TABLE V.
Effect of Azochloramid and Sulfanilamide upon Sulfanilamide-fast *E. coli.* Inoculum 2,000,000 *E. coli*/ml.

Sulfanilamide mg %	Azochloramid mg %	Turbidity 15 hr
0	0	49
100	0	45
25	0	47.5
0	.04	44.0
5	.04	0.5

culture was destroyed and it was again rendered sensitive to 5 mg % sulfanilamide as is shown in Table V.

Comment. In order to increase the accuracy of these experiments low concentrations of these agents were studied. The time of exposure is thereby lengthened and inaccuracies due to the time factor are eliminated. In order to produce these effects with short contact periods as would be desirable for clinical application appropriately increased concentrations of the agents are required.

Summary. These data indicate that Azochloramid potentiates the bactericidal effect of sulfonamides. This effect may be due to the inactivation of sulfonamide inhibitors by the chlorine compound.

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Measurement of Mean Blood Flow in Arteries and Veins by Means of the Rotameter.*

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In experiments designed to determine the accuracy of the thermostromuhr,[1, 2] the need arose for a simple and accurate method by means of which blood flow in arteries and veins of anesthetized dogs could be immediately quantitated from moment to moment for a considerable time period. For this purpose the rotameter[3] seemed

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† We wish to acknowledge the help of Drs. A. S. Weisberger, E. F. Schroeder, and Mr. D. Book in some of these experiments.

1 Gregg, D. E., Pritchard, W. H., Eckstein, R. W., Shipley, R. E., Steege, T. W., and Wearn, J. T., *Am. J. Physiol.*, in press.

2 Shipley, R. E., Gregg, D. E., and Wearn, J. T., *Am. J. Physiol.*, in press.

3 Schoenborn, E. M., and Colburn, A. P., *Transactions of the American Institute of Chemical Engineers*, 1939, **35**, 359.

to be the instrument of choice. Since this device apparently has not been used in physiological studies, attempts have been made to adapt it to the measurement not only of mean blood flows in arteries and veins but also of cardiac input.

Apparatus. The rotameter (Fig. 1, A and B) consists of a vertical transparent graduated tube (H) of constant taper within which is a small freely movable "float" (C or DEF). The height of the float in the tube is determined by the balance of the downward force (weight of float minus weight of displaced fluid) and the upward force (pressure drop across float times the maximal cross-sectional area of float). Increase in rate of flow disrupts this balance by increasing the pressure drop across the float, causing it to rise until the increase in the annular orifice reduces the pressure drop across the float to that existing at the previous flow level.

To insure minimal viscous drag all tubes and their connections should be of maximal diameter and minimal length, while the floats should be of minimal diameter and specific gravity. The rotameter design will be determined in part by the pressure and flow ranges in the vascular system in which flow is to be measured.

Critique of Apparatus for Arterial Flows. The float used for most flow ranges is usually made of stainless steel. Because of the viscous drag of blood on the float and tube a measurable part of the pressure head is permanently lost. The amount varies with each

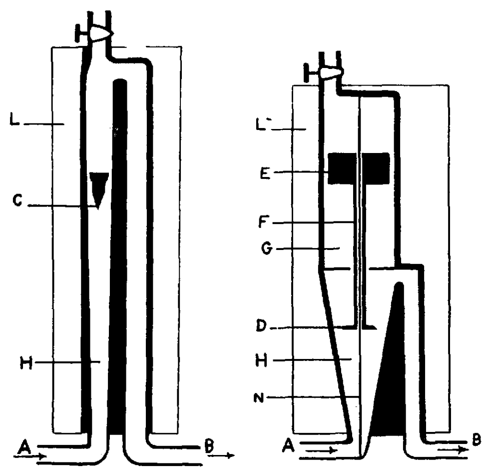

FIG. 1-A FIG. 1-B

Diagram of the rotameters used for measurement of mean blood flow in arteries and veins. *Part A,* rotameter used to measure small flows. *Part B,* rotameter with minimal viscous drag used to measure larger flows. *L,* Lucite jacket. Description in text.

rotameter ensemble and can be reduced by the use of lighter (aluminum) floats. Tests made on a rotameter (designed to measure coronary or femoral artery flow) indicate a pressure loss not exceeding 60 mm of water (Fig. 2, Curves 1 and 2). Such rotameters, as studied in a pump system reduce flow through themselves by not more than 3-4%. For larger flows through larger rotameters the flow reduction is even less.

In a pump system the mean float reading is not significantly affected by alterations in "heart rate" or stroke volume. Likewise, variations in direction and magnitude of the phasic rate of flow (recorded by the orifice meter[4]) even exceeding physiological limits are ineffective (Fig. 3, Part A).

However, it should be recognized that in any set-up the height of the float can be influenced by factors other than the rate of flow. Changes in the specific gravity of the blood introduce detectable but

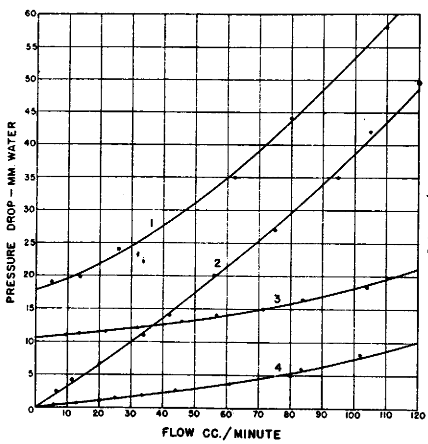

FIG. 2

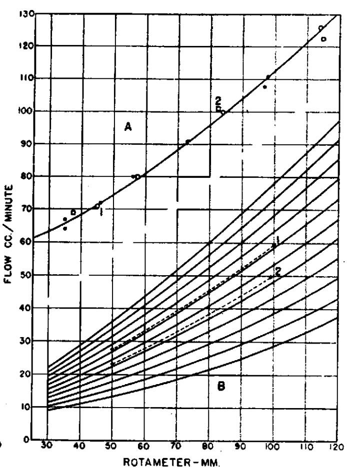

FIG. 3

FIG. 2.

Curves 1 and 2. Data obtained in gravity system with blood showing pressure loss at different rates of flow in small rotameter with (Curve 1), and without (Curve 2) stainless steel float. *Curves 3 and 4.* Similar to Curves 1 and 2 but obtained in larger rotameter with (Curve 3) and without (Curve 4) aluminum float. (For Curves 3 and 4, flow values $\times$ 10.)

FIG. 3.

Part A. Graph showing fidelity of rotameter in recording mean flow in the presence of flow pattern variations. Flow patterns are: linear, those which resemble a carotid, femoral, or left coronary artery pattern and those with very large periods of backflow and zero flow. Dots, control points with all forward flow. Circles, flow patterns containing backflow up to 30% in volume. Squares, flow patterns containing periods of zero flow up to 20% in time. Point 1, 30% backflow. Point 2, 20% zero flow. *Part B.* Curves 1 and 2, rotameter calibrations of same blood at different temperatures; Curve 1 at 35°C, Curve 2 at 28°C. Solid curves represent series of *in vitro* calibrations of a rotameter (Fig. 1-A) obtained in a gravity system with bloods of different viscosities. Description in text.

not significant errors in reading (less than 1%). Alterations in specific viscosity of blood over the physiological range of 3.7-7.0[5] and induced by change in temperature or composition of blood (hemoconcentration or dilution, or the addition of certain anticoagulants) will give correspondingly different calibration curves for a rotameter (Fig. 3, Part B). For larger flows in larger vessels the viscosity effect may be almost entirely eliminated by use of a float similar to that described by Fischer, *et al.*,[6] the major part of which is removed from the flowing stream with high velocity to a stagnant region of no velocity. This (Fig. 1-B) consists of a brass disc about ⅛ mm thick and a brass cylinder connected by a small thin-walled glass tube of such length that the disc (D) is in the flowing stream and the cylinder (E) in the stagnant area (G), the float assembly being guided by a fine wire (N).

Critique of Apparatus for Venous Flows. For flows in the large and small veins or for measuring cardiac input (flow through both venae cavae) floats similar to those for arterial flows may be used, but those made of aluminum are more satisfactory. Tests made with blood in a gravity system indicate a pressure loss varying from 11-18 mm water as the flow changes from 1 to 1000 cc/min (Fig. 2, Curves 3,4). When flow through the jugular vein or both venae cavae (in open chest dogs) is measured by this apparatus the venous pressure may rise by 5-15 mm water. Such apparently offers no serious impediment to the venous circulation.

Calibration. Since the height of the float in Fig. 1-B is determined almost entirely by changes in rate of flow alone, one set of *in vitro* calibration points with blood will establish the calibration curve accurate to ±5 to 10% and applicable to float readings taken during any experiment.

Since, in a given animal experiment, the height of the float in Fig. 1-A is dependent upon the blood viscosity as well as rate of flow, the calibration curve of the rotameter which is applicable to that experiment may be determined by one of the following procedures with an error of less than 10%: (1) A series of float and flow readings taken during an animal experiment will establish the calibration curve for that experiment.. (2) At the close of an experiment the rotameter is calibrated with the same dog's blood adjusted to body temperature. Such a calibration will correctly interpret float readings taken during the experiment provided the nature

[4] Gregg, Donald E., and Green, H. D., *Am. J. Physiol.*, 1940, **130**, 114.

[5] Eckstein, R. W., Book, D., and Gregg, Donald E., *Am. J. Physiol.*, in press.

[6] Fischer, K., Blechman, S., and Lipstein, E., *Transactions of the American Institute of Chemical Engineers*, 1940, **36**, 857.

of the experiment does not involve significant viscosity changes. (3) During an experiment, blood leaving the rotameter may be temporarily diverted into a graduate and one flow and float reading taken. By observing the position of this one point, a calibration curve (or interpolation) may be immediately chosen from a previously determined *in vitro* series covering the range of specific viscosities found in different dogs (such as the series shown in Fig. 3-B) which will apply to float readings taken during the course of the experiment. Any calibration curve (as shown in Fig. 3-B) which has been obtained with different blood but of the same viscosity as that known to exist during an experiment may not always be used to determine the flow in that experiment, since in many tests it has been found that bloods of the same specific viscosity (as determined by a capillary viscosimeter) may not have the same calibration curve.

In animal experiments a combination of heparin [1000 units/kilo and pontamine fast pink BL (150 mg/kilo)] usually prevents the accumulation of fibrin on the rotameter float. In long experiments the anticoagulant injection should be repeated. Heparin alone, except in very large doses, is inadequate to prevent such deposition for a sufficiently long experimental period.

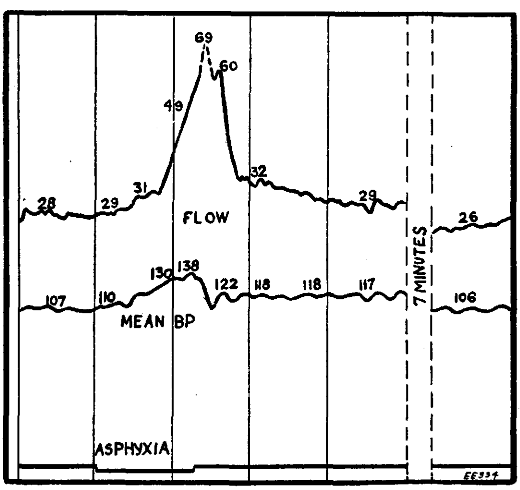

FIG. 4

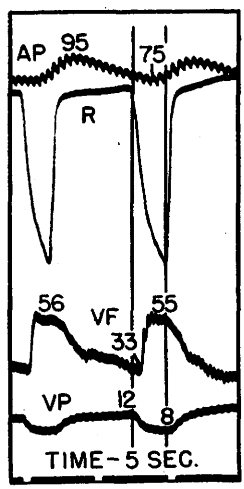

FIG. 5

FIG. 4.

Tracing of original kymograph record showing changes in mean blood flow (cc per minute) as recorded by rotameter in the left coronary artery and induced by temporary asphyxia. Vertical intercepts, one-minute intervals.

FIG. 5.

Reproduction of optical record showing effect of natural inspiratory attempt (trachea closed) on femoral vein flow as recorded by rotameter. AP, mean femoral artery pressure. R, respiration (vertical intercepts mark beginning and end of inspiration). VF, femoral vein flow in cc per minute. VP, mean femoral venous pressure.

Registration. (1) The height of the float indicating rate of flow may be visually noted from time to time. (2) Its position may be recorded on kymograph or photographic paper by means of a sighting attachment which is manually made to follow the movements of the top edge of the float.

Typical Records. Reproductions of original records are presented, showing the augmentation of blood flow in the left circumflex artery during temporary asphyxia (artificial respiration removed), Fig. 4, and in the femoral vein during an inspiratory attempt (trachea closed) Fig. 5.

Summary and Conclusions. The rotameter has been used to measure cardiac input and mean blood flow in the arteries and veins of the anesthetized dog. Typical records are shown. Tests indicate that in routine use the instrument will give reliable blood flow values with an error of less than 10%. Its use enables the experimenter to determine at a glance the moment to moment flow during the time that flow is actually being measured, an advantage not possessed by any other known method. The rotameter is so simple in operation that it should also serve a very useful purpose for the measurement of blood flows in student experiments in the classroom for which as yet no simple and reliable method has been available.

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Histamine Release in the Allergic Skin Reaction.*

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It has recently been shown that blood cells from an allergic individual release part of their histamine into the plasma when they are exposed to the allergen *in vitro*.[1] This experiment on humans confirmed previous findings on blood from animals sensitized to egg-white.[2, 3, 4] Furthermore, it helped to substantiate the assumptions

* Aided by a grant from the John and Mary R. Markle Foundation. Part of the experimental work was done in the Allergy Division of the Department of Preventive Medicine, Tulane University.

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2 Katz, G., *Science*, 1940, **91**, 2357.

3 Katz, G., *J. Pharm. and Exp. Therap.*, 1941, **72**, 22.

4 Dragstedt, C., Ramirez de Arellano, M., and Lawton, A. H., *Science*, 1940, **91**, 617.