various observatories. The Pulkova Observatory was in the front line for two and a half years in the fighting around Leningrad and has been completely destroyed by German shelling and bombing, though some of the instruments were saved. Most of its valuable astronomical library, probably the most complete in the world, has been lost; some of its treasures, including the manuscripts of Kepler, were fortunately saved. Its destruction was no doubt inevitable in the circumstances. But it was otherwise in the case of the Simeis Observatory, for no fighting took place in its vicinity. The Germans removed the telescopes (which have since been found in Potsdam, but in a state unfit for use), most of the library and most of the astronomical negatives; they then deliberately set fire to and destroyed the Observatory. The Observatories at Odessa, Kiev, Nikolaiev, Kharkov and Poltava were all badly damaged. Many of the observational records have been removed or destroyed, so that some of the co-operative programmes of observation, on which much work had been done, will have to be commenced anew. Many of the astronomers and some of their instruments were evacuated far into the interior. Some of the Pulkova astronomers were moved from Leningrad by aeroplane during the siege. Throughout the War a considerable amount of research in astronomy was continued in spite of the difficulties of the conditions.

The reconstruction of some of the damaged observatories has already been commenced. Plans have been prepared for the rebuilding of the Pulkova Observatory according to its original plan; the telescopes which were saved will be replaced in their original positions. But new additional instruments will be installed. Plans are under consideration for the establishment of a large astrophysical observatory in the Crimea, provided with powerful reflecting telescopes and with instruments of modern types; there may be also a subsidiary station somewhere in the southern hemisphere.

Mention may be made of the invention by Dr. Maksutov during the War of the new system of meniscus lens telescopes which, because only spherical surfaces are employed, are simple to manufacture. These telescopes are powerful and extremely compact. The largest meniscus telescope as yet constructed is of nine inches aperture; but telescopes of this type and of greater aperture are to be constructed for astronomical observation.

It is certain that the U.S.S.R. is destined to play a prominent part in the development of astronomy in the post-war years.

The Institute of Terrestrial Magnetism, established in Leningrad in 1940, embraces a wide field of work. It comprises sections for land magnetic surveys, sea magnetic surveys, magnetic observatories, magnetic cartography, ionospheric and cosmic ray observations, and theoretical investigations. Nineteen permanent magnetic observatories, including some high-latitude stations, were in operation when the War started. Six of these at Yanov, Stepanovka, Novgorod, Amvrossievka, Nizhnedevitsk and Pavlovsk were occupied by the Germans in 1941–42: same of the staffs were evacuated and some were made prisoners. When the Germans retreated they burned or blew up the observatory buildings in Pavlovsk, Novgorod and Nizhnedevitsk. Observational records and instruments were removed or destroyed. The magnetograms of the Second Polar Year stations have disappeared. Profs. Weinberg and Trubyatchinsky died of famine during the siege of Leningrad. Magnetic survey work has been continued during the War, and some expeditions were sent to the north of Siberia. Observations are made at regular intervals at a number of repeat stations for the determinations of secular changes. Magnetic anomalies associated with possibly useful mineral deposits have been studied. Solar, magnetic and ionospheric data are collected and summaries are published in ten-day cosmic bulletins.

The Institute is to be moved to a site near Moscow, where special buildings are to be erected, and the magnetic observatories destroyed by the Germans are to be re-established. Theoretical investigations in terrestrial magnetism and allied subjects are also carried out at the Institute for Theoretical Physics in Moscow, where Prof. Frenkel has recently developed new theories of atmospheric electricity and of the earth's magnetism. Among other work undertaken at this Institute are theoretical investigations of the scattering of light in the earth's atmosphere and of atmospheric transparency, and the study of the light of the night sky.

THEORETICAL PHYSICS

By Prof. M. BORN, F.R.S.
University of Edinburgh

IN the original group of British delegates to the Moscow conference, theoretical physics was well represented (Darwin, Dirac, Mott and myself); but I was the only one allowed by the Government to proceed. The following account is therefore based only on the observations of one pair of eyes and ears, which had to absorb a multitude of impressions vastly more interesting and important than even the most fascinating scientific things: a new and strange type of civilization in its various activities, social, economic, military, scientific, artistic, etc.

Theoretical physics can scarcely be separated from physics in general, on which Andrade has reported in a previous number of *Nature* (August 25, p. 223). I shall add a few remarks to his excellent account, but speak mainly about the more abstract branches of my subject. As the Soviet State is based on a definite philosophical system, the question arises whether this fact has any influence on the development of fundamental ideas in physics. I have found scarcely any traces of such an influence, and certainly no restrictions of research. The Russian physicist interprets the facts of observation in the same spirit of intellectual freedom as his Western colleague, and indulges in any speculation on cosmology, relativity or quantum theory without being censored. Nor does the question of the practical applicability play a great part, as many of the reports on other subjects have already stressed. Fundamental research is acknowledged as the basis for a sound growth of science, and a theoretical physicist is no more expected to produce results of economical importance than the roots of an apple tree to bear fruit; but if the roots are allowed to spread freely the branches carry a good crop.

The theory of relativity has a powerful representative in V. A. Fock (Moscow). A most important paper of his which appeared just before the War (February 1939) is little known in Britain. It contains the solution of the fundamental problem, also treated by Einstein (and collaborators), whether the field equations of gravitation are sufficient to determine the orbits of planets, or whether separate equations of motions are necessary. Fock's answer is that no such assumptions need to be made; he obtains Newton's laws as a first approximation for small bodies separated by large distances and develops the relativistic correction terms. I had a short discussion with Fock on Mises' foundation of the theory of probability and found him very sceptical: to define probability as the limit of relative frequencies in an actual series of trials seems to be a vicious circle, for there is no certainty of the existence of such a limit, but only a probability. I think Fock is right. He is also a great expert in quantum mechanics. I found him and the other Russian physicists perfectly acquainted with the newest developments, in particular of the theory of quantized fields and its application to radiation and mesons. J. Tamm (Moscow) and J. Frenkel (Leningrad) are working on these problems; their attitude to the well-known difficulties and perplexities is not much different from my own. To mention only one point, they are not satisfied by Eddington's ingenious theory of ultimate particles. Among the many other questions we discussed, I wish to direct attention to Frenkel's dynamic theory of atmospheric electricity, which has just appeared and seems to me very promising. As Andrade has already pointed out, Frenkel is attached to Joffe's laboratory in Leningrad and takes an active part in the interpretation of the experiments on semi-conductors and other things.

In an account of theoretical physics, the theoretical part of physico-chemistry cannot be excluded. In Moscow it is brilliantly represented by Frumkin, in whose laboratory well-planned work is done on the chemistry and physics of surface layers.

Russian physics suffered a great loss last year by the death of Mandelstam who, together with Landsberg, discovered almost simultaneously with Raman and independently the phenomenon since called the Raman effect. Mandelstam's optical school is continued under Landsberg's leadership. Another member of it is E. Gross, who discovered the splitting of spectral lines in a beam of light which is scattered by a liquid or a crystal, an effect due to the Doppler effect produced by the reflexion of the light waves on sound waves.

Russian physicists were very keen to learn something about work done in Britain, and I had to give several lectures. One of these was in the Lebedev Institute of Physics, the director of which, S. Vavilov, has just been elected president of the Academy of Sciences of the U.S.S.R. This visit gave me the opportunity of a glimpse of the celebrated laboratory and a discussion with its workers on diverse problems.

The limits of this article do not allow me to give an account of new discoveries in crystal physics and their explanation. I must, however, add a few remarks to Andrade's description of Kapitza's Institute for Physical Problems and the work done there. For this Institute contains a separate group of theoretical physicists under Landau's leadership who have made essential contributions to the low-temperature work going on. Kapitza himself is an expert in thermo-dynamics, which he applies as an engineer to the technical problems of the liquefaction of air, and as a physicist to research on liquid helium. It is most remarkable and characteristic of Russian science how applied and pure physics, experiment and theory, are here combined. Andrade has mentioned Landau's theory of superfluidity which was published in 1941, but has been improved by him and his collaborators. It will cause the theorists some 'headaches'; for though it is most successful in predicting experimental results, for example, the existence of two different velocities of sound (the normal one of about 220 m./sec. and a slow one of about 20 m./sec.), it also contains many obscurities. The first part deals with the quantization of the hydrodynamical equations for ideal liquids. The second part describes helium II as a mixture of two phases, or interpenetrating liquids, one having viscosity, the other not. This new and surprising idea is clear in itself but scarcely connected with the first part. The link is a consideration about the quantization of vortex motion, which leads to the conclusion that the range of energy states (of the whole liquid) consists of two parts separated by a gap $\triangle$, one part representing the irrotational, the other the vortex motion. The existence of this finite energy $\triangle$ prohibits, for slow motions of the liquid, the excitation of quanta, therefore the transfer of momentum from the walls, and this means lack of viscosity. Landau gives an expression for $\triangle$ in terms of density ρ, mass of the atom m and Quantum constant $\hbar$; the formula as published is wrong, but the idea is right. One has simply to remember the well-known expression for the so-called degeneration parameter from the Einstein-Bose or Fermi-Dirac statistics, $A = n\hbar^3/(m\triangle)^{3/2}$ where $n = \rho/m$ is the number of particles per unit volume. If $\triangle$ is expressed in terms of a critical temperature T_c, $\triangle = kT_c$, then for $T_c = 1°$ K. the dimensionless quantity A is very small for a gas, but of the order unity for a liquid*. Hence quantum effects can be expected for every liquid at temperatures of the order 1° K., but are only observable in helium as all other substances become solid at such low temperatures. Landau shows how the actual value of $\triangle$ can be determined from measurements of specific heat and finds that it is 8–9° K. This value is then used for further calculations, for example, of the two velocities of sound.

There are many other interesting investigations which I should like to discuss; but I have first to digest the reprints which were given to me in considerable numbers.

I cannot close this report without expressing my thanks to the Russian colleagues for the kind reception and hospitality we found in their midst.

* Landau's formula should read

$$\hbar^2 \rho^{2/3} m^{-5/3} = \hbar^2 n^{2/3} m^{-2/3} = A^{2/3} \triangle.$$

(*To be continued.*)

OBITUARIES

Colonel C. H. D. Ryder, C.B., C.I.E.

Colonel Charles Henry Dudley Ryder died on July 13 at Bognor Regis at the age of seventy-seven. He was the seventh son of Colonel Spencer Dudley Ryder and was educated at Cheltenham College and the R.M.A. Woolwich, whence he received a commission in the Royal Engineers. After the usual courses of instruction at Chatham, he proceeded to India and was posted in due course to the Survey of India, in which the whole of his subsequent career was spent.

Much of Ryder's earlier work up to the first World War was carried out on active service or deputation in China, Tibet, Persia and Turkey. Later he was