meter to study voltage-frequency relationships in action currents (Fig. 1). The overall frequency

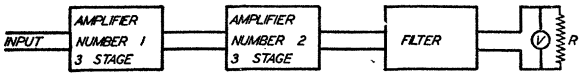

FIG. 1. A diagrammatic sketch of the voltage-frequency measuring unit.

deflection characteristic of the two amplifiers was linear between 100 and 6,000 cycles per second. The voltmeter had no frequency discrimination between 80 and 5,000 cycles per second. All the commonly studied muscles of the human body have been scouted in this preliminary report. The subject was asked to tense the muscles from which action currents were being led off until a full-scale deflection of 9 volts was obtained on the voltmeter. Then as each filter circuit was introduced the new reduced voltmeter deflection was noted. Thus it was possible to determine what proportion of the voltage generated by the contracting muscles was within the frequency range being passed by the filter circuit.

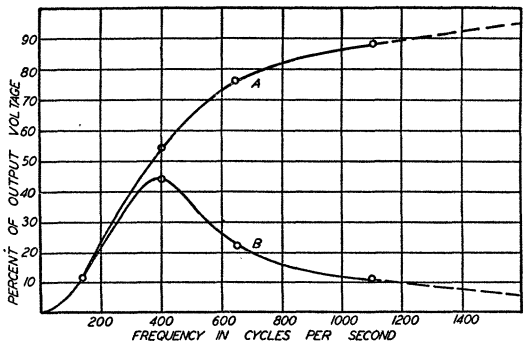

FIG. 2. Voltage-frequency curves for action currents from the tongue.

Curve B of Fig 2 shows the proportion of the total action current voltage in a given action current frequency band.[1] Several features of this curve strike our attention. Its general shape resembles that of a probability curve. The largest percentage of the voltage (44 per cent.) is expressed at 400 cycles per second and half of the total voltage generated falls between 130 and 450 cycles per second. This may be taken to mean that a large portion of the fundamental frequency is in the neighborhood of 400 cycles and that the second harmonic is an appreciable portion of the fundamental. Eleven per cent. of the voltage is above 1,100 cycles per second.

Curve A of Fig. 2 is an accumulative curve which shows what percentage of the total action current voltage may be expected to fall above or below a given action current frequency.

From these curves we may assume that the action current wave is a very complex one. It is indicative probably of direct, pulsating direct and alternating currents which may not have direct relationships with each other in respect to phase or time. The action current waves may not present harmonics. Rather they may be composed of fundamental, pure sine waves which are generated more or less crazily by the extremely complicated electrical generating network. If this is true then we should be able to isolate certain generating points by means of a system of filters having very narrow band widths.

It remains to test this method in a wide variety of problems in electrophysiology.

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SPECIAL ARTICLES

THE EFFECT OF CORTICO-ADRENAL EXTRACT ON ENERGY OUTPUT[1]

THE effect of extracts of the adrenal gland on the activity of muscle has been reported by many observers;[2] it is to be noted that attention has been directed primarily, however, to the action of epinephrine. More recently workers have reported on the effects produced by extracts of the adrenal cortex.[3] These investigations were in all cases carried out with nerve-muscle preparations. The intact, normal animal has not hitherto been used to demonstrate the effect of cortico-adrenal extract on the capacity to perform work. The substances used, furthermore, were of doubtful potency.

Dogs have been trained in this laboratory to run in a treadmill, and their total energy output in excess of basal metabolism has been determined in a series of experiments. The action of cortico-adrenal extract, prepared as previously described[4] according to the method of Swingle and Pfiffner,[5] and proved to be

[1] Reported in brief at the joint session of the Federation of American Societies for Experimental Biology, Montreal, Canada, April 11, 1931.

[2] M. Yoshimoto, *Quart. Jour. Exp. Physiol.*, 13: 5, 1922.

[3] A. Obré, *Compt. rend. soc. biol.*, 88: 585, 1923; J. Stefl, *ibid.*, 99: 985, 1928; F. de Mira and J. Fontes, *ibid.*, 98: 987, 1928; and 100: 602, 1929.

[1] Filter transmission characteristics were known and evaluated.

[4] S. W. Britton and H. Silvette, SCIENCE, 73: 322, March 20, 1931; *ibid.*, 373, April 3, 1931; *Amer. Jour. Physiol.*, 99: 15, 1931.

[5] W. W. Swingle and J. J. Pfiffner, *Amer. Jour. Physiol.*, 96: 153, 1931.

effective on adrenalectomized cats, was then tested. The material was injected intraperitoneally, and the subsequent effects on the ability to work were ascertained.

The working capacity of a normal (uninjected) dog is affected by training. It increases rapidly at first, but later it varies only slightly from the "standard output." Pulse rates increased from between 80 to 104 per minute during rest, to between 118 and 144 per minute at the end of a severe bout of exercise. The rates returned to normal within 20 to 40 minutes after the conclusion of an experiment. During the early stages of training the pulse rates were somewhat higher than those observed after a number of experiments had been carried out. The blood-sugar level in the normal dog showed a tendency to decrease during long-continued work, and to increase during the subsequent rest period. There was no close correlation between the glycemic level and the condition of the dog after exercise.

Injection of extract brought about a slight rise in the blood sugar of the resting, unexercised animal. The glycemic level was higher during experiments when the animal was under the influence of extract than when the effect of the extract was disappearing. Intraperitoneal injection of cortico-adrenal extract considerably increased the energy output. The extract was slowly acting in this respect, and exerted its maximum effect usually within 5 to 10 days. In one case, 20 cc of extract given intraperitoneally brought about a gradual increase in the total energy output in excess of basal metabolism. The increase reached a maximum of 115 per cent. in 10 days; thereafter a gradual decline in energy output was observed, and the previously established normal was eventually attained.

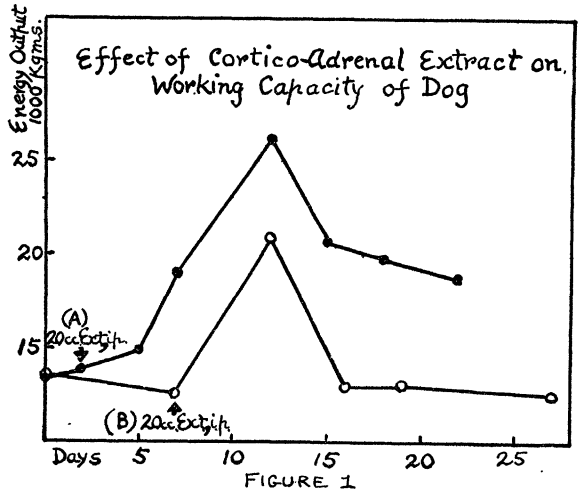

FIGURE 1

Fig. 1 shows graphically the effect of the extract on the energy output in excess of basal metabolism in two groups of experiments. Extracts of the adrenal cortex, of proven potency in overcoming adrenal insufficiency, are observed to augment markedly the capacity of the dog to perform work.

On man also cortico-adrenal extract has been found by ergographic record to increase notably the ability to carry out muscular exercise.

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VITAMIN G AND THE GROWTH FACTOR IN TOMATO JUICE

DURING the course of some vitamin assay determinations on canned tomato juice, we obtained evidence to show the lack of vitamin G (B_2) in either canned or fresh whole tomato juice. This is in disagreement with the findings of Goldberger and his associates[1, 2] and Hartley,[3] if we accept the statement that pellagra, black-tongue and dermatitis are all caused by the lack of vitamin G.

Evidence is also contained in table I for the differentiation of vitamin G and a purely growth-promoting factor. This distinction has previously been pointed out by Reader[4] and Williams and Waterman.[5]

The animals in the group reported here were young rats approximately four weeks old, weighing 30 to 40 grams each. They were placed in individual screen-bottomed cages and fed the following ration: Casein (acetic acid extracted) 18 per cent., cornstarch 66 per cent., Osborne and Mendel salt mixture 4 per cent., lard 10 per cent., and cod liver oil 2 drops per rat daily. After one week of depletion on the basal ration devoid of all factors of the B complex, constant weights were obtained. Graded doses of tomato juice, as indicated in the table, were then fed daily in separate cups for an eight weeks' period. Weights of the animals were recorded daily as well as symptoms of deficiency.

In the groups that lived long enough to develop a dermatitis, it always appeared in approximately 44 days, regardless of the amount of tomato juice fed. That the dermatitis shown by these rats was of nutritional origin, and not of epidemic nature, is indicated by the fact that they were kept on the same racks as some rats used in vitamin A assay experiments, and

[6] P. F. duPont fellow in physiology.

[1] Goldberger, Wheeler, Lillie and Rogers, U. S. Public Health Reports, 42: 1299, 1927.

[2] Goldberger and Wheeler, U. S. Public Health Reports, 43: 1385, 1928.

[3] Hartley, 1930 (personal communication to Sherman and Smith), "The Vitamins," p. 139, 1931.

[4] Reader, *Biochem. J.*, 24: 1827, 1930.

[5] Williams and Waterman, *J. Biol. Chem.*, 78: 311, 1928.