set up by British engineers, among whom were the Bairds, Handyside and the younger Matthew Murray. The early history of the engineering and other industries in Russia, however, is receiving the attention of Prof. P. P. Zabarskij and other

members of the Institute for the History of Science and Technics of the Academy of Sciences of the U.S.S.R., and already many interesting documents and facts have been brought to light and published.

PRESENT-DAY SCIENCE AND TECHNOLOGY IN THE U.S.S.R.

BY PROF. J. D. BERNAL, F.R.S.

SCIENCE is a collective human enterprise. It belongs to no country or race. Yet at different periods it has owed its chief advance to the activities of men first in one part of the world and then in another. Modern science originated in Italy in the sixteenth century, spread to the Low Countries, and thence to England and France. It was in England that it first achieved effective organization in the Royal Society. The nineteenth century saw it established in every industrial country of the world, notably in Germany and the United States. In each of these countries a characteristic contribution was made both to the extent of new knowledge and to the new means of gaining it. In this century, the contribution that the new Union of Socialist Soviet Republics has made to science is as significant as any of the major contributions of other origins in the past.

Science, of course, was not a new thing in Russia. It can date its introduction as a living force to the many-sided genius of Lomonosov in the eighteenth century; and Russians can well be proud of the achievements of such men as Mendeléeff and Pavlov. But all these were relatively isolated workers. In no sense could the state of science in Russia before the Revolution be compared with that of Germany or Great Britain. The great change which the revolution brought about was to make conscious for the first time the necessary connexion between the ordered development of science and the life and work of the whole community. In this, of course, the new Government was inspired by the ideas of Marx and Engels, who had taken a lifelong interest in the progress and importance of science. Lenin had a wider and deeper knowledge of science than any statesman of his day, and even in the most difficult period of famine and civil war he laid the foundations of an entirely new development of science.

The conscious utilization of science, though to a certain extent implicit in State scientific institutions such as the Kaiser Wilhelm Gesellschaft in Germany and the Department of Scientific and

Industrial Research in Great Britain, was foreign to the Western democracies; and this has made it difficult for many scientific workers to understand and appreciate the achievements of Soviet science. The task that was undertaken was not to push forward the bounds of knowledge by the work of a few isolated specialists, but to make scientific the whole productive and cultural activity of 160 million people, only a tiny minority of whom had any previous acquaintance with science or technology. The first twenty years of the Republic's life was occupied in a double task: the building up of scientific education, and the application of science to industrial, agricultural and medical needs. It was first necessary to create a body of competent scientific workers, starting from the handful that had sufficed for the needs of the Tzarist State. In 1919 there were only forty trained physicists in the whole of the Union. New schools, new universities, new scientific research institutes had to be founded and manned, and the necessary scientific instruments manufactured for them. Meanwhile, immediate problems of electrification, communications and agriculture had to be solved. This gigantic task could only have been achieved because it had behind it the enthusiastic interest and support of the whole people. It is characteristic of times of rapid progress and reconstruction that interest in knowledge should reach new heights. It was so at the dawn of the Greek City State, in the Italian Renaissance, in Civil War England; and it was certainly so not only for the Russians, but also for the submerged subject races of the old Empire—Mongols, Kazaks, Turkmen, Tartars, Georgians and Armenians.

In the creation of a new world it would be idle to look for the quietly pursued excellence and sound and acute scholarship that characterize an old-established and stable society. Science in the Soviet Union is not like science in Denmark or Switzerland. Nevertheless, the contribution to the advancement of knowledge made by the Soviet Union has been marked and important. In certain fields, especially in technology, Soviet discoveries

and applications have already made a deep impression abroad. In physics, for example, the work of the Leningrad School on the mechanics of crystal deformation was the starting-point of much of the recent great advance in the understanding of the strength of materials and of ways of improving them.

The Soviet Union has also led in the application of low-temperature techniques to industrial uses, particularly for oxygen, hydrogen and methane, where Prof. P. Kapitza's new processes are being energetically developed. Proposals for radical innovations, such as underground gasification of coal, eliminating at one stroke the whole of the laborious task of the miner, are characteristic of the Soviet approach. The widespread and strictly scientific survey of mineral resources has already led to discoveries of new mineral deposits exceeding all expectations.

In agriculture, the advantages of a common scientific basis and the removal of obstruction from tradition or vested interest have led to remarkable developments, notably in vernalization, the production of new hybrids such as perennial wheat, and the improvement of stock through artificial insemination. The development of public health services on a universal and rational basis has probably contributed more than anything else to immediate human welfare, and the new and universal use of stored blood for transfusion is largely due to Soviet initiative.

It is not in these achievements, however, that the ultimate value of the developments that have taken place in the Soviet Union is to be found. They are, so to speak, only an indication of what is to come when the principles of the organized development and utilization of science can be fully carried out, not only in the Soviet Union but also in the world at large. Nothing has aroused such interest, and at the same time such opposition, in scientific circles as the idea first adopted in the Soviet Union of the planning of science. The opposition is now largely silenced, because the conditions of war have made most scientific workers realize in their actual practice that planning is not only necessary, but is also quite compatible with individual initiative and enterprise. Curiously enough, the very consideration of a science planned in relation to social needs brings to light new problems, which in themselves act as a stimulus to radically new discoveries, by breaking up traditional associations of ideas which are the most effective bar to progress.

The actual system of planning which has been evolved in the U.S.S.R. in the past twenty years is much more comprehensive and more closely integrated with the life of the country than anything in Great Britain even in war-time. The general

direction of research is in the hands of the Academy of Sciences, which has grown from being an honorific society into a body controlling directly the research of some thousands of workers mainly on fundamental problems. The Academy is closely linked with the universities, which have grown enormously in number and size while steadily improving the standard of their scientific teaching. All university students are selected for ability and are supported by the State, as are the new science bursaries in Great Britain. In return, they must accept four or five years of work allotted to them after graduation. This system ensures an ample supply of the best brains for scientific and technical work. Already in 1934 the proportion of young men and women going to the university was five per cent, as against two per cent in Great Britain. Allowing for the greater population and for the fact that a far larger proportion take science, the annual output of scientific workers must be about twenty times what it is in Britain.

The greater part of the short-term research is carried out in the institutes of the commissariats of industry, agriculture and health. Research and development are closely linked, and the scientific workers are close to the problems arising in the workshop and the field. The actual plan of research is not imposed from above, but evolved after much discussion by the scientific workers themselves. It does not, however, stand by itself but is closely linked to the State Planning Commission, and thus forms part of the general production and cultural plan of the Union. The major short- and long-term problems are set by the needs of the country as a whole. How they are to be solved most quickly and effectively is left for the scientific workers themselves to determine. That is the essential safeguard for seeing that fundamental work is not neglected. The result of this integrated effort goes much beyond its immediate practical application; it is producing a society that is scientific through and through.

The difficulties which, particularly in the years preceding the War, surrounded the work of Soviet men of science have often led to doubts in the rest of the scientific world as to the ultimate efficacy of the system adopted. The bitter test of war is showing that in this field also the Soviets were building better than we knew. It is to be hoped that, fighting together in a common cause, scientific workers in Great Britain will come to understand, far better than from any description, the new spirit and method which characterize science in the U.S.S.R., and that, in turn, we may be able to provide some of the advantages of a long tradition of discovery and criticism. The new world for which we are all fighting and working will need every contribution that science can bring.