time $t_1$, but at a slightly greater time $t_2$, the exact evaluation of which requires a knowledge of the rate of displacement of the stylus and of the radius of the arc described by it.

It is evident from the foregoing remarks that the generally accepted procedures for the evaluation of the magnitude and speed of the reactions are not accurate, and require the introduction of corrections.

Since it is not possible to achieve identical tensions of the rubber of the Marey tambours, then, even if the styluses are of identical length and weight (which is in practice highly improbable), the displacements registered on the tracings will be different, although the volume changes in the two extremities may have identical. This gives rise to an apparent difference in the rates of development of the reaction in the two extremities, and to a spurious asymmetry of reaction, applying not only to its magnitude and speed of development but also to its direction at a given moment (Figure 3). This effect is due to one stylus lagging behind the other. It is, in order to establish asymmetry in magnitude and speed of a reaction, essential to switch the recording system over from the left to the right hand, or vice versa. Only then can we speak with assurance of the existence of asymmetry. Asymmetry in the direction of the reactions can be regarded as real only if we are able, visually or otherwise, actually to observe at any moment that the styluses are moving in opposite directions.

The routine registration of plethysmograms from both hands may serve as a reliable method of detecting distortions due to imperfections in the equipment.

In some cases we find that the plethysmograms take a very long time to return to their initial levels, both of the height of the tracing and of the amplitude of the oscillations. Such deviations may be the results of physiological changes connected with the prolonged alteration in the volume of the extremity. Special experiments showed, however, that changes in the volume of the part of the body within the plethysmograph are reflected not only in changes in tension in the receiving tambour, but also partly in the position of the wall of the plethysmograph which is a part of the rubber glove, lined with cotton wool, and bound to the apparatus. Such a wall cannot be considered to be "rigid," and it may often give rise to prolongation of the return of the plethysmogram to its initial level. We apply the following technique to the detection of this possibility. The whole system is connected with the atmosphere. If after this the gradual fall in the level of the tracing continues, the effect is a physiological one, while if it remains more or less constant the effect is of physical origin.

It follows from the above considerations that it is necessary to continue work on the designing of more reliable, although simple, instruments, of a sensitivity adequate for the given purpose, and within the means of a wide range of users.

## RECORDING OF ELECTROGRAMS OF WORKMEN DURING INDUSTRIAL WORK

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At present, physiologists studying the physiology of labor register electromyograms (EMG) and electroencephalograms (EEG) of subjects during performance of work under laboratory conditions in screened rooms, whereas electrocardiograms are recorded in the factory itself, using standard techniques, as close as possible to the workplace of the subject.

We undertook the problem of registering ECG and EMG recordings of persons working in industry, simultaneously with recordings of their industrial activities.

Having become acquainted with the techniques of registering bioelectrical activities in the clinic, and of taking the ECG and other bioelectrical records from aircraft pilots in flight (applied in aviation medicine),

involving radio transmission of electrophysiological information from the subject, and having investigated the limitations of electrography and the possible artifacts which might arise in metal working shops, we arrived at the conclusion that it is possible to take satisfactory ECG and EMG recordings from workmen performing their work in the factory itself, under ordinary bench conditions.

Since the movements of the workmen give rise to artifacts of muscular origin, which distort the ECG taken using standard leads, we applied the known procedure of placing the electrodes at such points of the chest of the subjects as would ensure maximum amplitude of the ECG, with minimum muscle potentials. Thus in the tracings of Figures 1 and 2 the ECG was recorded with electrodes in the pectoral position at $CR_4$ and on the back

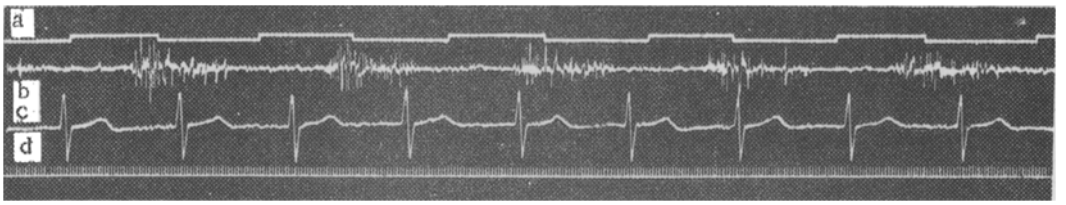


Fig. 1. Electrogram recorded during cutting of metal with a chisel. a) recording of impact of the hammer with the chisel (downward displacement of the line); b) EMG taken from the triceps muscle of the right arm; c) ECG; d) time signals (50 seconds).

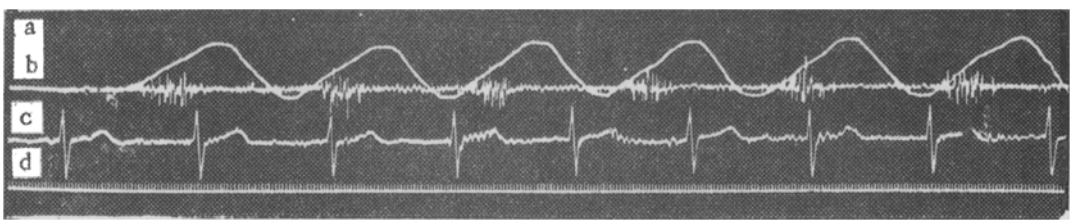


Fig. 2. Electrogram recorded during filing of metal. a) recording of movements of the file in a horizontal plane; b), c), and d) as in Figure 1.

between the rectus and oblique muscles. This arrangement of the electrodes permitted of satisfactory registration of ECG during cutting or filing of metals. It is also possible to have the electrodes at other locations.

Alterations in resistance in the area of contact of the electrodes with the skin give rise to variable emf effects, which cause distortions of the electrograms. For this reason we paid special attention to the attachment of the electrodes to the skin, and to the electrode paste used. We used cup electrodes, stuck to the skin with "Kleol," and VNIIMIO electrocardiograph electrode paste.* The magnitude of the resistance between the electrodes is also of considerable importance: if it is great, the possibility of leading in alternating current increases. We used electrodes of 15 mm diameter for the ECG, and of 8 mm diameter for the EMG. With these, the resistance between the electrodes was 1-3,000 ohms forthe ECG recordings, and 10-15,000 ohms for the EMG, and these values were achieved by thorough preparation of the skin before applying the electrodes.

In order to eliminate E.M.F. interferences arising during displacements of the leads we covered them with flexible shielding material, almost to the electrodes, and we connected the shielding material with the casing of the amplifier. This shielding was quite adequate for recording of ECG and EMG during voluntary movements of the subjects.

* VNIIMIO Paste No. 3, for use with lead electrodes, has the composition: starch 7%, stannous chloride 7%, finely powdered pumice 26%, glycerol 7%, "Diotsid" 0.05%, distilled water 53%.

It should be borne in mind that, in recording EMG of subjects making violent movements in a screened room, it is also necessary to use shielded electrode leads.

The chief shource of interference with electrography encountered in metal working shops is to be found in the variable electrical field of the power and lighting systems.

In order to eliminate these sources of interference we used a differential amplifier, connecting the body of the subject to its housing by means of a "null" electrode. With the resistances between the electrodes as mentioned above, the amplifier should have a discrimination coefficient of only about 1,000-1,500.

The equipment used by us for ECG and EMG recording at a workshop bench consisted of a two-channel amplifier and an oscillograph. Devices transforming elements of the movements of the workmen into electrical impulses were connected to the oscillograph. The input points of the amplifier were connected through shielded leads to a plug fastened to a belt worn by the workmen. Single shielded leads connected the plug to the electrodes.

The equipment had an independent current supply. In many cases the equipment did not need to be grounded.

We made ECG and EMG recordings, using the above-described equipment, from persons working in a metal-working shop. Figure 1 shows the electrogram recorded during cutting of metal with a chisel, and Figure 2 that during filing of metal. In addition, we took ECG and EMG recordings of men engaged in drilling metal on a lathe and with an electric drill, and in working a shaping lathe.

In working with grounded equipment it should be borne in mind that the subject is also grounded and strict safety precautions should be observed.

Should it be necessary to record a one-channel ECG, this may be done using the EKP-4 electrocardiograph, or some similar instrument. In such cases the electrode leads should be shielded.

Our results show that electrographic methods may be applied to the study of bioelectric processes taking place during work in a factory, and this facilitates the solution of a number of problems of the physiology of work under industrial conditions.

## INSTRUMENT FOR NARROWING THE LUMEN OF THE AORTA, IN SHORT EXPERIMENTS

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A study of arterial pressure levels, and of depressor nerve activity, in experimental aortic stenosis is of considerable importance to the development of modern cardiovascular surgery.

The existing instruments for determining the degree of narrowing of the lumen of the aorta are very imperfect [1, 2]. We were not able, from a search of the literature available to us, to find a single description of an instrument which would be simple in operation, and which would produce accurately any required degree of stenosis of the aorta, under conditions of short experiments in the laboratory.

The instrument devised by us (see Figure) consists of a metal cylinder, containing a threaded piston rod, a nut, a cap, and a movable guide. The cylinder is 12.5 × 0.5 cm. A window is cut in the upper third of its length, dimensions 5 × 0.5 cm, to enable movements of the piston rod to be observed. A scale is engraved on the right-hand side of the window, graduated in mm from 0 to 20 mm. The rod consists of three portions: a thread is cut