AN APPARATUS FOR RECORDING THE VOLUME BLOOD FLOW RATE

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The suggested apparatus, a pump-flowmeter in construction, is designed for the automatic recording of the volume rate of flow of venous blood in acute experiments on animals. In particular, it may be used for recording the volume velocity of the coronary blood flow by the method described by N. V. Kaverina [1]. It is simpler than the existing apparatuses used for this purpose [2], and it may be made from ordinary laboratory equipment.

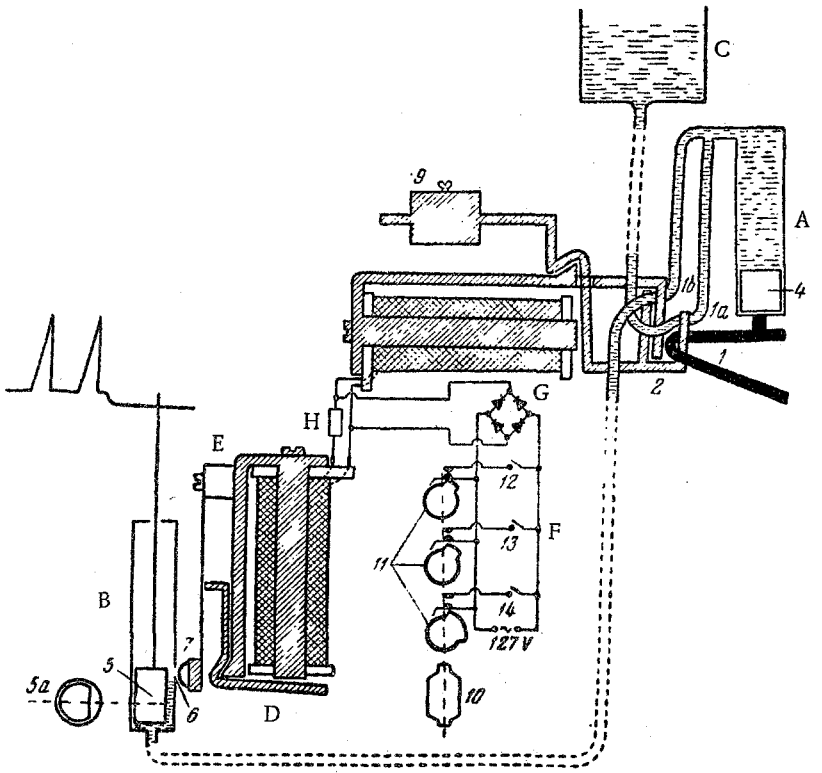

Diagram of the apparatus for recording the volume rate of blood flow.
For explanation, see text.

The apparatus (see figure) consists of two cylinders: working (A), fixed close to the blood vessels, and measuring (B), placed near the moving paper of a kymograph, at a level corresponding to the resistance to the blood flow in the particular vessel in intact animals. The working cylinder is joined by a system of tubes with the blood vessels, the measuring cylinder, and the pressure reservoir (C) containing water, periodically expelling blood from the working cylinder into the blood stream. Each cylinder is supplied with a relay (D and E). The electrical circuit of the apparatus also includes an interrupter (F), a rectifier (G) assembled from germanium diodes (D7-Zh), and a fixed resistor (H), limiting the current in the winding of the relay (E).

The operation of the apparatus takes place in the following order.

When no current is present in the electrical circuit, the artificial circulation is limited to the tube 1; blood enters one of its ends (the upper end in the figure) from the blood vessel and returns from the other end to the natural circulation. When the circuit is made, the lumen of the tube 1, and also of the tube 1a, is closed by a clamp 2 connected to the reed 3 of the relay D, as a result of which blood is directed into the cylinder A, displacing the plunger 4 and expelling an equal volume of water through the tube 1b into the cylinder B, raising the float in this cylinder to a corresponding level, and with it the attached pen. The escape orifice 6 of cylinder B is closed at this time by the cap 7, pressed home by the reed 8 of the relay E, the winding of which is included in the circuit parallel with the winding of the relay D. When the current ceases to flow in the circuit, water flows out from the cylinder B through the open escape orifice and the float returns to its original position. At the same time, the clamp 2, by the action of the weight 9 and the elasticity of the tubes 1 and 1a, releases these tubes and compresses the tube 1b, which prevents water from flowing into the reservoir C into the cylinder B. Water from the reservoir C is directed along the tube 1a into the cylinder A, and presses on the plunger 4, acting as a partition between the blood and water, and forces blood into the tube 1, where it mixes with the blood newly arriving and passing directly back into the blood stream. The figure corresponds to this phase in the operation of the apparatus.

The float 5 in cross section 5a is a circle from which an arc of 60° has been cut out. During regulation of the apparatus, the pen is so fixed that the cut side of the float corresponds to the escape orifice of the cylinder. This facilitates removal of water from the cylinder when the escape orifice is open. For the same considerations water is removed from the measuring cylinder B through an escape orifice in its sidewall directly to the exterior, into an open gutter. These arrangements facilitate the rapid return of the float (and, consequently, of the pen) to its lowest position, and allow the kymograph to remain in motion during the whole time of measurement of the velocity of the blood flow.

The metal cap 7 closes the escape orifice 6 by means of an elastic rubber bag, full of air, which it introduces into the orifice.

Making and breaking the electric circuit of the apparatus are done automatically by means of the interrupter F with a synchronized electric motor 10 operating at 2 rpm, setting in motion a shaft with a series of cams 11. With every revolution, these cams close the contacts placed over them, and the different cams close the contacts for different lengths of time; pushbutton switches 12, 13, and 14 enable the selective inclusion of contacts made by one of the cams in the electrical circuit of the apparatus, and thereby allow the duration of each closure of the circuit to be controlled within the limits demanded by the experimental conditions and depending on the value of the volume velocity of the blood flow. In particular, in our experiments in which we recorded the flow of blood from the coronary sinus in cats, the volume velocity in different animals varied within the range from 10 to 40 ml/min. The optimal (for registration of the blood flow) duration of closure of the circuit varied correspondingly from 3 to 10 sec with cylinders having an internal diameter of 9 mm.

It should be noted that when the apparatus is in use, blood is directed into the working cylinder only during the actual recording of the blood flow, and for the rest of the time it passes from vessel to vessel by the shortest route, without passing through the measuring system. This minimizes the volume of blood in the artificial circulation and also the time during which the blood remains there, and its degree of cooling.

SUMMARY

The instrument suggested represents a pump-flowmeter for recording the volume rate of blood flow from the coronary sinus and other veins in acute experiments on animals.