A Modified Bristle Flowmeter for Measuring Phasic Blood Flow.* (20293)

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Previous studies of venous return in this laboratory(1,2) have impressed us with the difficulty of recording phasic changes of venous flow with accuracy by the usage of flowmeters currently available. Since a number of problems requiring the study of phasic flow still remain, we have for some time attempted to adapt the Holzlöhner "stream-bristle" cannula for such studies(3-5). This instrument, based upon the blood velocity recorders of Chauveau-Lortet and de Burgh Daly(6), is particularly useful in that it measures both velocity and volume flow by recording electrically the deviation of a fine glass bristle suitably inserted into the blood stream by means of a specially constructed cannula. Further advantages are: 1) high fidelity response (500 cycles/sec.). 2) High and variable sensitivity. 3) Linear calibration. 4) Negligible resistance to blood flow. 5) Compactness. 6) Nonturbulence over the physiological flow range. 7) Registration of backflow.

One of the authors, (G.A.B.) who had the privilege of working with Holzlöhner in developing and constructing the stream-bristle cannulae, was aware of the difficulties in making the fine platinum-glass bristles. The recent availability of the RCA 5734 transducer vacuum tube, however, permitted the authors to construct a suitable modification of a bristle flowmeter of the Holzlöhner type.

Fig. 1 shows a schematic diagram of the modified stream-bristle cannula. The T-shaped cannula consists of 3 brass parts, (X,Y,Z) which can be assembled by threaded joints. The transducer tube (5734) is mounted in section X. Provision for pressure recording and for removing air bubbles is made by a side tube attached to section Y. Section Z is the cannula of fixed diameter introduced into the blood vessel. It can be turned to assure maximal bristle sensitivity. A very thin stainless steel filament is soldered to the plate-pin (P) and serves as a bristle (S) protruding into the blood stream. Deviation of the plate-pin causes the resistance of the RCA 5734 tube to vary. With the circuit connections shown in Fig. 2, this resistance variation in the transducer (T-1) gives rise to an electrical signal linearly proportional to flow. The signal is amplified by tubes T-2 and T-3. The output of the latter actuates a D-C power amplifier driving a mirror oscillograph. Relative freedom from drift is accomplished by battery plate and filament supplies, and the differential nature of the amplifier stage (T-2 and T-3).

Numerous flowmeter designs have been described in the literature, which have not satisfied the demands under actual animal experimental conditions. Holzlöhner's flowmeter

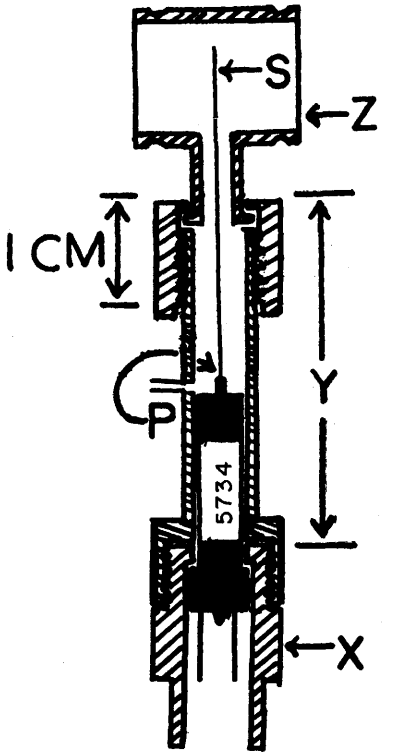

FIG. 1. Diagram of stream-bristle cannula. Description in text.

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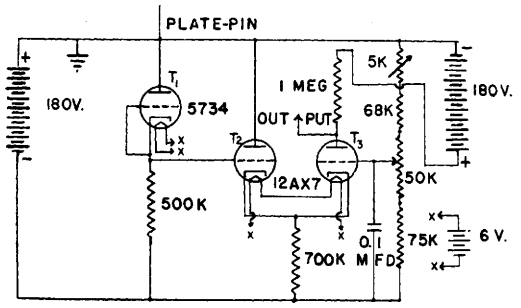

FIG. 2. Electronic circuit of RCA 5734 stream-bristle flowmeter. Description in text.

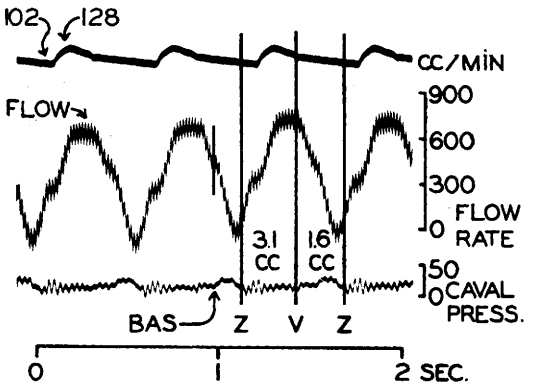

FIG. 3. Effect of cardiac movement on venous return. Tracings from top to bottom: Pressure in abdominal aorta in mm Hg. Superior vena cava flow. Pressure in superior cava in mm H_2O. Time 1/60 sec. in flow tracing.

has met these critical requirements, and the present modification, which has the same advantages, has been employed with equal success in this laboratory for blood flow determinations.

Low resistance to blood flow makes the stream-bristle cannula particularly suitable for an accurate analysis of the dynamics of venous return. Fig. 3 shows a segment of an original record taken with this modified bristle flowmeter. It depicts the changes of superior vena cava flow during a normal cardiac cycle in an open chest dog, when artificial respiration is stopped a few seconds for recording purposes. Simultaneous recording of the pressure pulses in the superior cava and abdominal aorta permit precise timing of the acceleration and deceleration of venous return. With the beginning of atrial systole (BAS), inflow is markedly slowed down from a rate of 500 cc/min to very low rates or even zero flow. At the end of atrial systole, flow begins to accelerate rapidly (Z—point in atrial pressure curve, occurring prior to closure of tricuspid valves). The inflow rate reaches its maximum (800 cc/min) prior to the opening of the tricuspid valves (V—point in the atrial pressure curve). Thereafter, flow is slowed down to varying degrees, and the cycle is repeated when flow again reaches its minimum during atrial systole. By measuring the area under the flow curve, it is possible to determine the amount of volume flow during different parts of the cardiac cycle. It is noted that inflow into the right atrium is almost twice as much during ventricular systole, when the tricuspid valves are closed and no blood can leave the atrium (3.1 cc from Z to V), than during ventricular diastole, when the tricuspid valves are open and atrium and ventricle form a common cavity (1.6 cc from V to Z). This demonstrates the active influence of ventricular contraction on the forward movement of blood in the central veins. The marked increase of venous return during the period when the tricuspid valves are closed, and blood cannot enter the ventricle, may be explained by the descent of the atrio-ventricular plane during ventricular systole, passively distending the atria for greater accommodation of blood. Changes of inflow from the inferior cava are expected to be similar, as one may conclude from simultaneous flow measurements with two Pitôtmeters in both superior and inferior cava(7).

Summary. A new type of electrically recording bristle flowmeter is described, which permits measurement of volume flow of blood and its phasic changes. By recording superior vena cava flow, direct evidence is presented that the greatest acceleration of blood and a marked volume inflow into the right atrium occurs during ventricular systole, when the tricuspid valves are closed. This demonstrates the active influence of ventricular contractions on venous return.

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2. Brecher, G. A., and Mixter, George, Jr., *Am. J. Physiol.,* 1953, v172, 457.
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4. Bergmann, G., *Z. f. Biol.,* 1938, v98, 536.

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Mechanism of Ovarian Control of Hypophyseal Gonadotrophic Function in Guinea Pig. (Experiments with Intrasplenic Grafts). (20294)

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Removal of one ovary does not affect the size of subsequent litters, *i.e.* the number of maturing follicles and of ova shed. Thus the conclusion was reached that follicular development is regulated by the production in the body of a fixed quantity of extra-ovarian substances ("law of follicular constancy") (1).† These extra-ovarian substances can now be identified with the pituitary gonadotrophins. On the other hand, it has been suggested that not only is follicular development quantitatively regulated by the production of these extra-ovarian substances but also that their use, or consumption, in the ripening follicles partakes in the maintenance of the normal ovarian and hypophyseal relationship; ovarian function would depend upon a balance between production and consumption of gonadotrophins(2). This concept though purely hypothetical was based on the experimental statement that an abnormal endocrine function of the ovary is observed after the removal of one entire ovary and the greater part of this second ovary. In similar animals with an ovarian fragment, or remnant, cystic hyperplasia of the endometrium, penetration of glands into the myometrium, uterine and extra-uterine tumors can be observed when the experiments are sufficiently prolonged(3). In the ovarian fragment signs of an abnormal follicular development may be present, as lutein cysts, occasionally also an hemorrhagic one. It was then assumed, though rather vaguely, that the overthrow of the normal ovarian hypophyseal relationship is due, under the described experimental conditions, to an imbalance between production and consumption of gonadotrophins in the ovarian remnant.

The concept of a regulatory influence exercised by the ovary on the hypophysis by the consumption of gonadotrophins was discarded when the control of the hypophysis by ovarian estrogens became a definitely established fact (4-6). The quantitative and timing conditions of this control are still under discussion (7,8). However, more recently the problem has been discussed on new experimental lines such as work with intrasplenic ovarian grafts in the rat; the important statement was made that the hypophysis of the female rat with both ovaries grafted into the spleen is not identical to that of a castrate in so far as it contains less gonadotrophins than the hypophysis of the castrated rat(9). This non-identity is shown also in the absence of castration cells in the hypophysis of castrated animals with intrasplenic ovarian grafts(10). These results were interpreted favoring the concept that consumption of gonadotrophins was a regulatory factor of the functional condition of the hypophysis(9). On the other hand, experiments made in this department have shown that in the guinea pig a small ovarian fragment *in situ* is capable of counteracting production of hemorrhagic follicles in the intrasplenic graft(11-13) even when follicular development in the fragment is very small, *i.e.*, when the assumed consumption of gonadotrophins apparently did not count(14).

In view of these discrepancies the following 2 comparative sets of experiments were made.

A. *Intrasplenic transplantation of variable*

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† Our concept was but a modernized and more "experimentalized" version of Hunter's, Heapes's, Sand's and Hammond's.