TABLE 2

ADRENAL CHOLESTEROL
(Percentage)

| Before ACTH | | | After ACTH§ | |
|---|---|---|---|---|
| Pair-fed controls | Early scurvy† | | Pair-fed controls | Early scurvy |
| 5.56 ± 0.20* | 7.09 ± 0.22 | $p < 0.01$ | 4.06 ± 0.39 | 4.04 ± 0.38 |
| Pair-fed controls | Late scurvy‡ | | | |
| 5.72 ± 0.48 | 2.56 ± 0.42 | $p < 0.01$ | | |

* Standard error of mean.
† Sacrificed 17 days after the last vitamin C injection.
‡ Sacrificed 27–37 days after the last vitamin C injection.
§ Sacrificed 6 hr after intraperitoneal injection of 1 mg/100 g of body weight.

was paired with a control animal of approximately the same weight, and each control animal was carefully limited in food intake to the amount eaten on the previous day by the deficient animal. An interval of 12–18 hr was allowed to elapse between the last vitamin C injection and the time of sacrificing each control animal.

When ready to be sacrificed, each animal was anesthetized with Nembutal (5 mg/100 g of body weight dissolved in normal saline) injected intraperitoneally. Blood for vitamin C analysis was obtained by heart puncture while the animal was still breathing. The abdomen was opened immediately thereafter, and the left adrenal rapidly removed for analysis by the method of Roe and Kuether (*8, 9*). The right adrenal was used for cholesterol analysis by the method of Schoenheimer and Sperry, as described by Sperry (*10*). The following tissues were also analyzed for vitamin C by the method of Roe and Kuether: liver, kidney, spleen, brain, and testis.

It has been found that in early scurvy the adrenal cholesterol concentration, rather than being reduced, is significantly higher than that of the controls (Table 2). The adrenal at this stage, although 95% depleted of vitamin C, responds to injection of ACTH (*11*) by showing a 42% reduction in cholesterol concentration after 6 hr ($p < 0.01$). Adrenal ascorbic acid was not further reduced in the scorbutic animals by injection of ACTH (Table 1). However, in the control animals a highly significant reduction was noted ($p < 0.001$).

In late scurvy, there is a marked decrease in adrenal cholesterol compared with that of the pair-fed controls (Table 2). This observation is at variance with a report of Baldwin, Longenecker, and King (*12*), who found no significant difference in adrenal cholesterol concentration[2] between the animals "in the last stages of scurvy" (1.70%) and the pair-fed controls (1.64%), both groups showing remarkably low levels. In view of the fact that the adrenal cholesterol may be lowered in response to a wide variety of stress situations, it is suggested that some unnamed stress may have been operating in the experiments of Baldwin *et al.* The use of chloroform anesthesia by these workers may have been in part responsible for the extremely low cholesterol values, since volatile anesthetics are likely to lead to respiratory anoxia, unless very carefully administered, and such a condition causes rapid reduction of adrenal ascorbic acid and cholesterol. The use of an anesthetic such as Nembutal dissolved in normal saline and warmed to body temperature before intraperitoneal injection has been found to be much the safer procedure (*2*).

Other explanations of the conflicting results are possible; for example, younger animals were used by Baldwin *et al.*, and the ability to withstand severe restrictions in food intake is much less in the young than in older animals. It should be emphasized that the present study was not concerned with terminal fasting, the control animals being far from moribund at the time they were sacrificed. It seems clear that the degree of stress imposed by the restricted food intake is much less than that imposed by the vitamin deficiency in its advanced stage.

[2] The adrenal cholesterol is reported by Baldwin *et al.* in terms of its percentage of the total adrenal lipid, the scurvy animals showing an average of 8.3, and the pair-fed controls, 6.9. The adrenal lipid for the two groups was 20.5% and 23.7%, respectively. Thus, the adrenal cholesterol expressed in g/100 g of adrenal tissue is $20.5 \times 8.3/100 = 1.70$ for the scurvy animals and $23.7 \times 6.9/100 = 1.64$ for the pair-fed controls.

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## A Universal Motion Analyzer Applied to Psychomotor Performance


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It has been recognized for some time that improved methods are needed for motion analysis and dimensional measurement of motor skills and psychomotor activities involved in typical domestic, industrial, and military performances. This report describes methods of motion analysis which provide: (*a*) automatic registration of elapsed time in the performance of any simple or complex motor task; (*b*) separate automatic registration of the different components of travel time and manipulation, or time involved in the

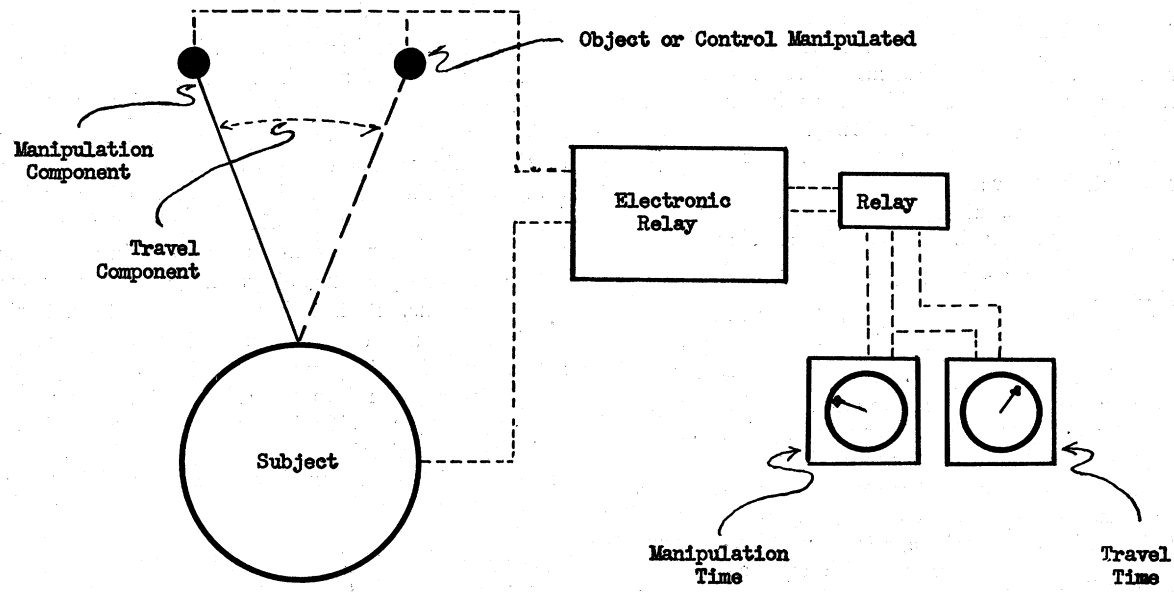


FIG. 1. The principal components of the motion analyzer.

task: and (*c*) flexibility and universality of application of the analytic method to different types of task situations. The name "Universal Motion Analyzer" has been applied to the apparatus developed for the purposes just indicated.

A critical element in analysis of human motion, which has been dealt with adequately by current methods of motion study only through great cost in equipment, is the separate measurement of the time characteristics of the travel component of a movement and the component of motion involving manipulation or contact with the object, control, or machine which is being handled. The universal analyzer, when applied to the timing of motion, provides a simple and relatively economical technique for such measurement of the different components of motion. The basic aspects of this technique are shown diagrammatically in Fig. 1. The apparatus consists of an electronic relay operated on a current level of subthreshold value for the human skin. Connections are made between this relay and the human operator and between the relay and the objects or controls to be manipulated. The electrical connection with the operator is made by means of an electrode attached to the ankle or to the upper arm. The electronic relay is made to activate a double-pole, double-throw external relay, which is used to activate precision time clocks or recording devices. One direction of action of this relay operates the clock, counter, or recorder which registers contact with the controls or objects manipulated. The other direction of

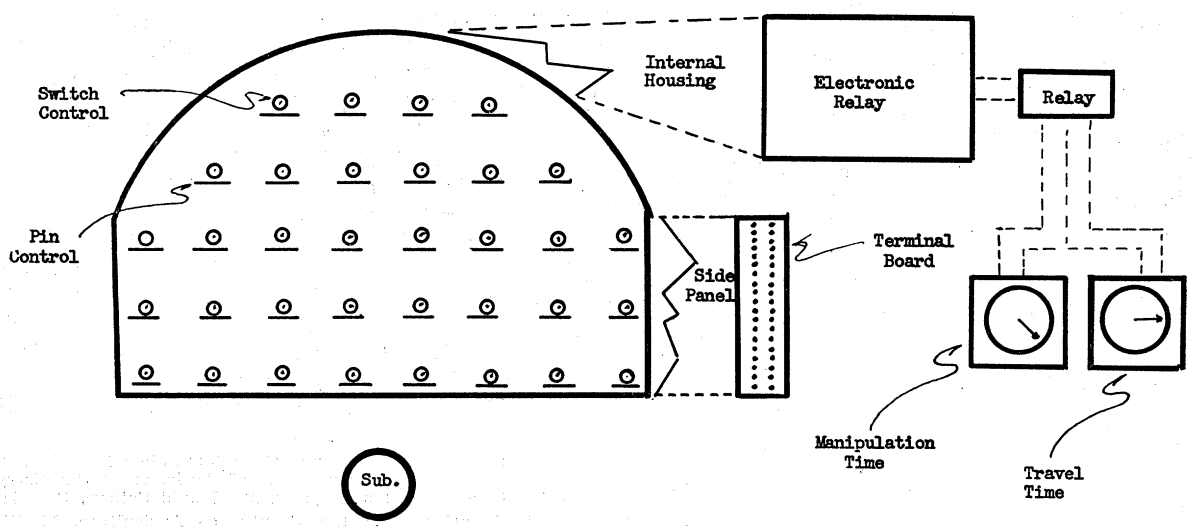


FIG. 2. The "Universal Motion Analyzer" applied to dimensional analysis of movements on a universal control panel.

action of the relay operates the second clock or recorder which registers the interval between contact with the object or control manipulated and any succeeding manipulation which may be made. When clocks are used in the apparatus, a third clock is employed for obtaining a measurement of total time. This total time value serves as a check on the component times obtained from the other two clocks. Clocks which may be read with precision to 0.001–0.005 sec are being used in present work with the apparatus.

The technique, as described, may be applied to any work situation or psychomotor task in which it is possible to insulate the subject operator from the controls or objects to be manipulated. Subject operators cannot detect the fact that they are acting as electrical conductors in the use of the equipment.

Rate of tapping of different members of the body, operation of hand and foot controls, manual grasping and manipulation of objects, repetitive movements involving transient contact with equipment, adjustment reactions in operation of scales, and operation of machines may all be analyzed by means of the simple principles involved here. The apparatus can be set up to obtain continuous records of repetitive movements in work situations in order to make studies of learning and fatigue and to obtain continuous performance records in manual and pedal motion. Recording apparatus which makes provision for cumulatively recording the time intervals involved can be attached to the device to secure separate rate records of travel and manipulation motions in continuous work.

The development of the technique described has provided a foundation for standardized dimensional analysis of predefined patterns of movement. One example of this application is shown in Fig. 2. A large panel 5 ft long and 3 ft high is constructed with switch controls and pins arranged at regular intervals on the panel. The pins are attached to small springs located behind the panel so that they will return to their original position after being grasped and released. Electrical connections are made between each of the switches and pins on the panel and a terminal board located in the housing of the apparatus. Appropriate controls for selected combinations of switches and pins to be operated are made through this terminal board. When hooked up with the motion analyzer, precise data can be obtained with respect to such dimensions of motion as the pattern of manipulation, plane of movement, direction of movement, length or extent of the movement, continuity or uniformity of the movement patterns, distance of travel from the body, number of repetitions of the movement, the body member involved, force requirements in manipulation, amplitude of manipulation, uniformity in pattern of manipulation, and any other quantitative dimension affecting the motions involved. Stimulus variations may be introduced for analysis of their effects on the motions under investigation. Through such application of the motion analyzer, standardized investigation of human work and control situations may be evolved to answer practical and theoretical questions of work arrangement, control arrangement, and physical conditions affecting performance. The same application of the analyzer constitutes a standardized test situation of significance for the appraisal of individual psychomotor performance which may be of vocational, medical, or military significance in certain situations.

In preliminary studies of learning aspects of movement patterns, it has been determined that the manipulative and travel components of simple movements are affected by practice quite differently. Detailed examination into the effects of training, and related phenomena of inhibition, transfer, and fatigue, which may be of prime significance in various aspects of human engineering work, are made possible by the techniques described.

## Investigation of the Forms of Phosphorus in Neutron-Bombarded Phosphates: Role of Hypophosphate[1, 2]

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In attempts to establish the states of combination of $P^{32}$ in neutron-bombarded orthophosphates, use has been made of phosphite as a carrier (*1–3*). The basis for such a use of phosphite apparently has been the work of Wilson (*4*) relative to the possibility of exchange of $P^{32}$ between orthophosphorous and orthophosphoric acids. Wilson considered it possible that the hydration of hypophosphoric acid was to some extent reversible. This was apparently the only reference in recent literature on the states of combination of $P^{32}$ in neutron-bombarded phosphates, which is indicative of the possibility that the hypophosphate form of phosphorus should be considered in such investigations. Work recently completed by the writer has indicated, however, that the formation of hypophosphate by interaction of orthophosphate and phosphite may be of considerable significance, more especially in the case of systems containing calcium.

According to Mellor (*5*) hypophosphoric acid has been prepared by (*a*) slow oxidation of phosphorus in moist air, (*b*) oxidation of phosphorus by cupric nitrate or silver nitrate in the presence of dilute nitric acid, (*c*) by the action of phosphorus on copper sulphate solutions, (*d*) by the slow oxidation of phosphorous acid in air, or (*e*) by oxidation of phosphorous acid with silver nitrate in neutral or ammoniacal

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[2] Contribution from the Faculty of Agriculture, McGill University, Macdonald College, Que., Canada. Journal Ser. No. 277.