reasonable to consider a heat labile toxic contaminant variably present which may mask the protective effect afforded by RES stimulation. Benacerraf's findings(1) suggest a deleterious effect upon adrenal cortical function, which doubtless plays a permissive role in resistance to endotoxin. The relatively greater sensitivity of zymosan-treated mice to *i.v.* than to *i.p.* endotoxin challenge, compared to normal controls challenged by the same routes, was found regardless of the type or preparation of zymosan. The slower absorption of the *i.p.* endotoxin challenge may allow a more effective detoxification by the RES in a pre-existing state of susceptibility.

Passive transfer experiments require further study; protection was afforded normal recipients by plasma of resistant zymosan "A"-treated donors, but, peculiarly, plasma of donors given zymosan "B" conferred neither protection nor the donors' own susceptibility to endotoxin challenge.

Summary. Pre-treatment of mice with different preparations of zymosan modified the lethal effect of a subsequent endotoxin challenge, ranging from increased resistance to increased susceptibility, despite equivalent RES stimulation. Source and degree of heating in preparation for injection were determinants. Greater relative sensitivity to *i.v.* than to *i.p.* challenge was found regardless of the zymosan used. Protection was not attributable to endotoxin contamination or to stimulation of serum antibody titer to the challenge. Zymosan produced a monophasic fever in the rabbit, differing from the biphasic endotoxin fever, and did not elicit an acute leucopenia.

The skilled technical assistance of Miriam Graff is gratefully acknowledged.

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Apparatus for Simultaneous Infusion and Multiple Blood Sampling. (26382)

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Continuous withdrawal of simultaneous arterial and venous blood samples is required in experimental procedures such as determination of regional blood flow(1,2). This can be done with some commercially available pumps. Rose and Pfaff(3) have described a mechanism designed specifically for this purpose. The design of these pumps, however, requires syringes to be placed at a distance from the experimental animal. This necessitates a long cannula with consequently a considerable volume of "dead space." Also, simultaneous infusion and withdrawal are possible with available commercial pumps only by using 2 separate units.

A description follows of an apparatus designed specifically for use in regional blood flow studies. Two objectives were kept in mind, (a) to place the syringes as close as possible to the experimental animal and thus reduce cannula length to a minimum, (b) to

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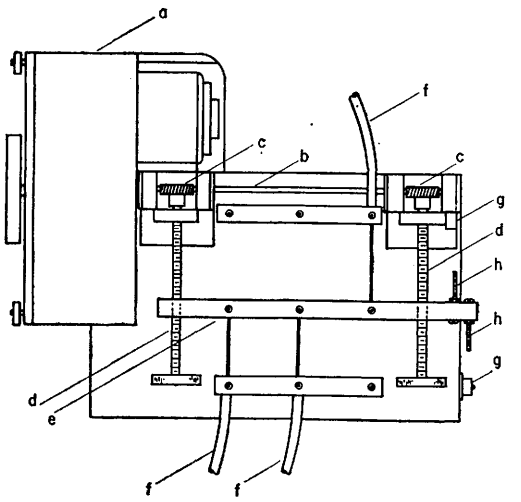

FIG. 1. Variable-speed drive assembly. (a) Harvard multi-speed transmission, (b) drive shaft, (c) worm gears, (d) lead screws, (e) drive bar, (f) push-pull wire choke assembly, (g) sub-micro limit switches, (h) contact screws.

allow simultaneous infusion and withdrawal.

Description of unit. The infusion-withdrawal pump is composed of 2 main components, a variable speed drive assembly and remote-operated syringe units. The drive assembly (Fig. 1) is powered by a Harvard Multi-Speed Transmission.‡ The output shaft of the Harvard unit (a) is connected by a flexible coupling to a drive shaft (b) having 2 worm gear drives (c) spaced approximately 7 inches apart. The worm gears drive 2 lead screws (d) which impart linear motion to a drive bar (e). The speed reduction of the worm gears is 5:1 and the lead screws are cut 16 threads per inch. A flexible push-pull wire choke assembly (f), approximately 18 inches long, transmits the linear motion of the drive bar to each remote-operated syringe unit. Travel of the bar is limited by sub-micro limit switches (g)

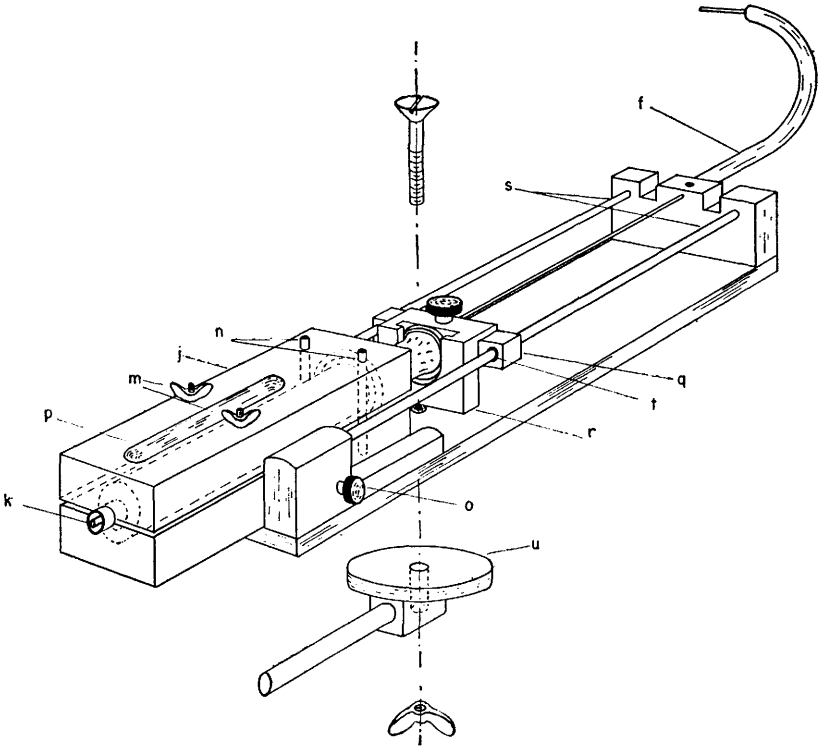

FIG. 2. Syringe unit. (j) Plexiglass split-block, (k) Luer-Lok connector, (m) bolts and wing nuts, (n) locating pins, (o) thumb screws, (p) slot in block, (q) sliding block, (r) interchangeable holder, (s) guide rods, (t) teflon bushings, (u) swivel base.

‡ Harvard Apparatus Co., Inc., Dover, Mass., Cat. No. 600-000.

in series with the Harvard unit. The switches are activated by contact with screws (h) threaded into the drive bar. Direction of travel of the drive bar can be reversed by means of a 3-position toggle switch on the reversible synchronous motor.

In the syringe unit (Fig. 2), the barrel of the syringe is held in an interchangeable plexiglass split-block (j) bored to size and fitted so the Luer-Lok connector (k) protrudes beyond the end of the block. Compression of the split-block by 2 bolts and wing nuts (m) holds the syringe barrel securely in position. The block in turn is positioned on the base of the unit by 2 locating pins (n) and held by 2 thumb screws (o). The top portion of the block is slotted (p) to give unobstructed view of the graduations on the syringe.

The flanged end of the syringe plunger is attached to a sliding block (q) by an interchangeable holder (r). The sliding block, which operates on 2 guide rods (s), is actuated by the push-pull wire choke assembly (f). Teflon bushings (t) in the sliding block reduce friction on the guide rods to a minimum. Each syringe unit is equipped with a swivel type base (u) for greater flexibility in positioning.

At maximum gear speed the linear speed of the syringe plunger is 0.75 in/min. This can be reduced in 12 steps to 1/5000 of the maximum rate. The movement of the plunger may become jerky at very low speeds but this can be overcome by using a syringe with a loosely fitting oiled plunger.

Simultaneous infusion and withdrawal can be achieved by attaching a wire choke assembly on either side of the drive bar. While simultaneous infusion and withdrawal must be carried out at the same gear speed, variation is possible in the choice of syringe size and concentration of infusate.

Discussion. Volume and variability of delivery were calculated from the weight of mercury delivered during a known time interval. Maximum rates of delivery with 2.0, 5.0 and 10.0 ml syringes were 1.181 $\pm$ 0.008, 2.034 $\pm$ 0.006 and 3.214 $\pm$ 0.006 ml per min, respectively (mean of 5 to 15 trials per syringe $\pm$ standard deviation). Variability of delivery at other speeds was comparable to that given for maximum rates.

Due to a certain degree of play in the cables, there is a time lag between switching the instrument on and movement of the syringe plunger. This lag is only a fraction of a second at higher speed settings but increases proportionally as rate of delivery or withdrawal decreases. This, however, is a practical problem only when operating at very low rates for a short period of time.

Movement of the cables after the apparatus has been switched on will result in a slight displacement of the syringe plunger. Therefore, care must be exercised not to move the cables accidentally after an experiment has started.

Summary. An infusion-withdrawal apparatus is described which eliminates the necessity for long cannulae between syringes and experimental animal and permits multiple infusion and withdrawal to be carried out simultaneously. Engineering plans are available from the senior author.

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