conveniently done by sticking the flattened end of the wire to the drum's surface with a bit of Tackiwax.[3] Finally, the kymograph drum is brought up to the writing point so that light contact is made. The kymograph is run at a speed which shows the characteristic ballistic waves to best advantage.

Fig. 2(A) shows a typical ballistic wave pattern which was obtained with the apparatus described, the waves being indicated by the customary letters. In some records the L, M, and N waves are indistinct. There is some difference of opinion as to whether these are only a result of after-vibrations or are caused by forced movements. Nevertheless, the first and more important waves appear distinctly. While not intended to give quantitative information concerning the cardiac output, this ballistocardiograph does register changes in that value and may be used to demonstrate to the student some of the factors known to influence the output of the heart. Suggested demonstrations are the effects of exercise, normal and sustained respiration, and drugs upon cardiac output. Fig. 2 (B, C, and D) shows records obtained before and after moderate exercise.

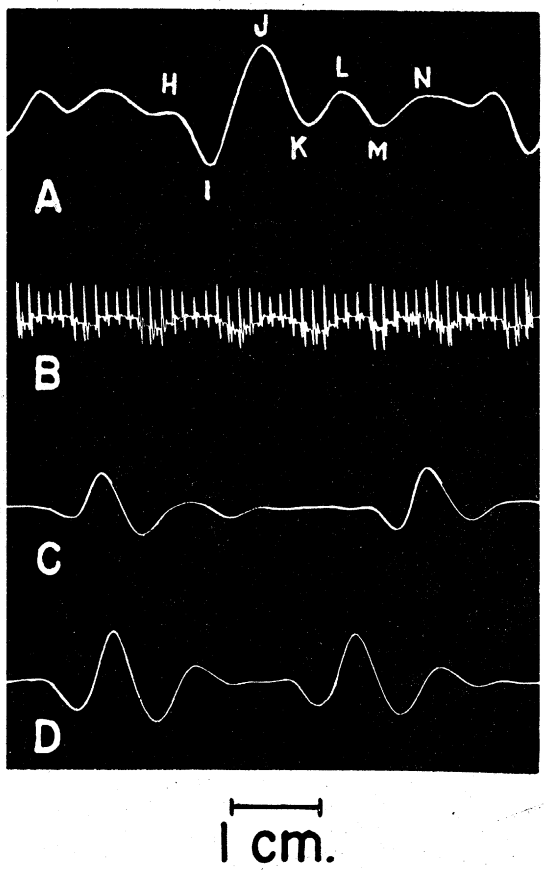

FIG. 2. Tracings obtained with the ballistocardiograph: A, typical pattern with the waves indicated by the customary letters; B, record obtained prior to exercise, with kymograph set at slow speed to show the respiratory waves to best advantage; C, continuation of B with kymograph set at higher speed; D, record of the subject in B and C after moderate exercise. (Note increased I-J distance.)

This ballistocardiograph produces the characteristic pattern of ballistic waves obtained with other, more elaborate instruments. Since the apparatus is inexpensive, is easily assembled, and does not require special training for its successful operation, it may be found useful as a teaching aid in the physiology laboratory.

[3] Cenco-softseal Tackiwax, Central Scientific Company, Chicago, Illinois.

Control of *Nosema* Disease of Potato Tuber Worm, a Host Used in the Mass Production of *Macrocentrus ancylivorus*

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In several laboratories where *Macrocentrus ancylivorus* Roh., an important parasite of the oriental fruit moth, *Grapholitha molesta* (Busck), is being propagated on the potato tuber worm, *Gnorimoschema operculella* (Zell.), serious losses in the production of parasites have been caused by a *Nosema*[1] disease which infects the tuber worm and the parasites reared from it. Infections of 80 per cent or more in the host stocks are not uncommon, and a large portion of the parasites that are produced on even moderately diseased host material may become infected. Diseased parasites are undesirable because they are short-lived and have lowered reproduction capacities.

Nosema disease in potato tuber worm stocks can be controlled by segregating a few pairs of disease-free moths and breeding them through successive generations in a location free of the disease. Although effective, this method is time consuming, and there is also the constant danger of reinfection.

A practical method of controlling *Nosema* disease was developed from suggestions of the junior author. This method takes advantage of the fact that the disease has been found to be transmitted through the host egg. Eggs of the potato tuber worm on paper sheets, which were obtained by the method described by Marvin (*1*), were placed in a water-tight metal envelope and immersed in a hot-water bath at 47° C. for 20 minutes. It was found that the eggs must be heated before being incubated. This treatment proved to be highly successful, reducing infections in the host stocks that developed from the treated eggs, and in the parasites reared from them, by 75 to 90 per cent. In one test the average incidence of *Nosema* disease in the parasites produced in eight trays that had been stocked with heat-treated eggs was only 2 per cent, as compared with 15 per cent in the parasites produced in four trays stocked with untreated eggs. All the eggs used in this test were from stocks that had received heat treatment in preceding generations. In concurrent tests the incidence of the disease was 44 per cent in parasites reared on host stocks, the eggs of which had not received heat treatments in preceding generations. In eggs that were heat treated after being incubated until nearly ready to hatch, only slight reduction in *Nosema* resulted. In experimental series in which complete

[1] Determined by R. R. Kudo, University of Illinois, Urbana.

production records were kept, the heat treatment that was used did not affect the viability of potato tuber worm eggs or lower the production of breeding stocks of this host insect.

This method for controlling *Nosema* disease lends itself well to the mass-production routine, and with little additional work it insures the production of parasites that are comparatively free of the disease.

Reference

1. MARVIN, P. H. *J. econ. Entomol.*, 1944, **37**, 560.

A Single Flashlight Source for Ultracentrifuge Research

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Most of the optical ultracentrifuge observations reported in the literature have been made with the aid of continuous light sources which yield sweep images (*8*). While these are, as a rule, satisfactory for the analysis of sedimenting boundaries and the computation of sedimentation constants and molecular weights, such records give no information on the actual appearance of the sedimenting material. All events occurring at the same latitude of the ultracentrifuge cell are integrated into a continuous streak or sweep across the field of observation. The application of refractive index gradient or schlieren methods to ultracentrifugal problems in conjunction with continuous light sources cannot be expected to reveal local disturbances, e.g. convection or streaming phenomena, existing conceivably in some regions of the sedimenting system.

Bjoernstahl (*2*) has synchronized a light source with the rotation of the rotor of the oil turbine ultracentrifuge to prevent stray light from reaching the photographic plate. Harvey and Loomis (*5*), in their centrifuge microscope, have employed first a stroboscopic and, later on, a semistroboscopic method of illumination for the study of small objects during rotation. A similar device has been suggested by Pickels (*6*) for use with a spinning top. In the course of development of a simple high-speed centrifuge with a plastic rotor (*7*), one of us (K. G. S.) employed a mechanical switch and a General Radio Strobotak light source with promising result. However, the flashing time of the Strobotak lamp amounts to about 1/30,000 second—long enough to cause blurring of the microscopic images even at moderate centrifugal speeds. A preliminary discussion of the problem with Prof. H. Edgerton, of Massachusetts Institute of Technology, led to the conclusion that the recording of images, free of noticeable blurring, would require an illumination time of the order of 1/1,000,000 second when making peripheral observations at ultracentrifugal speeds.

The problem, then, resolves itself into the need for a suitable flash source of high intensity and a synchronizing arrangement which will "trigger" the flash at the instant when the centrifuge cell is aligned with the camera or microscope.

[1] The kind advice of Prof. W. MacLean, of this Institute, and Dr. F. N. Barnes, of General Electric Company, is gratefully acknowledged.

The ultracentrifuge[2] used in the present experiments has a vertical lucite rotor, 6 inches in diameter. It is powered by a special electric motor, rated at 35,000 r.p.m. without load, which imparts to the plastic rotor a maximum speed of 21,000 r.p.m. through a flexible shaft, provided the rotor chamber is partially evacuated to reduce air friction.

For general information on flash photography, reference is made to the monograph of Edgerton and Killian (*4*). Whereas Edgerton, *et al.* (*3*) employed a special gaseous discharge tube with three electrodes, a General Electric mercury burner of the H-6 type was used in the present experiments. This light source has previously been employed by Barnes and Bellinger (*1*) in their studies of air-flow phenomena. The basic flash circuit, developed by these authors, was kindly placed at our disposal by N. F. Barnes. A transformer and a rectifier supply about 2,000 volts direct current to a 2-microfarad capacitor which, in turn, discharges through the H-6 lamp. Instead of a manual switch, a thyratron tube was used in the discharge circuit for the control of flashing rate. For triggering and timing the discharge, the light of an automobile headlight lamp is conducted through a plastic strip to the periphery of the porthole in the centrifuge casing. On the

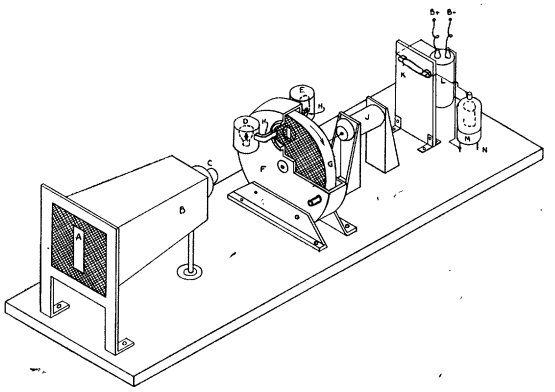

FIG. 1. Experimental arrangement: A, photographic image; B, camera; C, lens; D, synchronizing light source; E, photoelectric cell; F, centrifuge housing; G, plastic rotor with fluid cell; H, transparent plastic strips; J, electric motor; K, B-H-6 mercury lamp; L, 2-microfarad condenser; M, thyratron; N, control grid.

opposite side of the rotor a similar plastic strip conducts the light signal to a vacuum photocell. As the transparent sector of the analytical fluid cell passes through the region of the porthole, the light from the source strikes the photocell cathode. The resulting impulse is amplified, squared, and further differentiated by a RC network arrangement. It was found convenient to employ the trailing rather than the leading edge of the cell sector for the initiation of the flash. The amplified impulse is applied to the thyratron tube in the flash tube circuit, which is so arranged that the discharge through the H-6 source occurs precisely at the instant when the cell is in the center of the porthole and thus aligned with the axis of the photographic system. The camera is equipped with a 5-inch focal length lens. For observation by the schlieren method this system is augmented by a schlieren lens and a horizontal knife edge in front of the camera lens, which is adjustable in the vertical direction. The experimental arrangement is shown schematically in Fig. 1.

[2] This was built by the Development Division of the Fisher Scientific Company, Pittsburgh, in cooperation with one of the authors.