The periods of time required for the development of 3 stages in the hypnosis (anesthesia) were selected according to Carmichael and Posey[3, 4] in their studies with nembutal (pentobarbital sodium): (a) The time from the injection until the animal could not support and propel itself after stimulation by gently pulling the hair on the hips. This stage was considered the onset of sleep. (b) The time from the injection until the animal could be aroused sufficiently to walk forward after stimulation. This stage was considered the end of sleep. (c) The time from the injection until the animal could walk a distance of about a meter with a steady gait (without ataxia). This stage was considered the end of the hypnosis. Each animal was observed by this scheme after each injection and the data are illustrated in Fig. 1.

Summary. Guinea pigs were found to show a tolerance to delvinal sodium [5-ethyl-5-(1-methyl-1-butenyl) barbituric acid] on repeated administration of large doses of the drug. The average length of sleep dropped from 127.3 to 48.2 minutes following 8 semi-weekly injections of the drug, while the average length of hypnosis dropped from 191.9 to 104.1 minutes. The average weight of the guinea pigs increased from 250 to 380 g, which was more than a 50% increase in weight.

11950

An A.C. Induction Flow Meter for Measurement of Blood Flow in Intact Blood Vessels.

A. Kolin. (Introduced by H. H. Sobotka.)

From the Laboratories of the Mount Sinai Hospital, New York City.

The principle of the electro-magnetic flow meter[2] is based on the fact that an electromotive force is induced in the blood as it flows through a magnetic field (the direction of flow forming preferably a right angle with the magnetic lines of force).* The induced e.m.f.

---

[3] Carmichael, E. B., and Posey, L. C., Proc. Soc. Exp. Biol. and Med., 1933, **30**, 1329.

[4] Carmichael, E. B., and Posey, L. C., *Anesthesia and Analgesia*, 1937, **16**, 199.

* Further reference to the application of electro-magnetic induction in liquids may be found in Nos. 1, 3-9 of the bibliography appearing in this article.

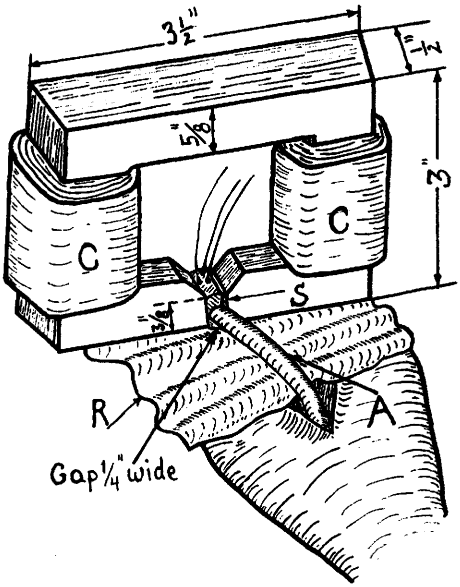

FIG. 1.

Diagram illustrating determination of blood flow in an exposed artery. C: Field coils of electro-magnet. S: bakelite sleeve. A: Artery. R: Dry rubber sheet insulating the exposed section of the artery from the adjacent tissues.

is linearly proportional to the velocity of flow. It is tapped by two electrodes placed at right angles to the magnetic lines of force and to the direction of flow. Owing to the electrical conductivity of the blood vessel wall the pick-up electrodes merely have to touch the outside of the vessel to establish a sufficient electrical contact with moving blood. Fig. 1 shows the perspective view of the arrangement and the dimensions of the magnet.

The modification presented here employs an electro-magnet fed by an alternating current. The use of an alternating magnetic field eliminates the disturbances due to polarization and variable galvanic potentials and makes it possible to use an a.c. amplifier. It introduces, however, the new difficulty of eliminating the a.c. voltage induced in the lead wires at zero flow. This interference has been abolished by the use of a special sleeve S and a compensating po-

[1] Fabre, P., *C. R. Ac. Sc.*, 1932, **194**, 1097.

[2] Kolin, A., PROC. SOC. EXP. BIOL. AND MED., 1936, **35**, 53.

[3] Kolin, A., *Am. J. Physiol.*, 1937, **119**, 355.

[4] Kolin, A., and Katz, L. N., *Ann. de Physiol. Physicochim. Biol.*, 1937, **13**, 1022.

[5] Katz, L. N., and Kolin, A., *Am. J. Physiol.*, 1938, **122**, 788.

[6] Wetterer, E., *Z. f. Biol.*, 1937, **98**, 26.

[7] Wetterer, E., *Z. f. Biol.*, 1938, **99**, 158.

[8] Jochim, K., *Am. J. Physiol.*, 1939, **126**, 547.

[9] Einhorn, H. D., *Proc. Roy. Soc. S. Africa*, 1940, **33**.

tentiometer P in conjunction with a filter F in the amplifying circuit. (Fig. 2.) The bakelite sleeve, S, contains a slit, Sl, which allows a blood vessel to slip into the round channel of the sleeve. This establishes the proper contact between the vessel wall and the electrodes, E_1 and E_2 (2/56 brass screws screwed into the bakelite flush with the channel wall). A coil, C, of 3 turns of copper wire is wound around the sleeve imbedded in the groove, G. The e.m.f. induced in this coil by the alternating magnetic field is applied to the terminals of the potentiometer, P, whose sliding contact is adjusted in order to cancel the undesired voltage induced at zero flow. This arrangement alone, however, is insufficient since it does

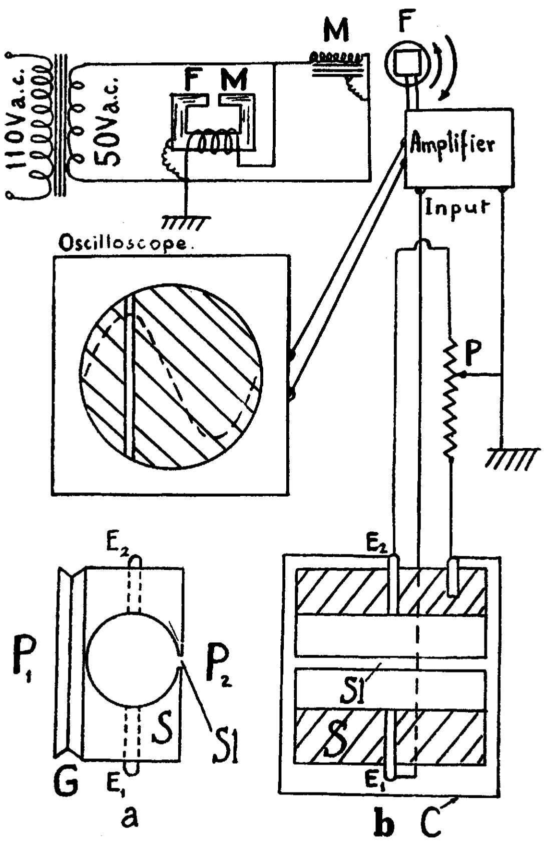

FIG. 2a.

Lateral view of the bakelite sleeve. P_1 and P_2 indicate the location of the magnet poles. S: Bakelite sleeve. Sl: Slit. G: Groove. E_1 and E_2: Pick up electrodes.

FIG. 2b.

Longitudinal section of the bakelite sleeve with the general flow-meter circuit. S: Sleeve. Sl: Slit. E_1 and E_2: Pick up electrodes. C: Coil (only one turn indicated instead of three). P: Potentiometer. F: Filter on turntable. M: Small magnet. FM: Flow-meter magnet.

not allow the phase of the compensating voltage to be varied. The variation of the phase is accomplished as follows: A No. 814-A General Radio amplifier is used in conjunction with the filter, No. 814-P3 (connected between the 2nd and 3rd stage). This filter, F, which passes a narrow frequency band around 60 cycles, is mounted on a turntable near a small laminated a.c. magnet, M, fed by the same transformer as the flow meter magnet, FM. A change of the orientation of the filter with respect to the magnet, M, results in a variation in magnitude of the voltage which is induced in the self-inductance of the filter. Reorientation of the filter with a simultaneous adjustment of the potentiometer, P, introduces in the amplifier output 2 alternating voltages of variable magnitude and a phase difference of 60 degrees. A combination of these voltages in suitable proportion allows a complete cancellation of the undesired voltage induced at zero flow.

The amplifier output voltage is applied to a cathode ray oscilloscope† with a horizontal sweep frequency of 60 cycles. The alternating voltage induced by flow produces a standing sine wave pattern, the maximum of which rises in linear proportion to the rate of flow and becomes inverted as the direction of flow is reversed. By screening off the oscillographic sine wave image‡ except for a narrow slit at the location of the maximum only a fluorescent point remains visible, which indicates the rate as well as the direction of flow. It can be readily photographed. Since there is no lag in

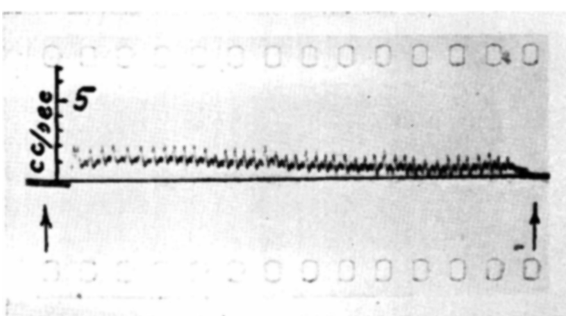

FIG. 3.
Excerpt from a tracing of blood flow through a dog's femoral artery following injection of pituitrin. (Film speed 8 cm/min.) Arrows indicate where blood flow was stopped by compressing the artery. The base line was drawn subsequently by connecting the horizontal sections obtained at zero flow. Amplification: 20% of the maximum gain.

† We used an RCA oscilloscope type: TMV-122C with its amplifier at maximum gain.

‡ Such a slotted mask can also be mounted in front of the photographic film which has the advantage of leaving the oscilloscope screen unobstructed.

induction of an e.m.f. the blood velocity during each phase of the cardiac cycle is instantaneously indicated. Fig. 3 shows a tracing of blood flow in an intact artery of a dog. The vessel was compressed from time to time to ascertain the location of the base line corresponding to zero flow. 0.1 cc/sec correspond at maximum amplification to a deflection of 1 mm so that a flow of .03 cc/sec still can be detected. The calibration is accomplished by perfusion of the excised blood vessel postmortem. The peak value of the magnetic field strength in the gap was 1500 Oersted. The entire magnet was coated with a layer of bakelite enamel, the pole pieces being particularly well insulated.

The method presented above has also been modified to permit the recording of flow in unexposed blood vessels *in situ*. A magnet with a gap large enough to enclose the neck of a medium-sized dog has been used. In order to measure the blood flow through the carotid artery, for instance, the sleeve is applied to the artery in the usual manner. The vessel is left in place, the lead wires are led off through the skin and the neck is closed. Thereafter one merely has to insert the neck between the large magnet poles to record blood flow. Further details on this modification of the method will be published elsewhere.

The author wishes to thank Dr. S. Feitelberg for his assistance in improving the photographic recording as well as for surgical help, and Drs. J. L. Weissberg and L. Gerber for their coöperation in extending the application of the method to unexposed blood vessels *in situ*.

11951 P

Guinea Pig Copulatory Reflex in Response to Aqueous Extracts of Adrenal Cortex.

OLAF TORSTVEIT AND C. H. MELLISH. (Introduced by R. K. Meyer.)

From the Department of Physiology, The Lakeside Laboratories, Inc., Milwaukee, Wisconsin.

It has been demonstrated that progesterone[1, 2] and desoxycorticosterone[3] will elicit the copulatory reflex in the spayed guinea pig

[1] Dempsey, E. W., Hertz, R., and Young, W. C., *Am. J. Physiol.*, 1936, **116**, 201.

[2] Collins, V. J., Boling, J. L., Dempsey, E. W., and Young, W. C., *Endocrinology*, 1938, **23**, 188.

[3] van Heuverswyn, J., Collins, V. J., Williams, W. L., and Gardner, W. U., PROC. SOC. EXP. BIOL. AND MED., 1939, **41**, 552.