *M* drives the pistons of four hypodermic syringes through a gear transmission system *G*. The syringes alternately withdraw liquid from, and force it into, four Perspex cylinders *C*. These contain polythene bags, which are connected to the vascular system through a valve *V*.

As shown in Figure 2, the power is transmitted by a mitre gear *1* to a rotating tube *2*, which has opposed male and female threads. When the tube rotates, a block *3*, on which two of the syringe pistons are mounted, moves along the tube, while the other two pistons, which are connected to a rod *4* that screws into the tube, move in the opposite direction. Thus, fluid is simultaneously forced into two of the cylinders and withdrawn from the other two. When the pistons reach the end of their stroke, the rotation of the tube is arrested by two adjustable stop nuts *5a*, *5b*. The whole stand then rotates a quarterturn in its mounting. During this movement a switch *6* is activated so as to reverse the direction of the motor and thus drive the tube in the opposite direction. At the same time the choke valve *V* in the hydraulic system is rotated a quarterturn by the mitre gear *7*.

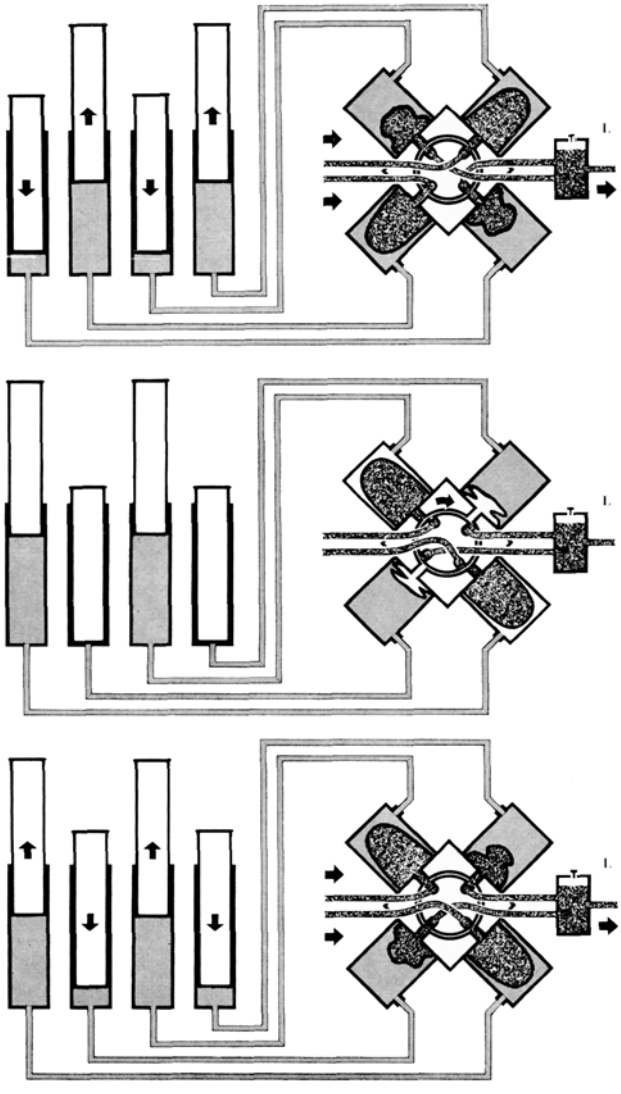

Fig. 3. Schematic presentation of the hydraulic system. *L* air separator.

The principle of the hydraulic system is illustrated in Figure 3*a–c*. The syringes withdraw liquid from, and force it into, the Perspex cylinders, and as a result the polythene bags in the cylinders expand and contract so that the blood is alternately withdrawn from, and returned to, the vascular system. In case a leak should appear in one of the bags, the injectors are filled with physiological saline. When the pistons reach the end of their stroke, the choke valve which connects the bags with the plastic tubing leading to the vascular system rotates a quarterturn. At this moment two of the bags are full and two are empty. Then, when the pistons change direction, the two full bags deliver blood into the channel that during the previous half-cycle had been fed from the now empty bags. The direction of the blood in the tubes leading to the vessels will thus be the same whatever the phase of the pumping cycle.

The injected blood passes through an air separator *L*, which removes any air bubbles that may have entered the system. The flow rate to the pump can be varied at the gear box. With 10 ml syringes the available rates are $6/2^{0,1,2...5}$ ml/min. Smaller syringes will give slower rates. The time relation between the arterial and venous blood in any measuring cells can be varied by adjusting the capacity of the supply tubes.

Range of application. The pump is intended for flows not exceeding 6 ml/min in each channel, and for continuous measurement of, for instance, arteriovenous pH, oxygen and carbon dioxide differences and differences in concentration of radioactively labelled substances. It is also useful for continuous dialysis of venous and arterial blood for chemical analysis of the dialysate. It can further be used for prolonged fractionated sampling from two sites: The blood can then be collected in a fraction collector controlled by the relay that reverses the pump motor. The volume of the fractions can be selected by varying the stroke of the syringes and the capacity of the polythene bags. To avoid any risk of back-flow in the veins, the flow rate in the pump should be less than the minimum rate in the vein from which the blood is being withdrawn. The possibility of such reflux should always be borne in mind when evaluating the observed measurements.

The pump has proved satisfactory for continuous measurement of the arteriovenous difference in concentration of radioactively labelled substances across the kidney of the rabbit[3]. It was run for several hours with no sign of haemolysis or coagulation, although heparinization had not been performed. The results promise well for similar measurements on larger laboratory animals, and even in clinical work.

Zusammenfassung. Eine Pumpe wurde konstruiert, welche das Blut durch zwei Kanäle der Zirkulation entzieht bzw. wieder zuführt. Der Vorgang erfolgt mit konstanter Geschwindigkeit, unabhängig von Druckschwankungen an der Entnahme- bzw. Zuführungsstelle.

Die Pumpe erwies sich als geeignet für die Aufrechterhaltung einer extracorporellen Zirkulation während der kontinuierlichen Messung arteriovenöser Konzentrationsdifferenzen von radioaktiv markierten Substanzen.

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[3] M. BERLIN, Acta phys. scand., to be published (1961).