would be determined by meteorological factors. It is possible that precipitation at this Ice-cap Station will be considerably less than at the French ice-cap station some 400 miles farther south, for the Ice-cap Station will be a greater distance from the track of depressions as they move north-eastwards along the east of Greenland and north-north-westwards up the Davis Strait.

The meteorological programme for the first year consists of the development of instruments and of micro-meteorology in conjunction with the glaciological research, which will be concerned mainly with the subject of regime. Accumulation and ablation will be measured at the Ice-cap Station and at two places on one of the marginal glaciers, one in the ablation and one in the accumulation area, where micro-meteorological stations will be set up. Accumulation will be measured at a dozen places on the glacier and at a number of places on the route to the Ice-cap Station. Accumulation in past years can be estimated by an interpretation of the profile of pits dug in the firn, and the penetration of temperature waves into the ice will be examined by temperature measurements in the ice. Ablation will be measured at intervals at several places on the glacier and on the ice-cap, and over short periods will be related to the radiation and to the vertical gradients of temperature, wind and humidity. The movement of glaciers will be studied in detail.

In order to study the propagation of radio waves across the polar regions, a programme of listening to European broadcasts over a range of frequencies at different times of day has been drawn up; further, if finances permit, soundings will be made of the ionosphere and measurements made of ionospheric winds.

The physiologist will study the acclimatization to cold by the members of the Expedition, will record variations of body temperature, especially during the Arctic night, and changes in basal metabolic rate. Experiments on nutrition, too, will be carried out.

The research programme for the second year depends on the financial position of the Expedition. The survey, and perhaps the geology, will be finished during the first year; but the glaciological programme is planned for two years, and the gravimetric survey will be continued to the west coast. The seismic party will finish the survey of the ice-cap by pushing farther towards Melville Bay, and an attempt will be made to investigate the nature of the rock beneath the ice-cap by refraction methods of seismic survey. Deep drilling will be attempted and, unless prevented from doing so by the plasticity of the ice, it is hoped that the depth will be reached at which the vertical temperature gradient in the ice becomes negative; the temperature and winds in the upper atmosphere will be measured to examine the effect of the Greenland ice-cap on the general circulation.

It is a sign of the times and of the nature of modern scientific expeditions that, in order to carry out their project, the sponsors have found it necessary to build up a novel form of combined operation. In the field, the work will be purely scientific; but the scientists will be assisted by young officers from the Services, who will thus gain valuable training and experience. A combined Service and scientific enterprise of this nature offers advantages to all concerned which none of the supporting bodies could realize alone except at a much greater cost. It is hoped that this happy marriage of men of arms and science may be the pattern for future expeditions of this kind.

PSYCHOLOGICAL AND PHYSIOLOGICAL ASPECTS OF FATIGUE

THE Ergonomics Research Society held a symposium on "Fatigue" at the College of Aeronautics, Cranfield, during March 24–27, at which the psychological and physiological aspects of the subject were reviewed. The 136 persons attending included representatives drawn from universities, the Armed and Civil Services, government research establishments, and private and nationalized industry. Twenty-four of the participants came from abroad.

The study of fatigue has traditionally been regarded as one of the points of close contact between physiology and experimental psychology, although it has been recognized that the problems of the two sciences in this respect are not identical and that the changes of function in peripheral organs which typify what may be called fatigue states at a physiological level are not capable of giving a direct explanation of so-called mental fatigue. Recent advances in both these sciences and in functional anatomy and industrial medicine have, as the papers in this symposium testified, preserved this contact. Manifestations of fatigue are different at different levels, but they display many common principles.

Perhaps the most important of these is that measures of the decrement of overall performance give a very incomplete picture of what happens in fatigue. Often there may be no change in overall achievement or in the adequacy of overall action; but, if detailed measures are taken of the functions which go to make up this total performance, some of them will be found to have changed markedly. The changes are, however, mutually compensatory and so keep the total performance steady. The situation is further complicated by the appearance of side-effects which may become more striking than the main effects which have produced them.

It was probably due to the recognition that the expression of fatigue is complex that few attempts were made at precise definition. Emphasis was laid rather upon the finding of measurable criteria of fatigue and the understanding of the places that these criteria occupy in the process which is being studied. In any normal performance many mechanisms at various levels of function are involved, of which only one or two may show changes with continued exercise. It is clear, therefore, that if a full understanding of what is happening is to be obtained, measurements must be sufficiently detailed to show which mechanisms have undergone a change of function and which have remained unchanged. Such measurements must be taken during performance at the actual task concerned. It is not satisfactory to transfer the subject at intervals from this task to others designed to 'test' fatigue, because he can usually mobilize his efforts to deal adequately with a short test even when his performance at a previous long-term task has shown substantial decrement.

This general position, as it applies to psychological studies, was stated by Sir Frederic Bartlett (Cambridge) in the opening paper. He suggested that the term 'fatigue' should be used to cover all those determinable changes in the expression of an activity which can be traced to continued exercise of the activity under its normal conditions, and which lead eventually to its deterioration. For indication of

these changes, we need to look especially to irregularity in the timing of the different phases of a complex activity, to the tendency for the display field presented to the subject to 'split up', so that he attends to some parts and neglects others, and to the widening of the field of possible responses from which the one to be made is selected—that is, loss of 'control' of the response.

This approach was taken up again at the end of the symposium by Prof. R. C. Browne (King's College, Newcastle) and by A. T. Welford (Cambridge). The comparable approach from the physiological side was presented by Prof. A. Hemingway (Leeds), who pointed out the need for considering a number of different mechanisms interacting to produce a dynamic equilibrium which may be upset in complex ways by a change affecting one mechanism only. A similar type of view was implicit in most of the other papers.

Speaking from the more strictly applied side, Prof. G. P. Crowden (London School of Hygiene and Tropical Medicine) urged that in physiological studies of fatigue it is necessary to consider both the nature of the activity, environmental stresses, the duration and rate of activity, and a number of individual factors.

The use of detailed physiological measures to study the demands of work in industry was demonstrated by Prof. E. H. Christensen (Stockholm), who stressed the need for making job analyses in terms of physiological demand and for considering the capabilities of people of different ages, etc., in relation to the physiological stresses of the working environment.

It is not possible in this article to give any adequate summary of the remaining papers; but they fall roughly into four groups:

Anatomical and Physiological. Some anatomical aspects of fatigue were discussed by H. D. Darcus (Oxford). Reports of research were given by E. Asmussen (Copenhagen) on the extent to which negative work is easier than positive; by H. R. Noltie (Leeds) on 'warming up' in relation to fatigue in athletics; and by J. W. T. Redfearn (Royal Army Medical Corps) on the use of finger-tremor as an indicator of fatigue. H. C. Weston and L. C. Thomson (Institute of Ophthalmology, London) described studies in problems of illumination and posture in relation to visual fatigue, and discussed various factors of difficulty in visual tasks. Films were shown by K. F. H. Murrell (Tube Investments, Ltd.) on the effects of simple devices to aid in the carrying of weights; and by W. H. Floyd (Middlesex Hospital Medical School, London) on electro-myographic records obtained from the *erectores spinæ* during trunk-bending movements.

Psychological. The relative roles of receptor and effector functions in the fatigue of motor skills was discussed by R. M. Gagne (Lackland Air Force Base, United States), and a research on the same subject was reported by W. T. Singleton (Cambridge). Evidence of satiation and frustration as determinants of fatigue was presented by D. Russell Davis (Cambridge), and of the breakdown of ability to reject unwanted sensory information by D. E. Broadbent (Cambridge). A study of the effects of age and heavy work was reported by I. M. Richardson (Aberdeen). Prof. T. A. Ryan (Cornell) and J. L. Kennedy (Rand Corporation) described attempts to obtain measurable criteria of mental effort from muscle action potentials.

Dealing with both physiological and psychological problems were two extremely interesting papers by visitors from the United States: Prof. A. Keys (Minnesota) outlined some of the work he and his associates have carried out on the effects of semi-starvation; and R. S. Schwab (Massachusetts General Hospital) discussed the uselessness of rest as a treatment of fatigue resulting from loss of motivation, and outlined work on muscular performance in normal persons and *myasthenia gravis* patients.

Effects of Heat and Cold. Work on the effects of heat was surveyed by T. Bedford (London School of Hygiene and Tropical Medicine) and by O. G. Edholm (Div. of Human Physiology, Medical Research Council Laboratories, Hampstead). Research on the prevention of heat effects due to impervious protective clothing was described by Prof. G. P. Crowden. Studies of performance under tropical conditions were outlined by Surgeon-Commander F. P. Ellis (R.N. Tropical Research Unit (Medical Research Council), Singapore), and under cold conditions in the Korean winter by W. S. S. Ladell (Colonial Medical Research Service, Nigeria).

Time-and-Motion Study. A discussion on fatigue allowance in time study was led by Prof. T. U. Matthew (Birmingham), who outlined the history and concepts of the subject, and by Prof. J. V. Connolly (College of Aeronautics, Cranfield), who appealed for the co-operation of other men of science in supplying time-study engineers with relevant information. In the subsequent discussion it was urged that physiological measures could be valuable aids in job assessment, provided it was recognized that a performance optimal in one respect might not be optimal in another—for example, a manner of working which involved minimum oxygen consumption might make undue use of a small group of muscles. The need to distinguish between fatigue and boredom was also stressed. Demonstrations of some new time-and-motion study techniques and apparatus were on show in Prof. Connolly's laboratory. A. T. WELFORD

DEVELOPMENTS AND SCIENCE IN THE SOVIET UNION*

By DR. S. M. MANTON (MRS. J. P. HARDING), F.R.S.

IN the summer of 1951 I accepted an invitation to visit the Soviet Union with other scientific workers and directors of medical institutions, where I travelled wherever I wished, accompanied or alone, for ten thousand miles. I belong to no political party or friendship society, and every facility was given to see as much as was possible in a short time, and, in addition, authoritative information was provided at meetings with deputy ministers and directors of various organizations in Moscow, Stalingrad and Tashkent.

Desert and steppe cover one million square miles of the Soviet Union. Twenty-two out of the past sixty-four summers have brought drought to the south Ukraine, and desert conditions prevail over 50 per cent of the central Asian States of Kazakhstan and Uzbekistan, and 85 per cent of Turkmenia. Afforestation schemes were begun in 1948, to be completed within fifteen years, and in 1950 great construction projects were started which by 1957 will

* Substance of a lecture delivered to the Linnean Society of London on February 21.